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TWENTIETH ANNUAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY,

CHARLES D. WALCOTT, DIRECTOR.

PART VI—Continued.

WASHINGTON:
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TWENTIETH ANNUAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY

PART VI (Continued).—MINERAL RESOURCES OF THE UNITED STATES, 1898
NONMETALLIC PRODUCTS, EXCEPT COAL AND COKE

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PETROLEUM.[1]

By F. H. OLIPHANT.

IMPORTANT FEATURES OF THE YEAR.

By a comparison of the tables of this report with those showing the development of the petroleum industry for the preceding years it will be found that the following features were conspicuous in 1898: (1) The total quantity of crude petroleum produced in the United States in 1898 showed a decrease as compared with the production in 1897; (2) there was a decrease in the number of wells drilled in 1898, as compared with 1897, in the Appalachian and in the Lima-Indiana fields; (3) there was a large increase in the production of crude petroleum in Texas in 1898 as compared with 1897; (4) only 6 per cent of petroleum product in the United States was outside of the Appalachian and the Lima-Indiana fields; (5) the stocks decreased; (6) the price increased; (7) the exports decreased.

DECREASE IN TOTAL PRODUCTION IN THE UNITED STATES.

The entire production of crude petroleum in the United States in 1898 was 55,364,233 barrels as compared with 60,475,516 barrels in 1897, showing a decrease of 5,111,283 barrels, equal to 8.45 per cent. The year 1898 stands third in the order of production; the product of 1896 was the largest of any year, and that of 1897 was only two-thirds of 1 per cent less than that of 1896.

DECREASE IN WELLS DRILLED IN 1898.

The total number of wells drilled in the Appalachian and the Lima-Indiana fields in 1898 was 7,186; of these, 1,539 were dry, as compared with 8,558 drilled in 1897, of which number 1,964 were dry. There was a decrease of 16 per cent in the number of wells drilled, while the number of dry holes decreased 22 per cent.

INCREASE IN TEXAS.

As in 1897, the State of Texas showed by far the greatest percentage increase in the important producing States in 1898. In 1898 the increase in production was 480,095 barrels, or seven barrels produced in 1898 for one in 1897.

[1] For much of the statistical information in this report credit should be given to the Oil City Derrick and to Miss Belle Hill for the careful compilation of most of the tables. Other special acknowledgments are given in the body of the report.

PERCENTAGE OF PRODUCT BY FIELDS.

The following table shows the percentage of the Appalachian, the Lima-Indiana, and all other fields combined:

Percentages of total crude petroleum produced in the several fields for 1896, 1897, and 1898.

Field.	1896.	1897.	1898.
	Per cent.	*Per cent.*	*Per cent.*
Appalachian	55.72	58.25	57.28
Lima-Indiana	41.43	37.71	36.70
All other	2.85	4.04	6.02
Total	100.00	100.00	100.00

The table shows a steady gain in the percentage of fields outside of the Appalachian and Lima-Indiana fields, this amount of production having doubled since 1896.

DECREASE IN STOCKS.

The total stocks of Appalachian and Lima-Indiana petroleum at the close of 1897 was 33,772,823 barrels as compared with 26,867,495 barrels in 1898, showing a decrease of 6,805,328 barrels in both fields, amounting to a decrease of 25 per cent. This decrease is entirely due to the shrinkage in the Lima-Indiana field, as the Appalachian field stocks increased 776,559 barrels in 1898. At the close of 1898 the Appalachian field held 40.3 per cent of the total stocks of petroleum and the Lima-Indiana field held 59.7 per cent.

INCREASE IN PRICE.

The average price per barrel for all the petroleum produced in the United States in 1898 was 79$\frac{4}{5}$ cents as compared with 67$\frac{3}{5}$ cents in 1897. This was an increase of 12$\frac{1}{5}$ cents per barrel, which is a gain of 18 per cent in price. Although the production was over five million barrels less, the value of the product of 1898 was $3,319,287 greater than the product of 1897. The average price of what is known as "Pennsylvania oil" in 1898 was 91$\frac{1}{8}$ cents as compared with 78$\frac{5}{8}$ cents in 1897, a gain of 12$\frac{3}{4}$ cents, or 16 per cent. The average price of Lima-Indiana petroleum during 1898 was 59$\frac{2}{5}$ cents per barrel as compared with 45$\frac{3}{5}$ cents in 1897, an increase of 13$\frac{4}{5}$ cents per barrel, equal to an advance of 30 per cent. The price ranged from 50 cents per barrel for Kansas petroleum up to $4 per barrel for Franklin natural lubricating petroleum and $7 per barrel for Wyoming natural lubricating petroleum.

DECREASE IN EXPORTS.

The total number of gallons of petroleum and its products exported in 1898 was 986,480,610, valued at $52,551,048, as compared with 994,297,757 gallons in 1897, valued at $59,057,547, showing a decrease of 7,817,147 gallons. This was a decline of three-fourths of 1 per cent in gallons and 12.3 per cent in value. More complete details of the petroleum exports will be found on pp. 10–14 of this report.

DECREASE IN THE APPALACHIAN FIELD.

This field includes all of the territory on the northwest flank of the Appalachian Mountains, extending in a general northeast-southwest direction, from southwestern New York, through Pennsylvania and West Virginia, and embracing a part of southeastern Ohio, continuing through Kentucky and Tennessee, and terminating in Alabama. The last-named State has produced no marketable petroleum, and Tennessee and Kentucky have produced only a small percentage.

The total production in this field was 31,711,857 barrels in 1898 as compared with 35,229,949 barrels in 1897, a decrease of 3,518,092 barrels, amounting to 10 per cent. The State of West Virginia increased 4 per cent. The greatest falling off was in southeastern Ohio. The amount and percentage of decrease and increase in 1898 and 1897, by States, is given in the following table:

Production of petroleum in the Appalachian field in 1897 and 1898, by States, showing increase or decrease.

State.	Production.		Increase.	Decrease.	Percentage.	
	1897.	1898.			Increase.	Decrease.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Per cent.*	*Per cent.*
New York	1, 279, 155	1, 205, 250		73, 905		5. 78
Pennsylvania	17, 982, 911	14, 743, 214		3, 239, 697		18. 02
West Virginia	13, 090, 045	13, 615, 101	525, 056		4. 01	
Southeastern Ohio	2, 877, 838	2, 148, 292		729, 546		25. 35
Total	35, 229, 949	31, 711, 857	525, 056	4, 043, 148		
Net decrease				3, 518, 092		9. 99

The State of West Virginia is conspicuous as being the only State in the Appalachian field that showed an increase. In 1897 the increase was 30.6 per cent over 1896.

DECREASE IN THE LIMA-INDIANA FIELD.

The Lima-Indiana field includes all of Indiana and that portion of northwestern Ohio in which Lima petroleum is produced. The production decreased from 22,805,033 barrels in 1897 to 20,321,323 barrels in 1898, a decrease of 12 per cent. Of this total Ohio produced in 1898 16,590,416 barrels as compared with 18,682,677 barrels in 1897, a decrease of 12 per cent. The production in Indiana in 1898 was 3,730,907 barrels as compared with 4,122,356 barrels in 1897, showing a decrease of 10.5 per cent. This field in 1897 showed an increase of 30 per cent over 1896.

OTHER STATES.

California produced 2,257,207 barrels in 1898 as compared with 1,903,411 barrels of petroleum in 1897, a gain of 18.5 per cent, and for the first time has produced more petroleum than the "white sand" pools of southeastern Ohio—being fourth in the order of States.

Ohio has produced since 1894 more petroleum than any of the States, and more than Pennsylvania and New York together.

Colorado and Kansas both show an increase. The tables in this report, showing production, value, and percentages of increase and decrease, give additional information for comparison.

PRODUCTION AND VALUE.

TOTAL PRODUCTION AND VALUE.

In the following table is given a statement of the total amount and the total value of all crude petroleum produced in the United States in 1897 and 1898, by States and important districts:

Total amount and value of crude petroleum produced in the United States, and average price per barrel, in 1897 and 1898.

State and district.	1897.			1898.		
	Barrels.	Value.	Average value per barrel.	Barrels.	Value.	Average value per barrel.
New York	1, 279, 155	$1, 005, 736	$0. 78⅝	1, 205, 250	$1, 098, 284	$0. 91⅛
Pennsylvania:						
Pennsylvania	17, 931, 631	14, 098, 745	. 78⅝	14, 684, 944	13, 381, 655	. 91⅛
Franklin	48, 880	195, 520	4. 00	56, 090	224, 360	4. 00
Smiths Ferry	2, 400	1, 560	. 65	2, 180	1, 987	. 91⅛
Total	17, 982, 911	14, 295, 825	. 79½	14, 743, 214	13, 608, 002	. 92 3/10
West Virginia:						
West Virginia.. / Burning Springs	13, 078, 011	10, 282, 586	. 78⅝	13, 603, 136	12, 395, 858	. 91⅛
Volcano *a*	11, 622	26, 150	2. 25	11, 965	30, 501	2. 55
Petroleum *b*	412	1, 442	3. 50			
Total	13, 090, 045	10, 310, 178	. 78¾	13, 615, 101	12, 426, 359	. 91 3/10
Ohio:						
Eastern and southern	2, 877, 193	2, 262, 193	. 78⅝	2, 147, 610	1, 957, 010	. 91⅛
Lima	18, 682, 677	8, 967, 685	. 48	16, 590, 416	10, 244, 582	. 61¾
Mecca-Belden	645	3, 120	4. 84	682	3, 618	5. 30½
Total	21, 560, 515	11, 232, 998	. 52	18, 738, 708	12, 205, 210	. 65 1/10

a Production of light oil in Volcano included with West Virginia's product.
b Production of light oil in Petroleum included with West Virginia's product.

Total amount and value of crude petroleum produced in the United States, and average price per barrel, in 1897 and 1898—Continued.

State and district.	1897.			1898.		
	Barrels.	Value.	Average value per barrel.	Barrels.	Value.	Average value per barrel.
Indiana	4, 122, 356	$1, 880, 412	$0. 45$\frac{3}{5}$	3, 730, 907	$2, 214, 322	$0. 59$\frac{2}{5}$
Kentucky	322	161	.50	5, 568	2, 784	.50
Missouri	19	174	9. 16	10	105	10. 50
Colorado	384, 934	332, 122	.86	444, 383	367, 447	.82$\frac{7}{10}$
California	1, 903, 411	1, 713, 102	.90	2, 257, 207	1, 917, 596	.85
Texas	65, 975	37, 662	.57	546, 070	277, 135	.50$\frac{4}{5}$
Indian Territory	625	2, 063	3. 30	0	0	0
Illinois	500	2, 000	4. 00	360	1, 800	5. 00
Wyoming	3, 650	29, 200	8. 00	5, 475	38, 325	7. 00
Kansas	81, 098	32, 439	.40	71, 980	35, 990	.50
Grand total	*a*60,475,516	40, 874, 072	.67$\frac{3}{5}$	*b*55, 364, 233	44, 193, 359	.79$\frac{4}{5}$

a In addition to this product, 4,377 barrels of crude were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

b In addition to this product, 19,125 barrels of crude were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

The increase or decrease in the production by States, as well as the percentages of increase or decrease in 1898 compared with 1897, is shown in the following table:

Total production of crude petroleum and percentage of increase or decrease, by States, in 1898 as compared with 1897.

State.	Production.		Increase in 1898.	Decrease in 1898.	Percentage.	
	1897.	1898.			Increase.	Decrease.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Per cent.*	*Per cent.*
New York	1, 279, 155	1, 205, 250		73, 905		5. 78
Pennsylvania	17, 982, 911	14, 743, 214		3, 239, 697		18. 02
West Virginia	13, 090, 045	13, 615, 101	525, 056		4. 01	
Ohio	21, 560, 515	18, 738, 708		2, 821, 807		13. 09
Indiana	4, 122, 356	3, 730, 907		391, 449		9. 50
Kentucky	322	5, 568	5, 246		1, 629. 19	
Missouri	19	10		9		47. 37
Colorado	384, 934	444, 383	59, 449		15. 44	
California	1, 903, 411	2, 257, 207	353, 796		18. 59	
Texas	65, 975	546, 070	480, 095		727. 57	
Indian Territory	625	0		625		100. 00
Illinois	500	360		140		28. 00
Wyoming	3, 650	5, 475	1, 825		50. 00	
Kansas	81, 098	71, 980		9, 118		11. 24
Total	60, 475, 516	55, 364, 233		5, 111, 283		8. 45

From the above table it will be noticed that, while the percentages vary largely in the columns showing increase and decrease, the total decrease is only 8.45 per cent. Comparing the product by States, it will be noticed that Texas shows the largest percentage of increase for any important amount of product, while Pennsylvania shows the largest percentage of decrease in the important states.

PRODUCTION, BY FIELDS.

The production of petroleum in the principal fields of the United States in 1895, 1896, 1897, and 1898 was as follows:

Production of petroleum in the United States in 1895, 1896, 1897, and 1898, by fields.

[Barrels of 42 gallons.]

Field.	Production.			
	1895.	1896.	1897.	1898.
Appalachian	30,959,139	33,970,222	35,229,949	31,711,857
Lima-Indiana	20,236,741	25,255,870	22,805,033	20,321,323
Florence, Colorado	438,232	361,450	384,934	444,383
Southern California	1,208,482	1,252,777	1,903,411	2,257,207
Kansas	44,430	113,571	81,098	71,980
Texas	50	1,450	65,975	546,070
Wyoming	3,455	2,878	3,650	5,475
Other	1,747	2,143	1,466	5,938
Total	52,892,276	*a* 60,960,361	*b* 60,475,516	*c* 55,364,233

a In addition to this total, 4,325 barrels of crude oil were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

b In addition to this total, 4,377 barrels of crude oil were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

c In addition to this amount, 19,125 barrels of crude oil were produced in Kentucky and Tennessee, for which, as none was sold or used, no value could be given.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES, 1859 TO 1898.

In the following table will be found a statement of the production of crude petroleum in the United States from the beginning of production, marked by the drilling of the Colonel Drake well in 1859, up to and including the production of 1898, the tables being by years and States:

Production of crude petroleum in the United States from 1859 to 1898.

[Barrels of 42 gallons.]

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	Colorado.	California.	Indiana.
1859..	2,000	....	....	....	....	....
1860..	500,000	....	....	....	....	....
1861..	2,113,609	....	....	....	....	....
1862..	3,056,690	....	....	....	....	....
1863..	2,611,309	....	....	....	....	....
1864..	2,116,109	....	....	....	....	....
1865..	2,497,700	....	....	....	....	....
1866..	3,597,700	....	....	....	....	....
1867..	3,347,300	....	....	....	....	....
1868..	3,646,117	....	....	....	....	....
1869..	4,215,000	....	....	....	....	....
1870..	5,260,745	....	....	....	....	....
1871..	5,205,234	....	....	....	....	....
1872..	6,293,194	....	....	....	....	....
1873..	9,893,786	....	....	....	....	....
1874..	10,926,945	....	....	....	....	....
1875..	8,787,514	*a* 200,000	*a* 3,000,000	....	*a* 175,000	....
1876..	8,968,906	31,763	120,000	....	12,000	....
1877..	13,135,475	29,888	172,000	....	13,000	....
1878..	15,163,462	38,179	180,000	....	15,227	....
1879..	19,685,176	29,112	180,000	....	19,858	....
1880..	26,027,631	38,940	179,000	....	40,552	....
1881..	27,376,509	33,867	151,000	....	99,862	....
1882..	30,053,500	39,761	128,000	....	128,636	....
1883..	23,128,389	47,632	126,000	....	142,857	....
1884..	23,772,209	90,081	90,000	....	262,000	....
1885..	20,776,041	661,580	91,000	....	325,000	....
1886..	25,798,000	1,782,970	102,000	....	377,145	....
1887..	22,356,193	5,022,632	145,000	76,295	678,572	....
1888..	16,488,668	10,010,868	119,448	297,612	690,333	....
1889..	21,487,435	12,471,466	544,113	316,476	303,220	33,375
1890..	28,458,208	16,124,656	492,578	368,842	307,360	63,496
1891..	33,009,236	17,740,301	2,406,218	665,482	323,600	136,634
1892..	28,422,377	16,362,921	3,810,086	824,000	385,049	698,068
1893..	20,314,513	16,249,769	8,445,412	594,390	470,179	2,335,293
1894..	19,019,990	16,792,154	8,577,624	515,746	705,969	3,688,666
1895..	19,144,390	19,545,233	8,120,125	438,232	1,208,482	4,386,132
1896..	20,584,421	23,941,169	10,019,770	361,450	1,252,777	4,680,732
1897..	19,262,066	21,560,515	13,090,045	384,934	1,903,411	4,122,356
1898..	15,948,464	18,738,708	13,615,101	444,383	2,257,207	3,730,907
Total.	572,452,211	197,584,165	73,904,520	5,287,842	12,097,296	23,875,659

a Including all productions prior to 1876.

Production of crude petroleum in the United States from 1859 to 1898—Continued.

Year.	Kentucky and Tennessee.	Illi-nois.	Kansas.	Texas.	Mis-souri.	Indian Terri-tory.	Wyo-ming.	United States.
1859								2,000
1860								500,000
1861								2,113,609
1862								*a* 3,056,690
1863								2,611,309
1864								2,116,109
1865								2,497,700
1866								3,597,700
1867								3,347,300
1868								3,646,117
1869								4,215,000
1870								5,260,745
1871								5,205,234
1872								6,293,194
1873								9,893,786
1874								10,926,945
1875								*b* 12,162,514
1876								9,132,669
1877								13,350,363
1878								15,396,868
1879								19,914,146
1880								26,286,123
1881								27,661,238
1882	*c* 160,933							30,510,830
1883	4,755							23,449,633
1884	4,148							24,218,438
1885	5,164							21,858,785
1886	4,726							28,064,841
1887	4,791							28,283,483
1888	5,096							27,612,025
1889	5,400	1,460	500	48	20			35,163,513
1890	6,000	900	1,200	54	278			45,823,572
1891	9,000	675	1,400	54	25	30		54,292,655
1892	6,500	521		45	10	80		50,509,657
1893	3,000	400	18,000	50	50	10		48,431,066
1894	1,500	300	40,000	60	8	130	2,369	49,344,516
1895	1,500	200	44,430	50	10	37	3,455	52,892,276
1896	*d* 1,680	250	113,571	1,450	43	170	2,878	*d* 60,960,361
1897	*d* 322	500	81,098	65,975	19	625	3,650	*d* 60,475,516
1898	*e* 5,568	360	71,980	546,070	10	0	5,475	*e* 55,364,233
Total.	230,083	5,566	372,179	613,856	473	1,082	17,827	886,442,759

a In addition to this amount, it is estimated that for want of a market some 10,000,000 barrels ran to waste in and prior to 1862 from the Pennsylvania fields; also a large amount from West Virginia and Tennessee.

b Including all production prior to 1876 in Ohio, West Virginia, and California.

c This includes all the petroleum produced in Kentucky and Tennessee prior to 1883.

d In addition to this amount, 4,325 barrels of crude oil were produced in Kentucky and Tennessee in 1896 and 4,377 barrels in 1897, for which, as none was sold or used, no value could be given.

e In addition to this amount, 19,125 barrels of crude oil were produced in Kentucky and Tennessee in 1898, but as none was sold no value could be given.

From the foregoing table it appears that the enormous amount of 886,442,759 barrels of crude petroleum has been taken out of the rocks since Colonel Drake drilled the first oil well near Titusville in 1859. If we allow 5.6 cubic feet to 1 barrel of petroleum it would amount to 4,964,079,450 cubic feet. The sides of the cube to contain this volume would be 1,706.5 feet in length. This amount of oil would fill a tank with a base of 1 square mile and a height of 178 feet.

For convenience of reference, a statement is given below of the production of petroleum in the United States from 1893 to 1898, by States:

Production of petroleum in the United States from 1893 to 1898, by States.

[Barrels of 42 gallons.]

State.	1893.	1894.	1895.	1896.	1897.	1898.
Pennsylvania and New York	20, 314, 513	19, 019, 990	19, 144, 390	20, 584, 421	19, 262, 066	15, 948, 464
Ohio	16, 249, 769	16, 792, 154	19, 545, 233	23, 941, 169	21, 560, 515	18, 738, 708
West Virginia	8, 445, 412	8, 577, 624	8, 120, 125	10, 019, 770	13, 090, 045	13, 615, 101
Colorado	594, 390	515, 746	438, 232	361, 450	384, 934	444, 383
California	470, 179	705, 969	1, 208, 482	1, 252, 777	1, 903, 411	2, 257, 207
Indiana	2, 335, 293	3, 688, 666	4, 386, 132	4, 680, 732	4, 122, 356	3, 730, 907
Kentucky	3, 000	1, 500	1, 500	1, 680	322	5, 568
Illinois	....	300	200	250	500	360
Kansas	....	40, 000	44, 430	113, 571	81, 098	71, 980
Texas	50	60	50	1, 450	65, 975	546, 070
Missouri	50	8	10	43	19	10
Indian Territory	10	130	37	170	625	0
Wyoming	....	2, 369	3, 455	2, 878	3, 650	5, 475
Total	48, 412, 666	49, 344, 516	52, 892, 276	*a* 60, 960, 361	*a* 60, 475, 516	*a* 55, 364, 233

a In addition to this amount, 4 325 barrels of crude oil were produced in Kentucky and Tennessee in 1896, 4,377 barrels in 1897, and 19,125 barrels in 1898, for which, as none was sold or used, no value could be given.

EXPORTS.

The following tables are the official statement of the export of petroleum and its products (mineral oils) for the year ending December 31, 1898, as compared with the preceding year:

Exports of mineral oils from the United States in 1898 and 1897.

Port and kind.	1898.		1897.	
	Gallons.	Value.	Gallons.	Value.
Crude petroleum	114, 915, 082	$4, 764, 111	121, 488, 726	$5, 020, 968
Naphtha	17, 026, 626	1, 053, 231	13, 430, 320	994, 781
Illuminating oil	761, 152, 107	38, 542, 082	795, 919, 525	46, 229, 579
Lubricating oil and paraffin	63, 968, 341	7, 385, 054	51, 228, 284	6, 478, 479
Residuum	29, 418, 454	806, 570	12, 230, 902	333, 740
Total	986, 480, 610	52, 551, 048	994, 297, 757	59, 057, 547
CRUDE.				
Delaware	62, 540, 629	2, 390, 650	68, 408, 057	2, 677, 035
New York	2, 653, 940	130, 850	3, 563, 263	238, 708
Philadelphia	49, 720, 513	2, 242, 611	49, 517, 406	2, 105, 225
Total	114, 915, 082	4, 764, 111	121, 488, 726	5, 020, 968
NAPHTHAS.				
Boston and Charlestown			517	155
Delaware	1, 616, 402	88, 410		
New York	8, 271, 719	540, 339	6, 604, 984	507, 955
Philadelphia	7, 138, 505	424, 482	6, 824, 819	486, 671
Total	17, 026, 626	1, 053, 231	13, 430, 320	994, 781
ILLUMINATING.				
Baltimore	45, 278, 794	2, 728, 019	45, 263, 498	2, 717, 912
Boston and Charlestown	687, 357	52, 565	1, 001, 639	74, 176
Delaware	23, 970, 772	909, 021	25, 531, 848	1, 675, 390
New York	498, 513, 494	26, 471, 434	497, 237, 227	26, 187, 342
Philadelphia	192, 701, 690	8, 381, 043	226, 885, 313	15, 574, 759
Total	761, 152, 107	38, 542, 082	795, 919, 525	46, 229, 579

Exports of mineral oils from the United States in 1898 and 1897—Continued.

Port and kind.	1898.		1897.	
	Gallons.	Value.	Gallons.	Value.
LUBRICATING AND PARAFFIN.				
Baltimore	989, 568	$121, 538	872, 429	$109, 418
Boston and Charlestown	148, 860	28, 358	185, 534	38, 564
New York	49, 816, 219	6, 195, 803	41, 629, 492	5, 577, 962
Philadelphia	13, 013, 694	1, 039, 355	8, 540, 829	752, 535
Total	63, 968, 341	7, 385, 054	51, 228, 284	6, 478, 479
RESIDUUM.				
Delaware	42	3	....	....
New York	13, 708, 800	329, 007	3, 054, 238	93, 866
Philadelphia	15, 709, 612	477, 560	9, 176, 664	239, 874
Total	29, 418, 454	806, 570	12, 230, 902	333, 740
Baltimore	46, 268, 362	2, 849, 557	46, 135, 927	2, 827, 330
Boston and Charlestown	836, 217	80, 923	1, 187, 690	112, 895
Delaware	88, 127, 845	3, 388, 084	93, 939, 905	4, 352, 425
New York	572, 964, 172	33, 667, 433	552, 089, 204	32, 605, 833
Philadelphia	278, 284, 014	12, 565, 051	300, 945, 031	19, 159, 064
Grand total	986, 480, 610	52, 551, 048	994, 297, 757	59, 057, 547

The average distillation of 100 gallons of crude petroleum is estimated to yield 76 gallons of illuminating oil, 11 gallons of gasoline, benzine, and naphtha, 3 gallons of lubricating oil, and 10 gallons of residuum and loss.

In the following table are given the exports of crude petroleum and its products from the United States from 1871 to 1898, together with a statement of the production of the United States in the years named. The figures of exports are from the Statistical Abstracts of the United States, published by the Bureau of Statistics, Treasury Department. The figures of production were collected by the writer and other agents of the Geological Survey.

Quantity of crude petroleum produced in, and the qualities and values of petroleum products exported from, the United States during each of the calendar years from 1871 to 1898.

Year ending December 31—	Production.		Exports.			
			Mineral, crude (including all natural oils, without regard to gravity).		Mineral, refined or manufactured. Naphthas, benzine, gasoline, etc.	
	Barrels (of 42 gallons).	Gallons.	*Gallons.*	*Dollars.*	*Gallons.*	*Dollars.*
1871....	5, 205, 234	218, 619, 828	11, 278, 589	2, 171, 706	8, 396, 905	895, 910
1872....	6, 293, 194	264, 314, 148	16, 363, 975	2, 761, 094	8, 688, 257	1, 307, 058
1873....	9, 893, 786	415, 539, 012	19, 643, 740	2, 665, 171	10, 250, 497	1, 266, 962
1874....	10, 926, 945	458, 931, 690	14, 430, 851	1, 428, 494	10, 616, 644	997, 355
1775....	12, 162, 514	510, 825, 588	16, 536, 800	1, 738, 589	14, 048, 726	1, 392, 192
1876....	9, 132, 669	383, 572, 098	25, 343, 271	3, 343, 763	13, 252, 751	1, 502, 498
1877....	13, 350, 363	560, 715, 246	28, 773, 233	3, 267, 309	19, 565, 909	1, 938, 672
1878....	15, 396, 868	646, 668, 456	24, 049, 604	2, 169, 790	13, 431, 782	1, 077, 402
1879....	19, 914, 146	836, 394, 132	28, 601, 650	2, 069, 458	19, 524, 582	1, 367, 996
1880....	26, 286, 123	1, 104, 017, 166	36, 748, 116	2, 772, 400	15, 115, 131	1, 344, 529
1881....	27, 661, 238	1, 161, 771, 996	40, 430, 108	3, 089, 297	20, 655, 116	1, 981, 197
1882....	30, 510, 830	1, 281, 454, 860	45, 011, 154	3, 373, 302	16, 969, 839	1, 304, 041
1883....	23, 449, 633	984, 884, 586	59, 018, 537	4, 439, 097	17, 365, 314	1, 195, 035
1884....	24, 218, 438	1, 017, 174, 396	79, 679, 395	6, 102, 810	13, 676, 421	1, 132, 528
1885....	21, 858, 785	918, 068, 970	81, 435, 609	6, 040, 685	14, 739, 469	1, 160, 999
1886....	28, 064, 841	1, 178, 723, 322	76, 346, 480	5, 068, 409	14, 474, 951	1, 264, 736
1887....	28, 283, 483	1, 187, 906, 286	80, 650, 286	5, 141, 833	12, 382, 213	1, 049, 043
1888....	27, 612, 025	1, 159, 705, 050	77, 549, 452	5, 454, 705	13, 481, 706	1, 083, 429
1889....	35, 163, 513	1, 476, 867, 546	85, 189, 658	6, 134, 002	13, 984, 407	1, 208, 116
1890....	45, 822, 672	1, 924, 552, 224	96, 572, 625	6, 535, 499	12, 462, 636	1, 050, 613
1891....	54, 291, 980	2, 280, 263, 160	96, 722, 807	5, 365, 579	11, 424, 993	868, 137
1892....	50, 509, 136	2, 121, 383, 712	104, 397, 107	4, 696, 191	16, 393, 284	1, 037, 558
1893 *a* ..	48, 412, 666	2, 033, 331, 972	111, 703, 508	4, 567, 391	17, 304, 005	1, 074, 710
1894....	49, 344, 516	2, 072, 469, 672	121, 926, 349	4, 415, 915	15, 555, 754	943, 970
1895....	52, 892, 276	2, 221, 475, 592	111, 285, 264	5, 161, 710	14, 801, 224	910, 988
1896....	*b*60, 960, 361	2, 560, 335, 162	110, 923, 620	6, 121, 836	12, 349, 319	1, 059, 542
1897....	*b*60, 475, 516	2, 539, 971, 672	121, 488, 726	5, 020, 968	13, 430, 320	994, 781
1898....	*c*55, 364, 233	2, 325, 297, 786	114, 915, 082	4, 764, 111	17, 026, 626	1, 053, 231

a Exports are for fiscal years from 1893 to 1896, inclusive.

b In addition to this amount, 4,325 barrels of crude oil were produced in Kentucky and Tennessee in 1896, and 4,377 barrels in 1897, for which, as none was sold or used, no value could be given.

c In addition to this total, 19,125 barrels of crude oil were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

Quantity of crude petroleum produced in, and the qualities and values of petroleum products exported from, the United States, etc.—Continued.

Year ending December 31—	Exports.			
	Mineral, refined or manufactured.			
	Illuminating.		Lubricating (heavy paraffin, etc.).	
	Gallons.	*Dollars.*	*Gallons.*	*Dollars.*
1871	132, 178, 843	33, 493, 351	240, 228	92, 408
1872	118, 259, 832	29, 456, 453	438, 425	180, 462
1873	207, 595, 988	41, 357, 686	1, 502, 503	517, 466
1874	206, 562, 977	30, 168, 747	993, 068	269, 886
1875	203, 678, 748	28, 168, 572	938, 052	265, 837
1876	220, 831, 608	44, 089, 066	1, 157, 929	370, 431
1877	307, 373, 842	51, 366, 205	1, 914, 129	577, 610
1878	306, 212, 506	36, 855, 798	2, 525, 545	698, 182
1879	365, 597, 467	32, 811, 755	3, 168, 561	713, 208
1880	286, 131, 557	29, 047, 908	5, 607, 009	1, 141, 825
1881	444, 666, 615	42, 122, 683	5, 053, 862	1, 165, 605
1882	428, 424, 581	37, 635, 981	8, 821, 536	2, 034, 487
1883	440, 150, 660	39, 470, 352	10, 108, 394	2, 193, 245
1884	433, 851, 275	39, 450, 794	11, 985, 219	2, 443, 385
1885	445, 880, 518	39, 476, 082	12, 978, 955	2, 659, 210
1886	485, 120, 680	39, 012, 922	13, 948, 367	2, 689, 464
1887	485, 242, 107	37, 007, 336	20, 582, 613	3, 559, 280
1888	455, 045, 784	37, 236, 111	24, 510, 437	4, 215, 449
1889	551, 769, 666	41, 215, 192	27, 903, 267	4, 638, 724
1890	550, 873, 438	39, 826, 086	32, 090, 537	4, 766, 850
1891	531, 445, 099	34, 879, 759	33, 310, 264	4, 999, 978
1892	589, 418, 185	31, 826, 545	34, 026, 855	5, 130, 643
1893 *a*	642, 239, 816	31, 719, 404	32, 432, 857	4, 738, 892
1894	730, 368, 626	30, 676, 217	40, 190, 577	5, 449, 000
1895	714, 859, 144	34, 706, 844	43, 418, 942	5, 867, 477
1896	716, 455, 505	48, 630, 920	50, 525, 530	6, 556, 775
1897	795, 919, 525	46, 229, 579	51, 228, 284	6, 478, 479
1898	761, 152, 107	38, 542, 082	63, 968, 341	7, 385, 054

a Exports are for fiscal years from 1893 to 1896, inclusive.

Quantity of crude petroleum produced in, and the qualities and values of petroleum products exported from, the United States, etc.—Continued.

Year ending December 31—	Exports.			
	Residuum (tar, pitch, and all other, from which the light bodies have been distilled).		Total.	
	Gallons.	*Dollars.*	*Gallons.*	*Dollars.*
1871	101, 052	10, 450	152, 195, 617	36, 663, 825
1872	568, 218	56, 618	144, 318, 707	33, 761, 685
1873	1, 377, 180	117, 595	240, 369, 908	45, 924, 880
1874	2, 504, 628	177, 794	235, 108, 168	33, 042, 276
1875	2, 323, 986	169, 671	237, 526, 312	31, 734, 861
1876	2, 863, 896	239, 461	263, 449, 455	49, 545, 219
1877	4, 256, 112	390, 077	361, 883, 225	57, 539, 873
1878	3, 126, 816	220, 835	349, 346, 253	41, 022, 007
1879	4, 827, 522	273, 050	421, 719, 782	37, 235, 467
1880	3, 177, 630	198, 983	346, 779, 443	34, 505, 645
1881	3, 756, 018	197, 321	514, 561, 719	48, 556, 103
1882	4, 265, 352	275, 263	503, 492, 462	44, 623, 074
1883	6, 502, 524	465, 350	533, 145, 429	47, 763, 079
1884	5, 303, 298	327, 599	544, 495, 608	49, 457, 116
1885	5, 713, 908	334, 767	560, 784, 459	49, 671, 743
1886	1, 993, 824	109, 673	591, 884, 302	48, 145, 204
1887	2, 989, 098	141, 350	601, 846, 317	46, 898, 842
1888	1, 870, 596	116, 009	572, 457, 975	48, 105, 703
1889	1, 858, 458	97, 265	680, 705, 456	53, 293, 299
1890	1, 830, 612	91, 905	693, 829, 848	52, 270, 953
1891	1, 002, 414	61, 382	673, 905, 577	46, 174, 835
1892	403, 032	38, 220	744, 638, 463	42, 729, 157
1893 *a*	541, 044	41, 661	804, 221, 230	42, 142, 058
1894	211, 008	14, 704	908, 252, 314	41, 499, 806
1895	137, 508	13, 063	884, 502, 082	46, 660, 082
1896	204, 960	14, 330	890, 458, 994	62, 383, 403
1897	12, 230, 902	333, 740	994, 297, 757	59, 057, 547
1898	29, 418, 454	806, 570	986, 480, 610	52, 551, 048

a Exports are for fiscal years from 1893 to 1896, inclusive.

FOREIGN MARKETS.

In the following table is given a statement showing the foreign markets for our oil in the past eight years. As will be seen from this table, the total exports of illuminating oils have increased.

Exports of petroleum in its various forms from the United States from 1891 to 1898, by countries.

Country and kind.	1891.	1892.	1893.	1894.
CRUDE.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
France	61, 663, 973	69, 100, 657	69, 424, 609	84, 434, 953
Germany	3, 107, 137	5, 247, 209	4, 182, 963	4, 877, 593
Spain	17, 103, 416	17, 064, 929	21, 112, 042	15, 176, 034
United Kingdom	....	....	....	....
Other Europe	2, 380, 600	1, 935, 014	3, 948, 842	2, 009, 727
Total	84, 255, 126	93, 347, 809	98, 668, 456	106, 498, 307
North America:				
Mexico	3, 854, 176	3, 499, 514	5, 508, 769	8, 026, 189
Cuba	3, 300, 455	6, 316, 406	6, 955, 315	6, 865, 549
Other North America	4, 338	425, 348	548, 068	534, 304
Total	7, 158, 969	10, 241, 268	13, 012, 152	15, 426, 042
All other countries	1, 000	3, 690	22, 900	2, 000
Total crude	91, 415, 095	103, 592, 767	111, 703, 508	121, 926, 349
REFINED.				
Naphthas.				
Europe:				
France	2, 831, 929	1, 561, 284	4, 080, 839	3, 764, 569
Germany	3, 227, 106	3, 471, 652	4, 127, 354	4, 278, 757
United Kingdom	5, 058, 325	6, 813, 416	8, 209, 526	6, 834, 760
Other Europe	824, 537	686, 398	658, 270	364, 135
Total	11, 941, 897	12, 532, 750	17, 076, 989	15, 242, 221
North America	86, 910	35, 762	122, 237	106, 454
West Indies	....	....	....	67, 195
South America	71, 192	89, 609	55, 940	79, 777
Asia and Oceanica	55, 005	57, 787	39, 625	57, 057
Africa	16, 143	12, 070	9, 214	3, 050
Total	229, 250	195, 228	227, 016	313, 533
Total naphthas	12, 171, 147	12, 727, 978	17, 304, 005	15, 555, 754

Exports of petroleum in its various forms from the United States from 1891 to 1898, by countries—Continued.

Country and kind.	1891.	1892.	1893.	1894.
REFINED—continued.				
Illuminating.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Belgium	32, 397, 015	31, 471, 121	33, 541, 439	36, 312, 974
Denmark	9, 135, 043	7, 019, 575	12, 262, 308	9, 290, 251
France	3, 764, 974	3, 005, 535	8, 161, 023	11, 812, 001
Germany	162, 187, 071	133, 417, 314	119, 277, 484	86, 388, 785
Italy	20, 955, 728	22, 324, 113	22, 815, 279	22, 945, 037
Netherlands	54, 879, 032	76, 607, 780	51, 298, 480	31, 868, 189
Sweden and Norway	8, 957, 350	11, 159, 824	16, 312, 922	9, 848, 074
United Kingdom	81, 028, 529	94, 901, 777	180, 996, 321	274, 555, 010
Other Europe	8, 759, 531	6, 450, 040	8, 654, 660	7, 232, 024
Total	382, 064, 273	386, 357, 079	453, 319, 916	490, 252, 345
North America:				
British North America	5, 230, 259	5, 735, 411	6, 341, 042	8, 218, 417
West Indies	3, 303, 506	4, 262, 935	4, 439, 118	4, 174, 856
Other North America	3, 303, 608	2, 250, 162	2, 204, 602	1, 759, 565
Total	11, 837, 373	12, 248, 508	12, 984, 762	14, 182, 838
South America:				
Argentina	3, 476, 192	4, 825, 196	4, 070, 719	3, 162, 846
Brazil	10, 470, 656	14, 028, 476	15, 556, 685	12, 154, 709
Uruguay	3, 165, 880	4, 293, 400	2, 882, 105	2, 520, 571
Other South America	4, 792, 161	6, 827, 814	6, 041, 571	5, 503, 680
Total	21, 904, 889	29, 974, 886	28, 551, 080	23, 341, 806
Asia and Oceanica:				
China	27, 160, 660	17, 370, 600	27, 874, 230	40, 377, 296
Hongkong	10, 814, 630	16, 529, 790	12, 758, 820	16, 888, 820
East Indies	63, 285, 770	55, 907, 410	57, 404, 175	85, 907, 557
Japan	31, 000, 629	23, 761, 930	26, 869, 510	37, 272, 450
British Australasia	10, 276, 095	10, 376, 260	11, 053, 991	11, 821, 881
Other Asia and Oceanica	4, 630, 690	3, 095, 516	2, 637, 250	2, 944, 958
Total	147, 168, 474	127, 041, 536	138, 597, 976	195, 212, 962
Africa	8, 058, 806	8, 865, 999	8, 206, 932	7, 049, 455
All other countries	85, 990	408, 650	579, 150	329, 220
Total illuminating	571, 119, 805	564, 896, 658	642, 239, 816	730, 368, 626

Exports of petroleum in its various forms from the United States from 1891 to 1898, by countries—Continued.

Country and kind.	1891.	1892.	1893.	1894.
REFINED—continued.				
Lubricating.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Belgium	2, 337, 030	2, 632, 954	2, 426, 926	2, 931, 204
France	3, 948, 257	2, 461, 722	2, 426, 659	3, 050, 547
Germany	4, 186, 225	4, 512, 639	3, 798, 953	5, 637, 471
Italy	591, 996	404, 971	788, 805	1, 356, 340
Netherlands	1, 504, 623	2, 229, 116	1, 842, 608	2, 346, 896
United Kingdom	18, 767, 573	18, 779, 806	17, 683, 132	19, 668, 767
Other Europe	111, 165	209, 713	249, 474	415, 385
Total	31, 446, 869	31, 240, 921	29, 216, 557	35, 406, 610
North America	570, 380	656, 991	1, 043, 770	1, 308, 586
West Indies	....	....	....	417, 123
South America	889, 610	798, 194	1, 207, 232	1, 509, 708
Asia and Oceanica	582, 392	813, 618	888, 032	1, 433, 191
Africa	25, 479	81, 352	77, 266	115, 359
Total	2, 067, 861	2, 350, 155	3, 216, 300	4, 783, 967
Total lubricating	33, 514, 730	33, 591, 076	32, 432, 857	40, 190, 577
Residuum (barrels).				
Europe	9, 058	6, 361	10, 404	2, 056
North America	28, 833	6, 622	2, 202	2, 460
All other countries	175	287	276	513
Total residuum	38, 066	13, 270	12, 882	5, 029

Country and kind.	1895.	1896.	1897.	1898.
CRUDE				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
France	72, 802, 459	79, 242, 152	100, 153, 929	85, 125, 657
Germany	3, 966, 870	817, 212	2, 430, 249	3, 585, 777
Netherlands	....	4, 455, 469	2, 400, 000	2, 400, 000
Spain	15, 188, 547	12, 869, 235	12, 049, 778	9, 914, 851
United Kingdom	3, 997, 013	....	....	5, 060
Other Europe	2, 590, 441	1, 212, 528	1, 345, 360	136, 314
Total	98, 545, 330	98, 596, 596	118, 379, 316	101, 167, 659
North America:				
Mexico	5, 229, 983	6, 779, 059	7, 090, 850	7, 713, 859
Cuba	6, 980, 372	4, 838, 657	4, 772, 589	3, 829, 463
Other North America	523, 579	708, 008	623, 958	585, 390
Total	12, 733, 934	12, 325, 724	12, 487, 397	12, 128, 712

Exports of petroleum in its various forms from the United States from 1891 to 1898, by countries—Continued.

Country and kind.	1895.	1896.	1897.	1898.
CRUDE—continued.				
South America:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Brazil	....	....	841,140	....
Other South America	....	....	....	1,026
Total	....	....	841,140	1,026
All other countries	6,000	1,300	18,390	....
Total crude	111,285,264	110,923,620	131,726,243	113,297,397
REFINED.				
Naphthas.				
Europe:				
France	1,564,360	1,672,056	2,103,725	1,713,646
Germany	4,900,028	2,814,217	2,800,883	6,135,309
Netherlands	....	....	1,400,000	1,500
United Kingdom	7,343,355	7,236,285	7,125,371	7,380,140
Other Europe	577,378	160,658	281,541	382,201
Total	14,385,121	11,883,216	13,711,520	15,612,796
North America	145,970	208,249	256,869	290,372
West Indies	84,299	104,062	83,529	18,261
South America	135,752	96,020	67,178	85,492
Asia and Oceanica	45,217	49,927	120,479	231,487
Africa	4,865	7,845	9,453	14,521
Total	416,103	466,103	537,508	640,133
Total naphthas	14,801,224	12,349,319	14,249,028	16,252,929
Illuminating.				
Europe:				
Belgium	35,385,765	35,413,132	42,437,133	44,317,797
Demark	14,626,436	12,693,927	14,001,755	18,969,052
France	6,204,663	5,338,501	2,736,190	5,875,777
Germany	100,829,413	121,841,266	114,583,356	137,981,137
Italy	28,017,572	22,648,184	24,525,066	18,705,089
Netherlands	45,900,640	122,510,644	126,341,441	134,204,836
Sweden and Norway	24,623,246	10,582,677	18,961,261	23,567,695
United Kingdom	279,064,424	181,883,052	185,200,507	179,160,587
Other Europe	6,586,826	8,149,109	7,870,994	9,321,437
Total	541,238,985	521,060,492	536,657,703	572,103,407

Exports of petroleum in its various forms from the United States from 1891 to 1898, by countries—Continued.

Country and kind.	1895.	1896.	1897.	1898.
REFINED—continued.				
Illuminating—Continued.				
North America:				
British North America	*Gallons.* 7, 621, 352	*Gallons.* 9, 534, 590	*Gallons.* 9, 522, 282	*Gallons.* 9, 952, 286
West Indies	4, 109, 358	4, 689, 128	4, 650, 470	4, 659, 518
Other North America	1, 501, 157	1, 493, 040	1, 379, 462	1, 627, 442
Total	13, 231, 867	15, 716, 758	15, 552, 214	16, 239, 246
South America:				
Argentina	5, 876, 742	7, 803, 218	9, 703, 792	10, 648, 733
Brazil	15, 315, 196	18, 490, 043	19, 819, 941	19, 569, 447
Chile	....	4, 325, 915	3, 622, 300	3, 923, 448
Uruguay	3, 898, 514	3, 622, 810	2, 821, 420	3, 576, 570
Other South America	7, 245, 123	4, 267, 282	4, 505, 965	4, 238, 638
Total	32, 335, 575	38, 509, 268	40, 473, 418	41, 956, 836
Asia and Oceanica:				
China	18, 022, 800	25, 694, 890	42, 516, 120	44, 324, 344
Hongkong	10, 595, 610	10, 499, 000	14, 977, 050	15, 637, 420
East Indies	46, 680, 054	43, 706, 780	45, 980, 260	48, 337, 514
Japan	24, 298, 170	33, 701, 038	46, 252, 501	51, 621, 050
British Australasia	14, 686, 752	13, 721, 827	15, 329, 222	18, 859, 348
Other Asia and Oceanica	3, 636, 230	3, 131, 405	3, 722, 800	3, 533, 495
Total	117, 919, 616	130, 454, 940	168, 777, 953	182, 313, 171
Africa	9, 676, 741	10, 280, 607	9, 988, 338	11, 563, 915
All other countries	456, 360	433, 500	571, 000	250, 006
Total illuminating	714, 859, 144	716, 455, 565	772, 020, 626	824, 426, 581
Lubricating.				
Europe:				
Belgium	2, 679, 832	4, 078, 951	3, 784, 941	3, 872, 617
France	3, 271, 804	5, 165, 586	4, 225, 199	5, 246, 208
Germany	5, 378, 398	5, 990, 561	6, 877, 196	8, 086, 776
Italy	1, 381, 587	1, 324, 994	1, 550, 688	1, 970, 890
Netherlands	2, 641, 209	2, 724, 546	2, 840, 832	4, 196, 352
United Kingdom	21, 209, 497	23, 436, 081	21, 301, 290	25, 724, 836
Other Europe	520, 025	815, 017	1, 011, 201	920, 919
Total	37, 082, 352	43, 535, 736	41, 591, 347	50, 013, 598

Exports of petroleum in its various forms from the United States from 1891 to 1898, by countries—Continued.

Country and kind.	1895.	1896.	1897.	1898.
REFINED—continued.				
Lubricating—Continued.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
North America	1,248,751	1,244,538	1,259,249	1,428,647
West Indies	316,274	213,304	114,942	186,285
South America	2,159,844	2,221,780	1,876,794	1,971,050
Asia and Oceanica	2,438,975	3,000,471	4,879,886	5,978,725
Africa	172,746	309,701	477,127	714,308
All other countries	....	....	....	1,752
Total	6,336,590	6,989,794	8,607,998	10,280,767
Total lubricating	43,418,942	50,525,530	50,199,345	60,299,365
Residuum (barrels).				
Europe	2,099	4,248	140,777	471,604
North America	1,045	438	566	1,680
All other countries	130	194	1,269	2,278
Total residuum	3,274	4,880	142,612	475,562

AVERAGE PRICE FOR REFINED OIL.

In the following table the average price per gallon of 70° Abel test refined oil, in barrels at New York, for each month of the past seven years is given:

	1892.	1893.	1894.	1895.	1896.	1897.	1898.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
January	6.45	5.33	5.15	5.87	7.85	6.13	5.40
February	6.42	5.30	5.15	6.00	7.35	6.26	5.48
March	6.32	5.34	5.15	6.75	7.40	6.36	5.82
April	6.10	5.52	5.15	9.12	7.00	6.13	5.67
May	6.06	5.20	5.15	8.20	6.75	6.23	6.00
June	6.00	5.21	5.15	7.83	6.85	6.14	6.16
July	6.00	5.15	5.15	7.65	6.55	5.87	6.27
August	6.08	5.18	5.15	7.10	6.65	5.75	6.44
September	6.10	5.15	5.15	7.10	6.85	5.74	6.60
October	6.03	5.15	5.15	7.10	6.90	5.55	7.21
November	5.80	5.15	5.15	7.88	7.15	5.40	7.35
December	5.45	5.15	5.61	7.77	6.35	5.40	7.40
Yearly average	6.07	5.24	5.19	7.36	6.98	5.91	6.32

NOTE.—Refined oil is loaded on bulk steamers at 2.50 cents per gallon below the above quotations.

PRODUCTION BY FIELDS, STATES, AND DISTRICTS.

The detailed results of operations in the Appalachian oil field in 1898 by States, fields, and districts, and in the Lima-Indiana field, are here presented. As the State of Ohio contains a part of both fields, that part outside of the southeastern district is discussed in connection with the latter.

APPALACHIAN OIL FIELD.

No important new pool was opened over the large area of this field during 1898. The attention of the producer was more particularly directed to the economical production of petroleum as well as the drilling of the territory already developed. In this he was successful, notwithstanding there has been a decrease of 10 per cent in the production. The number of wells drilled over the entire field decreased 10 per cent. The low price of petroleum, which was 65 cents per barrel at the beginning of the year, and did not reach $1 until August, had a depressing effect on new work. The introduction of the gas engine and improved pumping outfits have also been factors, enabling the operator to pump wells of small production profitably.

The lasting quality of many of the wells in the northern portion of the field has been a factor in keeping up the production. Many of these wells have been pumped continuously for twenty-one years and are still producing. Since January, 1877, there is a record of 87,096 wells completed in the Appalachian oil fields to the close of 1898. If we place a cost of $2,000 on each well, the total would be $174,192,000. Of these wells 14,814 were dry—that is, did not produce petroleum in paying quantity. The total number of wells completed since the beginning has been estimated at 100,000. At least 20,000 of these were destitute of petroleum in paying quantities, and it is probable that not more than 50,000 wells are producing in the Appalachian field at the present time, which gives an average of about two barrels per well per day.

Additional details will be found under the head of the various States in the Appalachian field, followed by statements combining all of the States that make up this field.

NEW YORK.

The northern portion of this great Appalachian oil field has enjoyed a season of activity; more particularly that portion of the Bradford district which reaches over into New York, known as the Chipmunk field. In the Allegany field, which is entirely inside of the State, 757,492 barrels of petroleum were produced in 1898, as compared with 771,606 barrels in 1897, a decrease of 1.8 per cent. There were 264 wells drilled in 1898, as compared with 350 drilled in 1897, a decrease of 25 per cent in the number of wells drilled. It is estimated that 16 per cent of the entire production of the Bradford district was from Cattaraugus County, New York, and amounted to 550,000 barrels in 1898, as compared with 507,549 barrels in 1897. The total production of petroleum in New York is placed at 1,307,492 barrels, at an average value of 91⅛ cents per barrel, as compared with 1,279,155 barrels, valued at 78⅝ cents per barrel in 1897. For the combined production of New York and Pennsylvania in the Bradford district, see tables under the head of Pennsylvania.

PENNSYLVANIA.

Bradford district.—As before stated, this district includes a part of the State of New York, as the field continues unbroken from Pennsylvania. In that part of the district south of New York nothing in the way of new territory or even extensions of the pools, beyond the lines previously determined, has been found. The production of this district was 3,444,299 barrels in 1898, as compared with 3,904,230 barrels in 1897, showing a decrease of 12 per cent. There were 488 wells drilled in 1898, and of this number 63 were dry, as compared with 696 wells drilled in 1897, of which number 114 were dry. The total number of wells drilled decreased 30 per cent.

The price advanced from a general average of 78⅝ in 1897 to 91⅛ cents in 1898, a gain of 16 per cent.

Toward the close of the year some fair wells were found in sands that are above the Bradford sand in the western portion of Tioga County, which would seem to indicate a new pool. This locality is 50 miles east of Smethport, McKean County, and is about the same distance from any other producing locality, being outside of what was heretofore considered the eastern limit.

Warren and Forest Counties district.—This district includes the southern portion of McKean County and the eastern and southeastern portion of Warren County, the northwestern portion of Elk County and the northeastern portion of Forest County, Pennsylvania. This district has been subdivided into the Tiona pool, the Warren and Clarendon pool, and the Middle pool or district. In 1898 the production of the Warren and Forest Counties district was 1,597,659 barrels as compared with 1,999,108 barrels in 1897, showing a decrease of 401,449 barrels. There were 388 wells completed in 1898, of which 94 were dry, as compared with 481 wells completed in 1897, of which 122 were dry. The production in this district decreased 20 per cent, while the number of wells drilled decreased 19 per cent in 1898 as compared with 1897.

Several good wells were secured in the Watsonville pool, but they lacked the gusher qualities of some of those found in 1896 and 1897.

Lower district.—This district includes the southwestern portion of Warren County, all of Venango County, all of Clarion, Armstrong, and Butler counties, and the western portion of Forest County, Pennsylvania. The production in this district in 1898 was 5,500,443 barrels, as compared with 6,825,599 barrels of crude petroleum in 1897, showing a decrease of 19 per cent. There were 772 wells drilled in 1898, of which 136 were dry, as compared with 1,792 wells drilled in 1897, of which 162 were dry. The decrease in wells was 57 per cent, yet the decrease in production was only 19 per cent. This is the oldest portion of the Appalachian field, and a large number of the wells have been pumping for more than twenty years. The increase in price caused more activity toward the close of the year. No new pools were opened, but there were several surprises in what was considered territory that would only produce very small wells.

Many wells in Butler County that were drilled through the 100-foot sand into the lower sands, owing to the large flow of salt water found in this sand, and which at that time were thought to be hopeless, have been pulled out, shot, and put to pumping in the 100-foot sand with good results.

Allegheny County district.—This county has been made a separate district. It produced 2,301,651 barrels of crude petroleum in 1898, as compared with 2,958,540 barrels in 1897, a decrease of 656,889 barrels, amounting to 22 per cent. This district shows a large decrease, which is due to the open character of the oil sand. It declined, however, 48 per cent in 1897 as compared with 1896. This field holds the once celebrated McDonald pool, in which several of the old gushers are still producing in a small way, and some of them have over one million barrels to their credit.

Washington County district.—This district produced 1,742,677 barrels in 1898, as compared with 2,175,712 barrels in 1897, showing a decrease of 20 per cent. This is the oldest producing field in the Southwest district, although the decrease has not been so great as in the Allegheny district. No new pools have been discovered, while some of the fifth sand producers helped to stay the decline.

Beaver County district.—This district produced 220,796 barrels in 1898, as compared with 317,926 barrels in 1897, showing a decrease of 31 per cent, which is the greatest decline of any district in Pennsylvania. Many of its wells find their oil in the Shanopin sand, which is usually open and soon drained, and the strippings are small. No new pools or even extensions were developed.

Greene County district.—This district produced 325,177 barrels in 1898, as compared with 258,065 barrels in 1897, showing a gain of 26 per cent. This is the only district in Pennsylvania showing a gain in 1898. This increase is in part due to the Fonner well, 8 miles north of Waynesburg, which was a very large producer and held up its production remarkably, having started off at 1,400 barrels per day when the sand was pierced in March, 1897, and was producing at the rate of 200 barrels at the beginning of 1898. A few wells, having a small production, have been drilled in its vicinity, but none of them will compare with the original well, and there are nearly a score of dry holes in all directions from it. A number of good wells have been found in the deep sand, generally considered the equivalent of the Gordon sand. One of these deep sand wells near Bristoria, on the Joshua Wood farm on Long Run, Allepo Township, came in in March, 1898, with about 1,000 barrels production and by the end of the year was producing over 300 barrels per day. This was without any agitation or pumping, showing wonderful "staying" qualities. Near the southwest corner of the State a number of fair wells were found, although there are numerous dry holes in this section.

Franklin district.—In the area lying between the Allegheny River and French Creek, at Franklin, Venango County, there is a product of natural lubricating petroleum known as the Franklin lubricating oil, whose peculiar qualities are known to the operators of all the leading railroads in the United States and Europe.

This oil is purchased principally by the Galena Oil Company, of Franklin, Pennsylvania, and marketed by them. This oil comes from what is known as the first sand, and is found on the river bottoms at a depth of about 300 feet. The sand is about 50 feet thick, and holds this oil invariably associated with salt water. The entire field extends 4 miles back from the river and is approximately 4 miles long, reaching back to the waters of Sugar Creek. The wells are pumped in clusters of from 50 to 100, many of them only producing a few gallons per day. The gravity of this oil in the old field, which has been producing for years, is 32° Baumè, and in the area outlying the old field it is about 34°. Its fluidity is not in any way affected by zero temperature.

The natural lubricating petroleum found at Volcano and Petroleum, in West Virginia, and that of the Mecca-Belden district, in Ohio, has similar qualities, and is also highly prized as lubricating oil, although their production is not one-fifth of that at Franklin, Pennsylvania. The production in the Franklin field in 1898 was 56,090 barrels of lubricating petroleum, as compared with 48,880 barrels produced in 1897, showing a gain of 15 per cent.

The production for a number of years has been close to 50,000 barrels. The price remained steady at $4 per barrel for several years.

PENNSYLVANIA AND NEW YORK OIL FIELD.

PRODUCTION.

For many years the production of these States covered almost the entire production in the United States, and there was no attempt to separate the output.

It is interesting to give separate statistics for New York, Pennsylvania, West Virginia, and Ohio, so far as they can be given separately, for these States cover nearly the entire production in the Appalachian oil field. This has been done for West Virginia and Ohio. The Bradford field extends continuously from Pennsylvania to New York.

It has been found difficult to separate stocks, shipments, etc., of the four States named above.

In the following table will be found a statement of the production of crude petroleum in Pennsylvania and New York in 1898, by districts and months:

Production of crude petroleum in Pennsylvania and New York in 1898, by districts and months.

[Barrels of 42 gallons.]

District.	January.	February.	March.	April.	May.
Allegany County, N.Y.	62, 818	56, 876	68, 366	63, 880	66, 004
Bradford	290, 502	270, 325	315, 645	290, 620	295, 635
Clarendon and Warren	33, 800	31, 520	30, 952	31, 150	32, 380
Middle	113, 762	85, 947	85, 681	86, 376	80, 269
Tiona	22, 688	20, 597	23, 752	21, 379	20, 980
Lower	505, 710	436, 535	517, 510	465, 944	474, 527
Washington County	156, 976	146, 845	159, 113	152, 225	149, 600
Allegheny County	199, 000	181, 596	204, 491	194, 835	203, 692
Beaver County	19, 953	15, 454	19, 191	17, 470	16, 715
Greene County	20, 024	14, 627	35, 529	30, 088	26, 787
Total	1, 425, 233	1, 260, 322	1, 460, 230	1, 353, 967	1, 366, 589
Franklin district	3, 794	3, 456	5, 165	5, 544	4, 570
Smiths Ferry district	180	185	175	190	185
Grand total	1, 429, 207	1, 263, 963	1, 465, 570	1, 359, 701	1, 371, 344

District.	June.	July.	August.	September.
Allegany County, N. Y	67, 395	62, 429	63, 639	63, 410
Bradford	285, 362	279, 426	286, 894	271, 648
Clarendon and Warren	33, 020	34, 738	35, 536	35, 033
Middle	82, 229	81, 019	77, 673	70, 542
Tiona	20, 952	20, 315	20, 371	20, 116
Lower	459, 307	441, 905	463, 541	441, 348
Washington County	148, 537	143, 113	148, 092	140, 396
Allegheny County	203, 964	188, 880	202, 583	178, 445
Beaver County	22, 275	18, 304	19, 365	14, 545
Greene County	24, 111	29, 292	29, 207	29, 344
Total	1, 347, 152	1, 299, 421	1, 346, 901	1, 264, 827
Franklin district	4, 754	5, 012	5, 065	4, 280
Smiths Ferry district	180	180	160	175
Grand total	1, 352, 086	1, 304, 613	1, 352, 126	1, 269, 282

Production of crude petroleum in Pennsylvania and New York in 1898, etc.—Continued.

[Barrels of 42 gallons.]

District.	October.	November.	December.	Total.
Allegany County, N. Y ..	61, 114	58, 269	63, 292	757, 492
Bradford	274, 851	279, 667	303, 724	3, 444, 299
Clarendon and Warren .	38, 111	38, 935	39, 037	414, 212
Middle	67, 634	56, 175	44, 693	932, 000
Tiona	20, 671	19, 149	20, 477	251, 447
Lower	433, 499	423, 631	436, 986	5, 500, 443
Washington County	135, 610	130, 935	131, 235	1, 742, 677
Allegheny County	184, 605	172, 819	186, 741	2, 301, 651
Beaver County	20, 862	18, 047	18, 615	220, 796
Greene County	28, 510	28, 283	29, 375	325, 177
Total	1, 265, 467	1, 225, 910	1, 274, 175	15, 890, 194
Franklin district	4, 798	3, 973	5, 679	56, 090
Smiths Ferry district	190	180	200	*a* 2, 180
Grand total	1, 270, 455	1, 230, 063	1, 280, 054	15, 948, 464

a This production only represents dump oil, the pipe-line runs of this district being included in runs of Beaver County.

All of the districts named in this table are wholly in Pennsylvania, excepting Allegany Country and a part of the Bradford district, previously discussed under the head of New York State.

Total product of crude petroleum in the Pennsylvania and New York oil fields from 1871 to 1898, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1871	418, 407	372, 568	400, 334	385, 980	408, 797
1872	583, 575	462, 985	461, 590	462, 090	537, 106
1873	632, 617	608, 300	665, 291	641, 520	776, 364
1874	1, 167, 243	835, 492	883, 438	778, 740	895, 745
1875	852, 159	719, 824	789, 539	675, 060	696, 508
1876	712, 225	668, 885	718, 177	701, 490	735, 351
1877	842, 890	783, 216	901, 697	972, 810	1, 127, 594
1878	1, 203, 296	1, 094, 856	1, 208, 380	1, 195, 890	1, 264, 862
1879	1, 369, 921	1, 261, 935	1, 499, 315	1, 530, 450	1, 644, 922
1880	1, 904, 113	1, 870, 008	2, 015, 992	2, 015, 700	2, 228, 931
1881	2, 244, 090	1, 913, 128	2, 274, 532	2, 205, 780	2, 393, 293
1882	2, 353, 551	2, 131, 332	2, 482, 170	2, 402, 790	2, 486, 572
1883	1, 948, 319	1, 756, 188	1, 830, 674	1, 816, 530	1, 962, 052
1884	1, 825, 838	1, 880, 650	2, 052, 262	2, 065, 860	2, 381, 854
1885	1, 652, 176	1, 437, 884	1, 638, 133	1, 780, 290	1, 771, 371
1886	1, 748, 958	1, 604, 848	1, 928, 448	1, 938, 360	2, 178, 373
1887	1, 990, 851	1, 827, 924	2, 007, 196	1, 960, 860	1, 993, 517

Total product of crude petroleum in the Pennsylvania and New York oil fields from 1871 to 1898, by months and years—Continued.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1888	1, 155, 937	1, 290, 718	1, 338, 877	1, 349, 403	1, 473, 362
1889	1, 542, 806	1, 332, 482	1, 628, 661	1, 635, 933	1, 821, 776
1890	2, 108, 248	2, 055, 424	2, 313, 189	2, 328, 870	2, 378, 382
1891	2, 830, 081	2, 287, 320	2, 360, 011	2, 337, 498	2, 288, 656
1892	2, 786, 528	2, 703, 663	2, 657, 432	2, 574, 814	2, 485, 040
1893	1, 723, 918	1, 671, 620	1, 900, 363	1, 682, 271	1, 763, 655
1894	1, 579, 420	1, 432, 251	1, 662, 595	1, 537, 500	1, 628, 149
1895	1, 570, 742	1, 318, 322	1, 585, 887	1, 656, 436	1, 630, 829
1896	1, 648, 367	1, 517, 806	1, 632, 234	1, 842, 564	1, 746, 089
1897	1, 591, 700	1, 556, 488	1, 730, 502	1, 611, 633	1, 619, 548
1898	1, 429, 207	1, 263, 963	1, 465, 570	1, 359, 701	1, 371, 344

Year.	June.	July.	August.	September.
1871	410, 340	456, 475	462, 582	461, 940
1872	491, 130	517, 762	549, 909	500, 430
1873	793, 470	867, 473	936, 138	954, 270
1874	621, 750	1, 033, 447	931, 519	840, 630
1875	696, 210	788, 361	718, 766	698, 940
1876	723, 600	763, 623	782, 223	780, 600
1877	1, 130, 790	1, 189, 005	1, 273, 759	1, 214, 910
1878	1, 217, 250	1, 283, 865	1, 341, 928	1, 315, 710
1879	1, 675, 650	1, 637, 767	1, 892, 302	1, 856, 700
1880	2, 158, 440	2, 248, 430	2, 341, 027	2, 346, 300
1881	2, 377, 860	2, 372, 678	2, 331, 727	2, 193, 420
1882	2, 825, 940	3, 258, 162	3, 104, 495	2, 620, 380
1883	1, 977, 900	2, 020, 394	1, 879, 437	1, 913, 370
1884	1, 862, 190	2, 059, 950	2, 099, 165	1, 948, 260
1885	1, 767, 210	1, 775, 804	1, 705, 961	1, 712, 790
1886	2, 335, 380	2, 418, 961	2, 413, 206	2, 418, 540
1887	1, 912, 860	1, 899, 525	1, 848, 877	1, 779, 930
1888	1, 450, 703	1, 394, 847	1, 382, 077	1, 273, 080
1889	1, 811, 485	1, 954, 168	1, 964, 227	1, 867, 610
1890	2, 370, 001	2, 524, 206	2, 514, 968	2, 584, 949
1891	2, 316, 988	2, 289, 089	2, 473, 398	2, 837, 562
1892	2, 439, 346	2, 360, 886	2, 328, 596	2, 125, 511
1893	1, 780, 836	1, 720, 088	1, 691, 652	1, 614, 021
1894	1, 663, 964	1, 624, 767	1, 612, 212	1, 512, 116
1895	1, 575, 940	1, 625, 958	1, 681, 579	1, 590, 696
1896	1, 784, 104	1, 853, 757	1, 726, 332	1, 699, 818
1897	1, 668, 286	1, 647, 363	1, 604, 954	1, 563, 483
1898	1, 352, 086	1, 304, 613	1, 352, 126	1, 269, 282

Total product of crude petroleum in the Pennsylvania and New York oil fields from 1871 to 1898, by months and years—Continued.

[Barrels of 42 gallons.]

Year.	October.	November.	December.	Total.
1871	485, 243	564, 610	477, 958	5, 205, 234
1872	442, 432	638, 610	645, 575	6, 293, 194
1873	942, 493	991, 470	1, 084, 380	9, 893, 786
1874	919, 739	861, 060	858, 142	10, 926, 945
1875	731, 073	700, 200	720, 874	8, 787, 514
1876	809, 162	786, 480	787, 090	8, 968, 906
1877	1, 269, 326	1, 173, 420	1, 256, 058	13, 135, 475
1878	1, 369, 797	1, 348, 950	1, 318, 678	15, 163, 462
1879	1, 836, 378	1, 710, 480	1, 769, 356	19, 685, 176
1880	2, 385, 636	2, 274, 420	2, 238, 634	26, 027, 631
1881	2, 323, 171	2, 266, 830	2, 480, 000	27, 376, 509
1882	2, 297, 658	2, 192, 940	1, 897, 510	30, 053, 500
1883	2, 076, 659	1, 958, 340	1, 988, 526	23, 128, 389
1884	1, 961, 866	1, 811, 700	1, 822, 614	23, 772, 209
1885	1, 874, 105	1, 761, 660	1, 898, 657	20, 776, 041
1886	2, 408, 111	2, 222, 790	2, 181, 625	25, 798, 000
1887	1, 843, 291	1, 125, 450	1, 288, 602	*a* 21, 478, 883
1888	1, 304, 518	1, 442, 405	1, 582, 741	16, 488, 668
1889	1, 959, 169	1, 913, 871	2, 055, 247	21, 487, 435
1890	2, 750, 698	2, 575, 941	2, 626, 035	*b* 29, 130, 910
1891	3, 575, 911	3, 834, 262	3, 578, 460	33, 009, 236
1892	2, 072, 022	1, 950, 553	1, 937, 986	28, 422, 377
1893	1, 616, 391	1, 533, 555	1, 616, 143	20, 314, 513
1894	1, 640, 982	1, 527, 752	1, 598, 282	19, 019, 990
1895	1, 621, 216	1, 594, 773	1, 692, 012	19, 144, 390
1896	1, 746, 257	1, 642, 846	1, 744, 257	20, 584, 421
1897	1, 605, 362	1, 538, 117	1, 524, 630	19, 262, 066
1898	1, 270, 455	1, 230, 063	1, 280, 054	15, 948, 464

a Not including 877,310 barrels dump oil and oil shipped by private lines. *b* Pipe-line runs.

In the following table is given a statement of the average daily production of crude petroleum in the Pennsylvania and New York oil fields for each month from 1871 to 1898. We desire to repeat that this table is not the same as the daily average receipts published by the pipe lines, but the daily average production, the total production including some oil that is not reported in the daily returns of the pipe lines. The averages are obtained by dividing the product of each month, in the table given elsewhere, by the number of days in each month, and the production of the year by 365 or 366, as the case may be.

Average daily product of crude petroleum in the Pennsylvania and New York oil fields each month for the years 1871–1898, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1871	13,497	13,306	12,914	12,866	13,187
1872	18,825	15,965	14,890	15,403	17,326
1873	20,407	21,725	21,461	21,384	25,044
1874	37,653	29,839	28,598	25,958	28,895
1875	27,489	25,708	25,469	22,502	22,468
1876	22,975	23,065	23,167	23,383	23,721
1877	27,190	27,979	29,087	32,427	36,374
1878	38,816	39,102	38,980	39,863	40,802
1879	44,191	43,515	48,365	51,015	53,062
1880	61,423	64,552	65,032	67,190	71,901
1881	72,390	68,326	73,372	73,526	77,203
1882	75,921	76,119	80,070	80,093	80,212
1883	62,849	62,721	59,054	60,551	63,292
1884	58,898	64,850	66,202	68,862	76,834
1885	53,296	51,353	52,843	59,343	59,141
1886	56,418	57,316	62,208	64,612	70,283
1887	64,221	65,283	64,716	65,372	64,307
1888	37,228	44,508	43,190	44,980	47,528
1889	49,768	47,589	52,537	54,531	58,767
1890	68,008	73,408	74,619	77,629	76,722
1891	91,293	81,690	76,129	77,917	73,828
1892	89,888	93,230	85,724	85,827	80,163
1893	55,610	59,701	61,302	56,076	56,505
1894	50,949	51,152	53,632	51,250	52,521
1895	50,669	47,083	51,093	55,215	52,607
1896	53,173	52,338	52,653	61,419	56,325
1897	51,345	55,589	55,823	53,721	52,243
1898	46,103	45,141	47,276	45,323	44,237

Year.	June.	July.	August.	September.
1871	13,678	14,725	14,922	15,398
1872	16,371	16,702	17,739	16,681
1873	26,449	27,983	30,198	31,809
1874	30,725	33,337	30,049	28,021
1875	23,207	25,431	23,186	23,298
1876	24,120	24,633	25,233	26,020
1877	37,693	38,335	41,089	40,497
1878	40,575	41,415	43,288	43,857
1879	55,855	56,057	61,042	61,890
1880	71,948	72,530	75,517	78,210

Average daily product of crude petroleum in the Pennsylvania and New York oil fields each month for the years 1871–1898, by months and years—Continued.

[Barrels of 42 gallons.]

Year.	June.	July.	August.	September.
1881	79,262	76,538	75,217	73,114
1882	94,198	105,102	100,145	87,346
1883	65,930	65,174	60,627	63,779
1884	62,073	66,450	67,715	64,942
1885	58,907	57,284	55,031	57,093
1886	77,846	78,031	78,426	80,618
1887	63,762	61,275	59,641	59,321
1888	48,357	44,995	44,661	42,436
1889	60,382	63,037	63,362	62,254
1890	79,000	81,426	81,128	86,165
1891	77,233	73,842	79,787	94,585
1892	81,312	76,158	75,116	70,850
1893	59,361	55,487	54,569	53,801
1894	55,465	52,412	52,007	50,404
1895	52,531	52,450	54,244	53,023
1896	59,470	59,799	55,688	56,661
1897	55,610	53,141	51,773	52,116
1898	45,070	42,084	43,617	42,309

Year.	October.	November.	December.	Yearly average.
1871	15,653	15,487	15,418	14,261
1872	14,272	21,287	20,825	17,194
1873	30,403	33,049	34,980	27,106
1874	29,669	28,702	27,682	29,937
1875	23,583	23,340	23,254	24,075
1876	26,102	26,216	25,390	24,505
1877	40,946	39,114	40,518	35,988
1878	44,187	44,965	42,538	41,544
1879	59,238	57,016	57,076	54,206
1880	76,956	75,814	72,214	71,114
1881	74,941	75,561	80,000	75,004
1882	74,118	73,098	61,210	82,338
1883	66,989	65,278	64,146	63,365
1884	63,286	60,390	58,794	65,129
1885	60,455	58,722	61,247	56,921
1886	77,681	74,093	70,375	70,679
1887	61,822	37,515	41,568	58,846
1888	43,694	48,080	51,057	45,058
1889	63,199	63,796	66,298	58,869
1890	88,732	85,865	84,710	79,810
1891	115,352	127,809	115,434	90,436
1892	66,839	65,018	62,516	77,657
1893	52,142	51,119	52,133	55,656
1894	52,935	50,925	51,557	52,110
1895	52,299	53,159	54,581	52,450
1896	56,331	54,762	56,266	56,241
1897	51,786	51,270	49,182	52,773
1898	40,982	41,002	41,292	43,694

SHIPMENTS OF PETROLEUM FROM PENNSYLVANIA, NEW YORK, AND WEST VIRGINIA.

The following table gives the number of barrels of crude petroleum shipped out of New York, Pennsylvania, and West Virginia either by pipe lines, railways, or river, from 1871 to 1898, inclusive:

Shipments of crude and refined petroleum, reduced to crude equivalent, out of the Pennsylvania, New York, and West Virginia oil fields from 1871 to 1898, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1871	437, 691	347, 718	383, 890	389, 147	587, 375
1872	476, 966	407, 606	276, 220	428, 512	510, 417
1873	573, 124	527, 440	668, 374	708, 191	768, 176
1874	843, 663	501, 220	518, 246	803, 409	899, 027
1875	453, 095	327, 776	693, 918	729, 581	681, 679
1876	677, 289	519, 193	623, 762	603, 037	646, 150
1877	743, 461	484, 904	913, 919	903, 526	1, 234, 324
1878	775, 791	774, 234	741, 512	846, 632	960, 894
1879	663, 998	702, 729	973, 879	1, 136, 188	1, 331, 469
1880	1, 650, 409	1, 395, 151	1, 613, 371	842, 268	1, 095, 259
1881	1, 061, 617	915, 028	1, 276, 746	1, 348, 398	1, 563, 436
1882	1, 657, 067	1, 787, 909	1, 718, 956	1, 678, 134	1, 827, 356
1883	1, 357, 815	1, 250, 824	1, 641, 899	1, 908, 379	1, 995, 634
1884	1, 686, 961	1, 723, 261	1, 873, 890	1, 643, 336	1, 899, 329
1885	1, 804, 028	1, 895, 021	1, 887, 034	1, 823, 726	2, 097, 099
1886	1, 991, 561	2, 032, 794	2, 055, 750	2, 070, 468	2, 032, 672
1887	2, 312, 067	1, 995, 757	2, 332, 324	1, 938, 278	2, 328, 564
1888	2, 265, 109	2, 163, 957	1, 979, 753	1, 928, 435	1, 773, 994
1889	2, 388, 609	2, 272, 060	2, 263, 009	2, 236, 004	2, 256, 122
1890	2, 637, 339	2, 146, 108	2, 148, 977	2, 317, 410	2, 474, 966
1891	2, 421, 419	2, 143, 611	2, 429, 664	2, 155, 511	2, 072, 139
1892	2, 418, 231	2, 441, 346	2, 584, 312	2, 336, 821	2, 277, 775
1893	2, 950, 184	2, 578, 185	2, 835, 719	2, 660, 292	3, 031, 362
1894	3, 138, 356	2, 652, 063	2, 909, 720	2, 844, 534	2, 817, 415
1895	3, 136, 494	2, 805, 695	2, 605, 078	2, 780, 249	2, 844, 465
1896	2, 539, 390	2, 249, 302	2, 437, 026	2, 226, 204	2, 417, 564
1897	2, 535, 553	2, 309, 050	2, 771, 647	2, 451, 242	2, 546, 296
1898	2, 909, 075	2, 133, 380	2, 627, 744	2, 422, 053	2, 393, 831

Shipments of crude and refined petroleum, reduced to crude equivalent, etc.—Continued.

[Barrels of 42 gallons.]

Year.	June.	July.	August.	September.
1871	501, 754	541, 137	528, 134	551, 075
1872	529, 228	591, 238	621, 954	541, 607
1873	696, 414	814, 449	864, 768	952, 955
1874	815, 413	940, 281	793, 865	1, 014, 570
1875	745, 986	904, 537	882, 089	1, 109, 392
1876	921, 862	1, 228, 539	1, 203, 402	1, 154, 549
1877	1, 391, 124	1, 096, 951	1, 425, 943	1, 563, 797
1878	1, 135, 119	1, 330, 454	1, 655, 651	1, 434, 225
1879	1, 369, 314	1, 625, 035	1, 808, 239	1, 627, 120
1880	975, 083	1, 231, 611	1, 394, 129	1, 252, 635
1881	1, 729, 697	1, 925, 532	2, 214, 877	2, 131, 950
1882	2, 172, 685	2, 402, 970	2, 047, 545	1, 992, 171
1883	1, 747, 789	1, 634, 407	2, 086, 478	2, 325, 574
1884	1, 827, 553	1, 740, 021	2, 000, 371	2, 292, 087
1885	2, 034, 025	1, 961, 152	2, 049, 099	2, 116, 659
1886	2, 117, 489	2, 418, 961	2, 059, 299	2, 157, 323
1887	2, 165, 439	2, 000, 173	2, 220, 768	2, 342, 227
1888	1, 956, 115	2, 098, 531	2, 223, 263	2, 289, 486
1889	2, 268, 280	2, 949, 597	2, 625, 825	2, 567, 459
1890	2, 486, 205	2, 640, 668	2, 538, 224	2, 648, 418
1891	2, 122, 085	2, 260, 176	2, 496, 255	2, 701, 461
1892	2, 070, 396	2, 312, 571	2, 624, 488	2, 738, 369
1893	3, 073, 319	3, 318, 633	3, 248, 286	2, 998, 775
1894	2, 913, 440	2, 924, 466	3, 254, 087	2, 963, 025
1895	2, 814, 942	2, 634, 296	2, 422, 969	2, 330, 147
1896	2, 248, 761	2, 540, 332	2, 404, 063	2, 542, 363
1897	2, 554, 516	2, 707, 317	3, 098, 793	2, 953, 713
1898	2, 435, 192	2, 563, 771	2, 695, 972	2, 585, 205

Year.	October.	November.	December.	Total.
1871	505, 071	480, 977	410, 822	5, 664, 791
1872	607, 468	477, 945	430, 786	5, 899, 947
1873	1, 010, 852	959, 589	955, 443	9, 499, 775
1874	543, 341	546, 117	602, 348	8, 821, 500
1875	871, 917	671, 066	871, 902	8, 942, 938
1876	524, 190	871, 496	1, 190, 983	10, 164, 452
1877	1, 268, 971	1, 205, 634	600, 019	12, 832, 573
1878	1, 747, 390	1, 281, 410	992, 688	13, 676, 000
1879	1, 662, 269	1, 453, 645	1, 532, 585	15, 886, 470
1880	1, 665, 933	1, 226, 030	1, 335, 613	15, 677, 492
1881	2, 080, 467	2, 066, 906	1, 969, 581	20, 284, 235

Shipments of crude and refined petroleum, reduced to crude equivalent, etc.—Continued.

[Barrels of 42 gallons.]

Year.	October.	November.	December.	Total.
1882	2,089,428	1,404,640	1,121,453	21,900,314
1883	2,215,421	2,065,602	1,749,547	21,979,369
1884	2,510,283	2,078,261	2,382,244	23,657,597
1885	2,050,150	1,857,080	2,138,253	23,713,326
1886	2,441,848	2,724,796	2,550,891	26,653,852
1887	2,573,008	3,462,082	2,608,341	27,279,028
1888	1,558,115	2,503,491	2,397,782	25,138,031
1889	2,747,284	2,393,131	2,671,518	29,638,892
1890	2,725,341	2,662,898	2,689,521	30,116,075
1891	2,799,214	2,601,434	2,781,530	28,984,400
1892	2,820,735	2,911,907	2,972,479	30,539,430
1893	3,314,390	3,092,039	3,149,675	36,250,859
1894	3,266,994	3,204,296	3,282,089	36,170,481
1895	2,569,738	2,648,609	2,406,751	31,999,433
1896	2,602,853	2,499,474	2,611,511	29,318,843
1897	3,634,805	3,316,574	2,761,749	33,641,255
1898	2,847,002	2,408,069	2,383,925	30,405,216

In the early history of the oil business a very large percentage of the crude oil went direct from the field to the refineries, either by wagon, boat, or railway, and was lost sight of until shipped as refined oil, which was reduced to the equivalent of crude petroleum by allowing one barrel of crude to produce three-fourths of a barrel of refined, or a barrel of refined was regarded as being the equivalent of one and one-third barrels of crude. Since 1888 nearly the entire amount of crude petroleum has passed through the pipe lines, and is given under the head of "Shipments from the Appalachian field by months."

WELLS COMPLETED IN PENNSYLVANIA, NEW YORK, WEST VIRGINIA, AND THAT PART OF OHIO INCLUDED IN THE SOUTHWESTERN FIELD.

In the early production of petroleum almost all of it came from New York and Pennsylvania. In after years oil was found in Ohio near Macksburg and Marietta, and on the Little Kanawha River in West Virginia. These points were so far isolated that it was not difficult to keep them separated, so for a number of years there was a correct table of wells drilled in Pennsylvania and New York. Now it is almost one continuous field from western New York to the Little Kanawha River of West Virginia, a part extending over into Ohio from West Virginia at and near Sistersville, on the Ohio River, and the following table includes the wells drilled in this portion of Ohio.

To obtain the totals of all wells drilled in the Appalachian field we would have to add to this table those comprised under the head of the southern Ohio district, which are shown in a table given on a previous page.

Number of wells completed in Pennsylvania, New York, West Virginia, and that part of Ohio included in the southwest district each month from 1872 to 1898.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1872 ..	37	120	89	121	135	84	128	118	82	100	64	105	1,183
1873 ..	93	94	100	105	102	130	114	120	106	101	100	98	1,263
1874 ..	102	104	110	113	109	101	121	107	104	120	106	120	1,317
1875 ..	190	187	195	186	172	190	200	210	201	220	217	230	2,398
1876 ..	240	231	242	200	202	261	248	270	209	273	272	272	2,920
1877 ..	281	241	291	269	320	403	317	255	322	467	391	382	3,929
1878 ..	274	226	211	409	470	269	203	186	174	229	248	165	3,064
1879 ..	136	132	238	270	402	330	327	283	210	232	227	261	3,048
1880 ..	320	230	367	500	426	310	338	368	356	364	336	302	4,217
1881 ..	222	220	271	316	406	374	336	332	312	322	363	406	3,880
1882 ..	347	340	385	432	469	340	185	253	164	117	150	122	3,304
1883 ..	125	126	142	209	231	228	261	309	321	321	302	272	2,847
1884 ..	229	227	256	298	311	244	268	145	89	59	73	66	2,265
1885 ..	64	62	82	116	213	242	217	283	356	397	384	345	2,761
1886 ..	270	280	291	328	343	365	357	313	253	272	221	185	3,478
1887 ..	158	162	138	160	148	162	159	142	134	100	101	96	1,660
1888 ..	57	52	56	49	56	97	82	96	132	229	307	302	1,515
1889 ..	284	288	353	401	431	537	549	508	478	559	540	471	*a*5,435
1890 ..	553	482	522	556	534	571	555	579	571	567	520	348	6,358
1891 ..	310	243	275	288	314	304	334	333	281	237	245	197	3,361
1892 ..	175	171	137	167	170	154	174	141	142	158	160	143	1,892
1893 ..	125	84	130	127	172	213	193	145	158	139	137	167	1,790
1894 ..	180	170	202	261	307	349	319	341	362	373	368	316	3,548
1895 ..	271	195	324	425	601	754	772	766	735	686	613	534	6,676
1896 ..	537	514	499	569	658	744	673	589	594	581	622	625	7,205
1897 ..	544	408	368	428	485	553	603	557	455	417	404	352	5,574
1898 ..	306	237	256	302	302	343	364	393	434	487	491	511	4,426

a Includes 36 wells drilled in Franklin district, data for which by months was not obtainable.

SOUTHEASTERN OHIO.

Some of the tables under the head of the Southwest district include that portion of Ohio opposite Sistersville, in Washington and Monroe counties, and is discussed under the head of Pennsylvania, as it is impossible to separate the States completely. The discussion of the Appalachian oil field in Ohio will be found under the head of that State.

WEST VIRGINIA.

This State is the only one in the Appalachian field that has shown an increase in production in 1898 over that of 1897. The production for 1898 was 13,615,101 barrels of petroleum as compared with 13,090,045 barrels in 1897, a gain of 4 per cent, indicating that the production has about reached its highest point, although it will probably surpass the production of Pennsylvania in 1900, and will then stand at the head of the States producing what is known as "Pennsylvania petroleum." There are still many possibilities of undeveloped territory to the south, and possibly lower sands yet undeveloped in the fields now producing, that may greatly increase the production in this State in the years to come. One of the serious drawbacks is the depth of the lower sands. Some of the wells are now producing oil from sands that are about 3,600 feet in depth, which places the producing sand about 2,000 feet below tide.

The northwestern portion of this State contains the bottom of the trough of the Appalachian coal field, in which the Pittsburg coal descends until it is only a few feet above sea level.

The upturned edges of the great lenticular basin (with its longest axis running northeast and southwest), with minor folds and crumples in slightly inclined strata, has entangled large deposits of both petroleum and natural gas in the white and pebble sands that have so vigorously responded when pierced by the drill. In the immediate future the largest amount of the world's supply of this high grade petroleum must in all probability come from the prolific fields of this State.

There are many producing sands in the various pools scattered over the State. In a number of instances the same well, after exhausting the upper producing sand, has been drilled deeper and another large deposit of petroleum found in the lower sand.

The following, giving the oil and gas horizons of West Virginia, is taken from the recent geological report, by Prof. I. C. White, State Geologist:

From the numerous well records given over a large region of the State, as well as from the running commentary thereon, it will be perceived that there are several well-defined oil and gas horizons between the Permian rock (Upper Carboniferous) at the top of the Carboniferous and the Corniferous limestone at the base of the Devonian beds. These may be grouped together and classified as follows, in descending order in which they occur:

No. XV.	Upper Coal Measures. Monongahela River series.	Carroll sand.
No. XIV.	Barren Measures. Elk River series.	Island Run sand (Morgantown). First Cow Run sand. Upper and Lower Dunkard sand.
No. XIII.	Lower Coal Measures. Allegheny River series.	Second Cow Run sand. "Gas" sand of Marion and Monongalia counties.

No. XII.	Pottsville conglomerate beds. New River and Pocahontas Coal series.	"Gas" sand of Cairo. "Salt sand." Maxton and Cairo sands.
No. XI.	Mauch Chunk red shale. Mountain or Greenbrier limestone.	No oil or gas sands, unless the Maxton sand belongs here. No oil or gas horizons, except as part of the "Big Injun" below.
No. X.	Pocono sandstone.	"Keener" sand. "Big Injun" sand. "Squaw" sand.
No. IX.	Catskill red beds. Upper Devonian series. Venango oil sand group.	Gantz sand (Berea). Fifty-foot sand. Thirty-foot sand. Campbell's Run sand, "Gordon" sand. Whetstone Run sand, "Gordon" sand. Flat Run "Gordon" of Fourth sand. McDonald or Fifth sand. Elizabeth or Sixth sand.
No. VIII.	Chemung, Hamilton, and Corniferous beds. Middle and Lower Devonian.	No well-defined oil or gas horizons yet discovered in these rocks in West Virginia. Warren and Bradford sands of Pennsylvania are supposed to belong in upper portion.

The depth at which oil is found varies greatly with the sand and the locality. In Pleasants County the wells range from 300 to 500 feet in depth, and in Marion County from 2,250 to 3,500 feet. In the first named oil is found in the Cow Run and the Dunkard sand, the latter in the Gordon and Fifth sand. The highest sand in the scale that has produced oil is the Morgantown, the lowest the Elizabeth sand. The former is 220 feet below the Pittsburg coal, the latter 2,400 to 2,500 feet below. The color and gravity of the oil vary greatly even in the same sand. The color ranges from an almost transparent fluid of light gravity to oil that is almost black, with various shades of green and amber. The gravity varies from 26° Baumé, found in the lubricating-oil districts of Wood County, to that of 63½° Baumé, found in Marshall County. All of the West Virginia petroleum gives a large percentage of illuminating products and paraffin. It is free from sulphur and easily refined.

As before stated, the increased production in 1898 over 1897 was 526,056 barrels, a gain of 4 per cent. The increase for 1897 over 1896 was over 3,000,000 barrels, or 30.64 per cent, while the gain for 1896 was 23.39 per cent. The production has increased over 500 per cent since 1891. The average price for 1898 was 91.3 cents per barrel, as against 78⅝ cents in 1897, and $1.18 in 1896.

The most notable development of the West Virginia fields in 1898 was the Whisky Run pool, in Ritchie County, in the Big Injun sand. The first well was drilled on the William Albricht farm late in 1897, and started at 250 barrels a day. It led to a good deal of drilling and a number of good producers were discovered, but a few hundred acres comprised the extent of the pool. In May 85,000 barrels were placed to its credit, but the next month it started on the down grade. Its June output was 40,000 barrels, and by December it had declined to 25,000 barrels. During the year 60 wells were completed in the Whisky Run field, but only 43 were paying producers. The salt-sand territory of Ritchie County likewise attracted considerable attention during the year, but, though extending over a large area, it proved rather spotted and the average output of the wells was small.

Wood County provided several strong attractions for oil operators during the year. Its shallow territory made drilling very cheap, and experimental wells could be completed without a great outlay of money. The greatest volume of the new work was recorded in the Berea grit territory. The Ogden pool was pretty thoroughly defined in 1897, but the Hendershot district was extended westward to Murphystown, where numerous small wells were obtained and a prolific pool of considerable area developed. Three miles south of Williamstown, in Wood County, great excitement was created in August over a well near the Ohio River that started at 20 barrels an hour. A rush of operators followed, and at one time 15 wells were drilling on as many acres of ground. A pool of Cow Run sand was opened up, that on the whole proved highly satisfactory to the investors, and resulted in adding a large amount to the total production of the State. Pleasants County likewise held out some inducements in the way of Cow Run sand territory, but aside from a little pool in French Creek, near Calcutta, and some shallow wells farther west on French Creek, nothing noteworthy was developed. A large stretch of territory east of St. Marys was drilled over, but dry holes were more largely in evidence than producing wells.

Tyler County furnished little in the line of new territory or production that was remarkable during the year. The Elk Fork pool in that county was the most prominent development in 1897, when it produced 1,504,290 barrels of petroleum. Its yield for 1898 aggregated 1,487,159 barrels. During the latter part of the year an extension was found to the northeast of Elk Fork that has supplied a number of wells that deserve to be placed in the "gusher" class. One on the Fluharty farm, struck near the close of the year, started off at 30 barrels an hour. The oil was obtained from the Big Injun instead of the Keener sand. The Centreville development at one time appeared quite promising, but of 15 wells drilled one-half were dry. The deep-sand territory near Stringtown, owing to its regularity, was also a very prominent factor and played an important part in adding to the production of Tyler County.

The deep Gordon and Fifth sand territory of Wetzel County was conspicuous for a large new production in 1898. The territory along Piney Fork was the scene of the most active operations and large producers were almost invariably the rule. The Big Injun sand developments in

Wetzel were likewise productive of good results. A small pool of Big Injun petroleum was opened up near Brink in August, where the largest Big Injun producer of the year was discovered. It was located on the E. Batson farm, and its first day's yield was over 1,200 barrels.

The deep-sand developments of Flat Run and Campbell's Run, in Monongalia and Marion counties, which were thought to have been defined in the previous year, both added large extensions to their productive areas and supplied some phenomenal producers during 1898. No limits have yet been fixed for these pools and the indications are that they will reach the Pennsylvania line, and it will be some time before all their available territory is exhausted. The great depth of the wells makes drilling very expensive and it takes a long time to get a well down to the deep Gordon sand. Monongalia County yielded more oil in 1898 and furnished more and larger wells than any other county in the Mountain State.

A large amount of work was done in Ritchie County between Cairo and Ritchie mines, and a number of fair wells were secured both in the Salt sand and Big Injun sand. The number of dry holes was large, however, and on averaging up the dry holes with the producing wells it is doubtful if the development in this county has made any money for the producers. The sand which produces the great percentage of petroleum is generally known as the Salt sand. Its position is above the "Big limestone," and in the many thousands of wells in Marion, Monongalia, and Tyler counties, it invariably furnishes a large flow of salt water, which has to be cased off before drilling through the limestone into the Big Injun sand.

Harrison County contains a promising development in the sixth or possibly the fifth sand, 160 feet below the Gordon sand, located near Jarvisville. Operations began in this county in 1897 by a well on the Payne farm drilled to this deep sand in search of gas, and although the development has provided nothing of the sensational order, some fairly profitable producers have been obtained and comparatively few dry holes. The "wildcatter" has been very industrious in Roane, Wirt, and Calhoun counties, but although many experimental wells have been sunk and a large amount of money expended in prospecting, the expected pools have not yet been brought to light. The theory of a series of white sand pools, stretching through the State on a southwesterly course into Kentucky and Tennessee received very little encouragement from the test wells drilled in these three counties. This is due in a great measure to the thickening of the sands and shales below the Pittsburg coal, causing the measures to be nearly level, although the rocks above the coal show a very decided rise to the south and southwest. The northern portion of Doddridge County produced a number of fairly good wells in the Big Injun sand, but nothing worthy of any special mention. There are a few wells producing petroleum and salt water from what is considered to be the "50-foot" in the northwestern corner of Lewis County. The recent volume of the West Virginia survey, by Prof. I. C. White, gives a large collection of important data bearing on the oil and gas production in this State.

PRODUCTION.

The production of crude petroleum in West Virginia, by months, from 1890 to 1898, is shown in the following table:

Total production of crude petroleum in West Virginia, by months, from 1890 to 1898.

[Barrels of 42 gallons.]

Month.	1890.	1891.	1892.	1893.	1894.
January	38, 644	48, 902	195, 512	577, 933	838, 400
February	38, 061	123, 841	186, 455	468, 794	684, 532
March	44, 842	229, 966	185, 468	630, 877	754, 398
April	39, 804	226, 020	181, 708	594, 190	688, 458
May	39, 160	232, 076	206, 142	705, 714	742, 701
June	35, 610	223, 734	261, 900	682, 040	699, 498
July	34, 096	221, 127	328, 485	724, 494	767, 728
August	31, 505	238, 451	411, 114	843, 706	717, 844
September	50, 342	219, 528	420, 882	847, 558	674, 791
October	46, 387	220, 076	451, 157	792, 719	694, 187
November	45, 062	207, 477	467, 446	757, 170	654, 887
December	49, 065	215, 020	513, 817	820, 217	660, 200
Total	492, 578	2, 406, 218	3, 810, 086	8, 445, 412	8, 577, 624

Month.	1895.	1896.	1897.	1898.
January	647, 220	757, 574	869, 210	1, 207, 645
February	541, 511	729, 229	844, 833	1, 036, 382
March	642, 222	785, 261	938, 673	1, 215, 958
April	646, 862	799, 509	942, 252	1, 149, 462
May	670, 330	855, 699	1, 016, 213	1, 160, 991
June	621, 733	853, 224	1, 063, 053	1, 065, 999
July	742, 326	843, 872	1, 142, 045	1, 104, 530
August	734, 517	874, 595	1, 283, 358	1, 134, 236
September	717, 170	876, 308	1, 254, 770	1, 133, 592
October	713, 138	884, 716	1, 269, 522	1, 130, 713
November	721, 411	851, 488	1, 261, 766	1, 116, 752
December	721, 685	908, 295	1, 204, 350	1, 158, 841
Total	8, 120, 125	10, 019, 770	13, 090, 045	13, 615, 101

Total amount and values of crude petroleum produced in West Virginia from 1889 to 1898, inclusive.

Year.	Regular crude.			Lubricating crude.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
1889	520, 511	$595, 730	$\$1.14\frac{1}{2}$	23, 602	$58, 097	$\$2.46\frac{1}{8}$	544, 113	$653, 827	$\$1.20\frac{1}{8}$
1890							492, 578	501, 198	$1.01\frac{3}{4}$
1891							2, 406, 218	1, 612, 826	.67
1892							3, 810, 086	2, 119, 901	$.55\frac{6}{10}$
1893	8, 433, 412	5, 398, 522	.64	12, 000	27, 000	2.25	8, 445, 412	5, 425, 522	.64
1894	8, 563, 954	7, 182, 794	$.83\frac{9}{10}$	13, 670	38, 923	2.85	8, 577, 624	7, 221, 717	.84
1895	8, 109, 782	11, 017, 651	$1.35\frac{6}{7}$	10, 343	21, 119	2.04	8, 120, 125	11, 038, 770	1.36
1896	10, 005, 966	11, 794, 532	$1.17\frac{7}{8}$	13, 804	35, 086	2.54	10, 019, 770	11, 829, 618	1.18
1897	13, 078, 011	10, 282, 586	$.78\frac{5}{8}$	12, 034	27, 592	2.29	13, 090, 045	10, 310, 178	$.78\frac{3}{4}$
1898	13, 603, 136	12, 395, 858	$.91\frac{1}{8}$	11, 965	30, 501	2.55	13, 615, 101	12, 426, 359	$.91\frac{3}{10}$

In the following table is given the production of oil in West Virginia from the beginning of operations, so far as obtainable (that previous to 1877 being partially estimated) from 1887 to 1898:

Production of petroleum in West Virginia.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
Previous to 1876..	3,000,000	1883......	126,000	1892......	3,810,086
1876......	120,000	1884......	90,000	1893......	8,445,412
1877......	172,000	1885......	91,000	1894......	8,577,624
1878......	180,000	1886......	102,000	1895......	8,120,125
1879......	180,000	1887......	145,000	1896......	10,019,770
1880......	179,000	1888......	119,448	1897......	13,090,045
1881......	151,000	1889......	544,113	1898......	13,615,101
1882......	128,000	1890......	492,578	Total.	73,904,520
		1891......	2,406,218		

WELL RECORDS OF WEST VIRGINIA.

The operations in the West Virginia oil fields are included under the head of the Southwest division in the general summaries of the Pennsylvania or Appalachian region. The fact that the northeastern end of the Mannington district overlaps into Pennsylvania, and that a large portion of the Sistersville field lies in southeastern Ohio, makes it rather difficult to determine the exact number of wells completed that should be credited to West Virginia. In the following tables the record of the principal producing sections of the West Virginia oil fields are presented. It should be borne in mind that a portion of the wells credited to Sistersville belong in southeastern Ohio, and that some of those credited to the Mannington district are located along the southern border of Pennsylvania:

Total number of wells completed in West Virginia fields in 1898, by months and counties.

Month.	Sistersville.	Mannington.	Wood County.	Pleasants County.	Ritchie County.	Burning Springs.	Roane County.	Total.
January	12	71	24	9	12	1	0	129
February	15	59	23	3	13	0	0	113
March	7	32	27	9	19	1	0	95
April	8	41	32	12	25	3	0	121
May	16	35	17	13	18	1	1	101
June..........	15	50	19	11	30	4	1	130
July	16	54	37	13	17	4	3	144
August........	15	44	39	13	17	4	1	133
September ...	26	59	48	13	21	6	1	174
October	29	77	38	15	17	5	2	183
November....	30	75	47	9	11	2	2	176
December	36	84	40	15	20	3	3	201
Total	225	681	391	135	220	34	14	1,700

Initial daily production of wells completed in West Virginia fields in 1898.

[Barrels of 42 gallons.]

Month.	Sisters-ville.	Man-ning-ton.	Wood County.	Pleas-ants County.	Ritchie County.	Burn-ing Springs.	Roane County.	Total.
January	529	5, 300	1, 419	35	365	0	0	7, 648
February	610	2, 617	769	0	373	0	0	4, 369
March	292	2, 772	1, 334	65	1, 750	0	0	6, 213
April	75	2, 285	1, 245	109	1, 670	8	0	5, 392
May	597	2, 123	1, 159	156	1, 765	5	0	5, 805
June	370	2, 385	800	160	542	12	0	4, 269
July	196	2, 187	1, 065	104	327	33	20	3, 932
August	1, 070	3, 241	1, 111	120	778	20	0	6, 340
September	467	4, 252	1, 497	270	142	30	5	6, 663
October	414	3, 533	956	138	491	20	0	5, 552
November	609	3, 966	1, 277	255	290	3	10	6, 410
December	432	3, 226	1, 102	515	450	13	0	5, 738
Average	472	3, 157	1, 145	160	745	12	3	5, 694

Total number of dry holes in West Virginia fields in 1898.

Month.	Sisters-ville.	Man-ning-ton.	Wood County.	Pleas-ants County.	Ritchie County.	Burn-ing Springs.	Roane County.	Total.
January	3	21	5	5	1	1	0	36
February	6	15	4	3	0	0	0	28
March	1	6	4	6	4	1	0	22
April	5	12	12	4	3	1	0	37
May	8	3	1	1	4	0	1	18
June	5	8	3	4	6	1	1	28
July	4	12	8	6	8	1	2	41
August	6	9	9	5	6	1	1	37
September	9	8	10	4	9	1	0	41
October	6	14	10	6	4	1	2	43
November	9	15	11	3	3	1	1	43
December	15	22	9	0	4	1	3	54
Total	77	145	86	47	52	10	11	428

KENTUCKY.

Eastern Kentucky.—This portion of the State is still hoping for better wells, although nothing of value has been added during 1898 to what was already developed. Several dry holes were drilled by the New Domain Oil and Gas Company in Pike County, but nothing of value was found. A deep well was also completed near Williamson, on the Kentucky side of the Tug River. Most of these wells have found open sands heavily charged with salt water and a little gas. The New Domain Oil and Gas Company has pumped about 12,000 barrels of oil into the tanks located near the wells on the right of Beaver Creek, in Floyd County, but so far the production has been only four to five barrels to the well. This company is now drilling farther south, near the head waters of Mud Creek.

The sand rocks, slates, and shales in eastern Kentucky are of such a character as to lead the prospector to infer that somewhere they will hold oil instead of salt water and gas. The inference has not been realized as yet. It must be remembered, however, that the possible oil rocks cover a large area in the southeastern portion of the State. A very large portion of it is difficult of access, and the few wells scattered over the large area have tested only a very small part of it. It has been predicted by experts and others who ought to know, that this portion of the State will at some time in the future produce large quantities of the best quality of petroleum.

South Central Kentucky.—Although there were but few wells drilled in this portion of the State during 1898, yet there are a number of wells drilled previously which are capable of producing a paying quantity of petroleum. The most productive territory so far developed in this section has been on Otter and Beaver creeks in Wayne County. A paying well was secured by Messrs. D. Dwight & Co. From the best information obtainable, a product of over 400 barrels per day is here waiting for transportation. The wells are only from 380 to 540 feet in depth. The oil has a gravity of 34.5° Baumé and is free from sulphur. Arrangements have been made for the construction of 36 miles of 3-inch line, connecting this section on Otter and Beaver creeks with Somerset, on the Cincinnati Southern Railroad. There are several other wells of small production scattered over Wayne, Barren, Pulaski, Allen, and Cumberland counties that would produce oil in moderate quantities if they were connected by pipe line or railroads.

During 1894 and 1895 a large amount of prospecting was done, and many deep, expensive holes were drilled without result into the great underlying deposit of close limestone. In prospecting for salt as far back as 1818, Mr. Martin Beatty struck a large flow of oil on Big Fork of the Cumberland River at 171 feet. This was allowed to escape into the river, and, taking fire, it produced a tremendous conflagration. This was forty-one years before the first oil well was drilled by Captain Drake, of Titusville, Pennsylvania.

Operations in Barren County date back to 1865. There were some 13 wells producing near Oil City during 1898, being operated by the Interstate Petroleum Company. One of these wells during its life is said to have produced 40,000 barrels. The oil is found at 120, 240, and 325 feet. The deepest wells yield most of the petroleum, which is low in gravity, dark in color, and contains considerable sulphur. The oil is found in limestone generally, quite hard; in some instances an impure sand holds the petroleum.

PRODUCTION.

The total production of oil in Kentucky, so far as has been ascertained, is as follows:

Production of petroleum in Kentucky from 1883 to 1898.

[Barrels of 42 gallons.]

Year.	Production.	Year.	Production.
1883	4,755	1891	9,000
1884	4,148	1892	6,500
1885	5,164	1893	3,000
1886	4,726	1894	1,500
1887	4,791	1895	1,500
1888	5,096	1896	1,680
1889	5,400	1897	322
1890	6,000	1898	5,568

TENNESSEE.

The only well producing petroleum in Tennessee is the Bobs Bar well, some 15 miles west of Jamestown, Fentress County. This well was drilled in 1896, is only 276 feet deep, is completely surrounded by dry holes, and continues to be one of the mysteries. Since it was opened it has produced 12,800 barrels of petroleum up to the close of 1898; 6,522 barrels were produced in 1898, showing a daily average production of 18.9 barrels. The oil is of a light-green color, with a specific gravity of 0.8464 (35° Baumé). It is free from grit, as the leather cups used in the working barrel need replacing only at long intervals, only 12 having been used in the life of the well.

There is no market for this oil, as it is 30 miles away from the nearest railroad. The National Transit Company have erected two iron tanks of a combined capacity of 40,000 barrels, and into these tanks the oil has been accumulating, none having been sold. There are many wells that were drilled in former years that had small shows of oil near the surface, but the deeper drilling found only compact limestone, with some blue-lick water in the very deep ones. The only solution of the continued production of the Bobs Bar well is that the well fortunately pierced a cavern in the limestone which has been filling up for untold ages and which it has been draining.

PRODUCTION OF APPALACHIAN OIL FIELD FROM 1889 TO 1898, BY STATES.

The following table gives the production of the different States in the Appalachian field from 1889 to 1898, outside of the small production in Kentucky and Tennessee.

The difficulty in completely separating the New York and Pennsylvania production, owing to the Bradford pool continuing without interruption from one State to the other, has made it necessary to combine the totals for these two States.

Production of petroleum in the Appalachian oil field from 1889 to 1898.

[Barrels of 42 gallons.]

Year.	Pennsylvania and New York.	West Virginia.	Southeastern Ohio.	Total.
1889	21, 487, 435	544, 113	318, 277	22, 349, 825
1890	28, 458, 208	492, 578	1, 116, 521	30, 067, 307
1891	33, 009, 236	2, 406, 218	424, 323	35, 839, 777
1892	28, 422, 377	3, 810, 086	1, 193, 414	33, 425, 877
1893	20, 314, 513	8, 445, 412	2, 602, 965	31, 362, 890
1894	19, 019, 990	8, 577, 624	3, 184, 310	30, 781, 924
1895	19, 144, 390	8, 120, 125	3, 694, 624	30, 959, 139
1896	20, 584, 421	10, 019, 770	3, 366, 031	33, 970, 222
1897	19, 262, 066	13, 090, 045	2, 877, 838	35, 229, 949
1898	15, 948, 464	13, 615, 101	2, 148, 292	31, 711, 857

From the above table it will be seen that the production for the year 1898 decreased 3,518,092 barrels as compared with 1897—a decrease of 10 per cent. In 1897 there was an increase of 4 per cent over 1896.

PRODUCTION IN THE APPALACHIAN OIL FIELDS, BY MONTHS.

In the following table is given the production of crude petroleum in the Appalachian oil field from 1893 to 1898, by months:

Production of crude petroleum in the Appalachian oil field from 1893 to 1898, by months.

[Barrels of 42 gallons.]

Month.	1893.	1894.	1895.	1896.	1897.	1898.
January	2,491,853	2,627,123	2,469,941	2,727,891	2,754,761	2,816,280
February	2,350,490	2,330,582	2,083,087	2,528,867	2,663,406	2,465,715
March	2,769,501	2,671,051	2,504,645	2,711,088	2,935,568	2,864,176
April	2,493,590	2,494,772	2,588,727	2,933,487	2,809,148	2,688,999
May	2,673,648	2,654,299	2,586,710	2,888,502	2,902,571	2,714,058
June	2,669,110	2,637,416	2,488,551	2,916,018	2,990,489	2,595,135
July	2,658,141	2,659,718	2,673,621	2,972,001	3,035,334	2,572,648
August	2,757,351	2,605,494	2,753,417	2,871,118	3,115,375	2,667,974
September	2,682,296	2,465,689	2,685,766	2,831,507	3,035,321	2,578,710
October	2,651,591	2,638,689	2,717,958	2,901,781	3,078,061	2,581,226
November	2,513,281	2,460,880	2,661,700	2,745,756	2,983,616	2,527,486
December	2,652,038	2,536,211	2,745,016	2,942,206	2,926,299	2,639,450
Total	31,362,890	30,781,924	30,959,139	33,970,222	35,229,949	31,711,857

From the above table it is seen that the months of the first half of 1898 produced the largest amount of petroleum, the reverse of 1897.

PIPE-LINE RUNS IN THE APPALACHIAN OIL FIELD IN 1898.

Usually the terms "production" and "pipe-line runs" are considered as synonymous, but production is always slightly in excess of runs. The expression "pipe-line runs" means the amount of oil that the pipe lines have received from the wells, and as the pipe lines do not run all the oil in the tanks at the wells, it would be remarkable if the same amount remained in the tanks at the wells at the close of each year. The true yearly runs would be obtained if there were the same amount on hand at the end of the year that there was at the beginning. If there were more, the difference should be subtracted from the total runs to get the total production. As there is some oil delivered to cars and to refineries that is not handled by the pipe lines, the total production will be more than the pipe-line runs. The production in the Appalachian oil field in 1898 was 31,711,857 barrels, the runs 31,156,449, making a difference of 555,408 barrels in excess of pipe-line runs.

In the following table will be found the pipe-line runs in the Appalachian oil field in 1898, by lines and by months:

Pipe-line runs in the Appalachian oil field in 1898, by lines and months.

[Barrels of 42 gallons.]

Month.	National Transit.	Tide Water.	Southwest.	Franklin.	Eureka.
January	740, 384	132, 166	370, 700	3, 794	1, 185, 563
February	634, 605	122, 094	323, 435	3, 456	1, 051, 454
March	742, 680	142, 135	380, 062	5, 165	1, 203, 725
April	680, 508	128, 701	355, 076	5, 544	1, 151, 258
May	690, 992	130, 240	360, 035	4, 570	1, 166, 804
June	681, 531	128, 279	350, 357	4, 754	1, 088, 454
July	646, 407	126, 680	339, 276	5, 012	1, 071, 656
August	672, 169	128, 340	351, 496	5, 065	1, 140, 259
September	636, 951	121, 051	329, 935	4, 280	1, 125, 284
October	621, 956	121, 970	326, 562	4, 798	1, 097, 548
November	594, 610	129, 998	309, 993	3, 973	1, 127, 034
December	600, 429	149, 804	336, 531	5, 679	1, 149, 370
Total	7, 943, 222	1, 561, 458	4, 133, 458	56, 090	13, 558, 409

Pipe-line runs in the Appalachian oil field in 1898, by lines and months—Continued.

[Barrels of 42 gallons.]

Month.	Elk.	Emery.	Producers and Refiners' Pipe Line Company, Limited.	Buckeye-Macksburg.	Total.
January	17,694	28,230	95,429	175,546	2,749,506
February	16,318	32,390	97,721	164,419	2,445,892
March	16,902	33,975	110,099	184,451	2,819,194
April	16,735	29,744	107,962	182,567	2,658,095
May	17,049	29,060	101,551	185,388	2,685,689
June	15,550	23,111	104,716	174,768	2,571,520
July	17,219	21,953	103,337	161,163	2,492,703
August	14,309	22,818	108,799	184,659	2,627,914
September	14,794	22,331	102,926	171,760	2,529,312
October	16,133	20,592	107,120	175,956	2,492,635
November	15,427	22,877	105,711	179,490	2,489,113
December	16,099	24,227	114,833	197,904	2,594,876
Total	194,229	311,308	1,260,204	2,138,071	31,156,449

AVERAGE DAILY PRODUCTION OF THE APPALACHIAN OIL FIELD FROM 1893 TO 1898, INCLUSIVE, BY MONTHS AND YEARS.

The daily average production, which follows closely the pipe-line runs reported daily in all the oil exchanges, is generally accepted by the producer and refiner as the standard by which comparisons are made. The amounts are obtained by dividing the monthly production by the number of days in each particular month. The average yearly production is secured by dividing the total by 365 or 366, as the case may be.

Average daily product of crude petroleum in the Appalachian oil field each month for the years 1893 to 1898, by months and years.

[Barrels.]

Month.	1893.	1894.	1895.	1896.	1897.	1898.
January	80,382	84,746	79,676	87,996	88,863	90,848
February	83,946	83,235	74,396	87,202	95,122	88,061
March	89,339	86,163	80,795	87,454	94,695	92,392
April	83,120	83,159	86,291	97,783	93,638	89,633
May	86,247	85,622	83,443	93,177	93,631	87,550
June	88,970	87,914	82,952	97,201	99,683	86,504
July	85,746	85,797	86,246	95,871	97,914	82,988
August	88,947	84,048	88,820	92,617	100,496	86,064
September	89,410	82,190	89,526	94,384	101,177	85,957
October	85,535	85,119	87,676	93,606	99,292	83,265
November	83,776	82,030	88,723	91,525	99,454	84,249
December	85,550	81,813	88,549	94,910	94,397	85,143
Average	85,926	84,334	84,820	92,815	96,520	86,882

The above table includes some petroleum not handled by the pipe lines, owing to its proximity to refineries, to which it is hauled or delivered by private lines.

The decrease in daily production in 1898 as compared with the previous year was 9,638 barrels, amounting to 10 per cent.

SHIPMENTS OF PETROLEUM FROM THE APPALACHIAN OIL FIELD.

The following table gives the total deliveries of petroleum by pipe lines in the Appalachian field from 1891 to 1898, inclusive, by years and months. These figures must not be regarded as showing the actual consumption. They represent what the pipe-line companies transported out of their receiving tanks and delivered to customers in the regular way of business, amounting to 30,405,936 barrels in 1898, as compared to 33,664,324 barrels in 1897, a decrease of 3,258,388 barrels from the number of barrels transported in 1897:

Total shipments of petroleum in the Appalachian oil field from 1891 to 1898, by months.

[Barrels of 42 gallons.]

Month.	1891.	1892.	1893.	1894.
January	2, 475, 783	2, 420, 825	2, 957, 358	3, 141, 722
February	2, 170, 172	2, 443, 546	2, 584, 742	2, 656, 026
March	2, 430, 705	2, 586, 075	2, 843, 938	2, 912, 594
April	2, 157, 605	2, 338, 421	2, 666, 199	2, 846, 805
May	2, 073, 199	2, 278, 027	3, 033, 700	2, 819, 413
June	2, 163, 811	2, 108, 386	3, 074, 443	2, 914, 400
July	2, 260, 996	2, 314, 405	3, 319, 658	2, 927, 036
August	2, 498, 573	2, 626, 043	3, 248, 873	3, 256, 397
September	2, 704, 645	2, 770, 472	3, 000, 740	2, 966, 864
October	2, 802, 254	2, 824, 508	3, 316, 914	3, 271, 371
November	2, 604, 135	2, 916, 265	3, 096, 578	3, 208, 560
December	2, 783, 766	2, 978, 921	3, 152, 238	3, 286, 087
Average	2, 427, 137	2, 550, 491	3, 024, 615	3, 017, 273
Total	29, 125, 644	30, 605, 894	36, 295, 381	36, 207, 275

Total shipments of petroleum in the Appalachian oil field from 1891 to 1898, by months—Continued.

[Barrels of 42 gallons.]

Month.	1895.	1896.	1897.	1898.
January	3, 140, 864	2, 543, 518	2, 538, 501	2, 909, 176
February	2, 808, 801	2, 252, 417	2, 311, 488	2, 133, 424
March	2, 608, 232	2, 438, 900	2, 773, 710	2, 627, 845
April	2, 781, 379	2, 227, 514	2, 454, 018	2, 422, 105
May	2, 845, 334	2, 418, 590	2, 546, 696	2, 393, 831
June	2, 816, 698	2, 249, 062	2, 556, 161	2, 435, 248
July	2, 634, 880	2, 540, 332	2, 707, 317	2, 563, 825
August	2, 424, 843	2, 404, 298	3, 100, 209	2, 696, 018
September	2, 332, 271	2, 542, 963	2, 956, 036	2, 585, 253
October	2, 573, 915	2, 606, 494	3, 638, 301	2, 847, 108
November	2, 655, 325	2, 502, 035	3, 320, 084	2, 408, 127
December	2, 410, 084	2, 614, 072	2, 761, 803	2, 383, 976
Average	2, 669, 386	2, 445, 016	2, 805, 360	2, 533, 828
Total	32, 032, 626	29, 340, 195	33, 664, 324	30, 405, 936

STOCKS OF PETROLEUM IN THE APPALACHIAN OIL FIELD.

In the following table will be found a statement of the stocks of petroleum in the tanks of the pipe-line companies in the Appalachian oil field at the close of each month from 1891 to 1898:

Total stocks of petroleum in the Appalachian oil field at the close of each month from 1891 to 1898.

[Barrels of 42 gallons.]

Month.	1891.	1892.	1893.	1894.
January	11, 068, 179	16, 973, 225	17, 305, 206	11, 755, 219
February	11, 340, 147	17, 416, 399	17, 042, 245	11, 384, 776
March	11, 419, 782	17, 587, 512	16, 834, 533	11, 295, 959
April	11, 793, 604	18, 028, 753	16, 641, 773	10, 751, 983
May	12, 138, 347	18, 464, 378	16, 285, 855	10, 639, 454
June	12, 455, 630	19, 056, 902	15, 845, 548	10, 381, 209
July	12, 640, 790	19, 446, 441	15, 182, 551	9, 869, 915
August	12, 791, 156	19, 563, 635	14, 730, 600	9, 210, 959
September	13, 039, 230	19, 394, 242	14, 261, 432	8, 730, 456
October	13, 936, 108	19, 039, 149	13, 559, 543	8, 038, 376
November	15, 413, 864	18, 529, 914	12, 904, 344	7, 283, 988
December	16, 457, 089	18, 037, 385	12, 316, 611	6, 499, 880
Average	12, 874, 494	18, 461, 495	15, 242, 520	9, 653, 515

Total stocks of petroleum in the Appalachian oil field at the close of each month from 1891 to 1898—Continued.

[Barrels of 42 gallons.]

Month.	1895.	1896.	1897.	1898.
January	5,859,348	5,499,477	9,904,200	10,851,673
February	5,087,498	5,741,797	10,308,262	11,170,947
March	4,942,643	6,005,732	10,426,110	11,370,864
April	4,730,819	6,697,481	10,772,213	11,611,688
May	4,506,874	7,153,922	11,088,493	11,909,904
June	4,275,506	7,791,359	11,485,001	12,052,282
July	4,306,287	8,182,582	11,830,322	11,976,516
August	4,592,906	8,672,385	11,794,707	11,908,617
September	4,908,593	8,924,639	11,872,575	11,852,553
October	5,013,941	9,178,509	11,246,836	11,490,444
November	4,988,092	9,409,098	10,870,883	11,572,734
December	5,344,784	9,745,722	11,010,044	11,786,603
Average	4,879,775	7,750,225	11,050,804	11,629,569

The foregoing table shows an increase in the amount of crude petroleum stored in the tanks of the several pipe-line companies at the close of the year, a gain of 776,559 barrels in 1898 above the stocks at the end of 1897, and it is upon this oil in stock as security that pipe-line certificates are issued. This they must protect by the purchase of fresh oil, if necessary, to make good any loss by evaporation, bursting of pipes, losses by fire, or settlings in the bottoms of tanks of paraffin, sand, and water, known as B. S., which is unsalable for refining purposes.

The shipments added to or subtracted from stocks, as the case may be, are always less than the runs, and oil is purchased by the pipe-line company to make good these losses, but the purchased oil does not appear in the statement of runs. The table of stocks does not include all the oil held, but only that held by the pipe-line companies. A large percentage is held temporarily at the wells in individual tanks.

PRICES OF CRUDE PETROLEUM IN THE APPALACHIAN OIL FIELD.

The prices of crude petroleum in the Appalachian oil field, as arranged in the following table, show the monthly and yearly average price of pipe-line certificates or the price of crude petroleum at the primary markets from 1860 to 1898. In the early history of the industry covered by the table, before the introduction of pipe lines, the prices quoted usually meant the price at the wells or at some point not far distant. In late years the price given is that of pipe-line certificates, which are issued to holders of a thousand barrels of oil in any of the districts; or a producer or owner may "bunch" his production in the different districts to secure the issuing of a 1,000-barrel certificate as soon as it has been run into the tanks of the pipe-line company. These certificates are made payable to bearer and are therefore transferable; they are subject to a transportation charge in the district of 20 cents per barrel and a charge for storage at the rate of 25 cents per 1,000 barrels when the price is less than $1, 30 cents when over $1 and less than $1.50, and 40 cents for all over $1.50 per barrel. It is to be returned for exchange to the pipe-line company within six months after its issue, or subject to a charge of one-twentieth of 1 per cent daily thereafter until exchanged. To cover losses by fire or lightning, it is subject to an assessment pro rata on all oil in the custody of the pipe line. None of these charges are included in the prices of petroleum as quoted, and therefore the prices given are the prices at or near the wells.

The average price covers the ordinary grades of oil. They do not include special oils, such as that from the Franklin lubricating district or that of Petroleum and Volcano of West Virginia, nor the Mecca-Belden district of Ohio, but only such oil as Pennsylvania oil and such as is used chiefly for the production of illuminants. It is also true that in some of the districts oil is worth more than ordinary Pennsylvania oil and in some districts it is worth less. This is owing to the fact that some districts produce oil that furnishes a larger percentage of illuminating oil and a larger percentage of by-products. Oil that has remained in tanks at the wells for a long period loses a percentage of its illuminating properties, and is worth less than what is known as fresh oil or petroleum recently produced at the wells.

These averages, it should be understood, are not the true averages—that is, averages that consider the price and the quantity sold at that price—but they are the averages of the prices obtained for certificate or for oil at the primary markets from day to day. It is probable that the true average prices would be slightly under the averages obtained by averaging the prices. The figures given in the following tables are, under these conditions, the only ones that can be ascertained, and do not vary much from the true average:

Monthly and yearly average prices of pipe-line certificates of crude petroleum at wells from 1860 to 1898.

[Per barrel of 42 gallons.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
1860....	$19.25	$18.00	$12.62½	$11.00	$10.00	$9.50	$8.62½	$7.50	$6.62½	$5.50	$3.75	$2.75	$9.59
1861....	1.00	1.00	1.00	.62½	.50	.50	.50	.25	.20	.10	.10	.10	.49
1862....	.10	.15	.22½	.50	.85	1.00	1.25	1.25	1.25	1.75	2.00	2.25	1.05
1863....	2.25	2.50	2.62½	2.87½	2.87½	3.00	3.25	3.37½	3.50	3.75	3.85	3.95	3.15
1864....	4.00	4.37½	5.50	6.56	6.87½	9.50	12.12½	10.12½	8.87½	7.75	10.00	11.00	8.06
1865....	8.25	7.50	6.00	6.00	7.37½	5.62½	5.12½	4.62½	6.75	8.12½	7.25	6.50	6.59
1866....	4.50	4.40	3.75	3.95	4.50	3.87½	3.00	3.75	4.50	3.39	3.10	2.12½	3.74
1867....	1.87½	1.85	1.75	2.07½	2.35	1.90	2.62½	3.15	3.40	3.55	2.50	1.87½	2.41
1868....	1.95	2.00	2.55	2.82⅛	3.75	4.50	5.12½	4.57½	4.00	4.12½	3.75	4.35	3.62½
1869....	5.75	6.95	6.00	5.70	5.35	4.95	5.37½	5.57½	5.50	5.50	5.80	5.12½	5.63¾
1870....	4.52½	4.52½	4.45	4.22½	4.40	4.17½	3.77½	3.15	3.25	3.27½	3.22½	3.40	3.86
1871....	3.82½	4.38	4.25	4.01	4.60	3.85½	4.79	4.66	4.65	4.82½	4.25	4.00	4.34
1872....	4.02½	3.80	3.72½	3.52½	3.80	3.85	3.80	3.58½	3.25	3.15	3.83½	3.32½	3.64
1873....	2.60	2.20	2.12½	2.30	2.47½	2.22½	2.00	1.42½	1.15	1.20	1.25	1.00	1.83
1874....	1.20	1.40	1.60	1.90	1.62½	1.32½	1.02½	.95	.95	.85	.55	.61½	1.17
1875....	1.03	1.52½	1.75	1.36½	1.40	1.26½	1.09	1.13	1.33	1.32½	1.44	1.55	1.35
1876....	1.80	2.60	2.01	2.02½	1.90½	2.01¾	2.24½	2.71⅜	3.81	3.37½	3.11	3.73	2.56¼
1877....	3.53¼	2.70	2.67½	2.58	2.24	1.94⅝	2.07½	2.51	2.38	2.56¾	1.91	1.80	2.42
1878....	1.43	1.65¼	1.59	1.37½	1.35¼	1.14	.98¾	1.01	.86⅝	.82½	.89⅜	1.16	1.19

Monthly and yearly average prices of pipe-line certificates of crude petroleum at wells from 1860 to 1898—Continued.

[Per barrel of 42 gallons.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
1879....	$1.03	$0.98	$0.86¼	$0.78½	$0.76	$0.68⅜	$0.69⅞	$0.67⅛	$0.69⅜	$0.88⅛	$1.05⅝	$1.18⅛	$0.85⅞
1880....	1.10¼	1.03⅛	.88¾	.78	.80	1.00	1.06¼	.91	.96	.96⅞	.91⅞	.91⅝	.94½
1881....	.95½	.90⅜	.83⅜	.86¼	.81⅞	.81¼	.76⅞	.78⅛	.97⅛	.91¼	.85¼	.84⅜	.85⅞
1882....	.83⅛	.84½	.81⅜	.78⅜	.71½	.54⅜	.57⅜	.58⅝	.72⅛	.93¾	1.14	.96	.78⅛
1883....	.93¾	1.01	.97⅝	.94⅜	1.00⅛	1.16⅜	1.05⅞	1.08	1.12½	1.11⅛	1.14½	1.14¾	1.05¾
1884....	1.11	1.04⅜	.98⅛	.94	.85⅝	.68⅝	.63½	.81⅞	.78	.71⅛	.72½	.74⅜	.83½
1885....	.70⅞	.72⅜	.80⅜	.78½	.79	.82	.92½	1.00¼	1.00¾	1.05½	1.04⅜	.89⅝	.87⅞
1886....	.88⅜	.79⅞	.77¼	.74⅛	.70	.66½	.66	.62⅛	.63⅜	.65⅛	.71⅝	.70⅝	.71¼
1887....	.70	.64⅝	.63⅜	.64⅞	.64⅛	.62⅝	.59¼	.60⅛	.67	.70⅞	.73⅞	.80¾	.66¾
1888....	.91¼	.91⅝	.98⅝	.82⅝	.86¾	.75⅞	.80⅝	.90⅛	.93⅝	.90⅝	.85⅜	.89¼	.87⅝
1889....	.86⅝	.89¼	.90⅞	.88	.83⅛	.83⅞	.95⅛	.99½	.99⅛	1.01⅜	1.08½	1.04⅛	.94⅛
1890....	1.05¾	1.05⅛	.90	.82⅝	.88⅞	.89¼	.89⅛	.89¼	.81⅞	.80⅛	.72⅜	.67¼	.86¾
1891....	.74¼	.78⅜	.74¼	.71½	.69¾	.68⅛	.66½	.64	.58½	.60½	.58¾	.59⅝	.67
1892....	.62⅜	.60¼	.57⅛	.57⅞	.57⅜	.54⅛	.52½	.55	.54⅜	.51⅜	.52	.53¼	.55⅝
1893....	.53½	.57⅜	.65¼	.68¾	.58¾	.60¼	.57⅝	.58⅞	.64⅝	.70¾	.73⅞	.78¼	.64
1894....	.79¾	.80⅝	.82	.84¼	.86	.89⅜	.83⅛	.81	.83	.83	.83	.91½	.83⅞
1895....	.99	1.04⅜	1.09¾	1.79	1.74¼	1.53⅝	1.46⅝	1.26⅙	1.22⅜	1.24¼	1.48⅜	1.42	1.35⅞
1896....	1.42⅝	1.36⅝	1.28½	1.22½	1.15⅜	1.14¾	1.08¼	1.05	1.12	1.15	1.16	.98	1.17⅞
1897....	.88	.90⅛	.92⅙	.85⅞	.86¾	.86¼	.76¾	.71	.69¾	.67⅜	.65	.65	.78⅝
1898....	.65	.67¾	.78⅝	.73¾	.82¼	.87⅛	.93¼	.97⅝	1.01¾	1.13⅛	1.16⅜	1.17½	.91⅛

The above table shows a gain in each month during the year 1898, excepting in the month of April, when it declined 4⅞ cents per barrel.

For a number of years the prices of certificate oil, that term meaning the oil taken as standard and merchantable by the pipe lines, ruled the market or selling price of crude petroleum. These certificates were bought and sold on the floor of the oil exchanges. In past years there was a large amount of oil held as stocks, and as these were depleted it was necessary for the pipe-line companies to recall a large number of these certificates. As the stocks were reduced it came to pass that a comparatively small amount of oil would control the entire trade. On January 23, 1895, the following notice was posted at the various offices of what was known as the Seep Purchasing Agency, Mr. Joseph Seep being the purchaser for the refineries of the Standard Oil Company:

"From this date the prices quoted are not those of certificate oil, but the prices paid by the Seep Purchasing Agency."

There was at times considerable difference in the prices paid for certificates and that paid by the Seep agency, as shown by the quotations at the Oil City Exchange.

To enable anyone wishing to dispose of 1,000 barrels of oil in the tanks of the pipe lines at the price paid by the oil exchange, the Seep agency will negotiate the sale free of charge for the party having the oil in the line and will pay the average price upon which sales were made in the exchange on that day.

In the following table is given the range of prices paid producers in the Pennsylvania region in 1898. Prices are given for those dates in which changes were made. The great volume of trade is controlled by the prices under Pennsylvania, which includes all the oil sold in New York, nearly all sold in Pennsylvania, nearly all sold in West Virginia, and a very large proportion of that sold in Ohio:

Range of prices paid for petroleum in the Appalachain oil regions by the Seep Purchasing Agency in 1898.

Date.	Pennsylvania.	Tiona.	Corning.	Newcastle.	Barnesville.
January 1	$0.65	$0.75	$0.48	$0.40	$0.55
February 16	.67	.77	.50	.42	.57
February 17	.68	.78	.51	.43	.58
February 23	.70	.80	.53	.45	.60
February 25	.73	.83	.56	.48	.63
February 26	.76	.86	.59	.51	.66
February 28	.80	.90	.63	.55	.70
March 1	.82	.92	.65	.57	.72
March 8	.80	.90	.63	.55	.70
March 9	.79	.89	.62	.54	.69
March 14	.78	.88	.61	.53	.68
March 17	.77	.87	.60	.52	.67
April 2	.75	.85	.58	.50	.65
April 21	.74	.84	.57	.49	.64

Range of prices paid for petroleum in the Appalachain oil regions by the Seep Purchasing Agency in 1898—Continued.

Date.	Pennsylvania.	Tiona.	Corning.	Newcastle.	Barnesville.
April 22	$0.72	$0.82	$0.55	$0.47	$0.62
April 23	.71	.81	.54	.46	.61
May 5	.75	.85	.58	.50	.65
May 6	.80	.90	.63	.55	.70
May 7	.85	.95	.68	.60	.75
May 11	.83	.93	.66	.58	.73
May 12	.82	.92	.65	.57	.72
May 19	.84	.94	.67	.59	.74
May 20	.86	.96	.69	.61	.76
June 7	.87	.97	.70	.62	.77
June 11	.86	.96	.69	.61	.76
June 15	.85	.95	.68	.60	.75
June 21	.86	.96	.69	.61	.76
June 22	.87	.97	.70	.62	.77
June 24	.89	.99	.72	.64	.79
June 27	.90	1.00	.73	.65	.80
June 28	.92	1.02	.75	.67	.82
July 11	.94	1.04	.77	.69	.84
July 19	.95	1.05	.78	.70	.85
July 20	.93	1.03	.76	.68	.83
July 21	.92	1.02	.75	.67	.82
July 22	.90	1.00	.73	.65	.80
July 25	.92	1.02	.75	.67	.82
July 26	.94	1.04	.77	.69	.84
July 27	.96	1.06	.79	.71	.86
August 15	.97	1.07	.80	.72	.87
August 18	.98	1.08	.81	.73	.88
August 22	1.00	1.10	.83	.75	.90
September 16	1.02	1.12	.85	.77	.92
September 23	1.04	1.14	.87	.79	.94
September 27	1.06	1.16	.89	.81	.96
September 29	1.05	1.15	.88	.80	.95
October 4	1.07	1.17	.90	.82	.97
October 6	1.08	1.18	.91	.83	.98
October 7	1.10	1.20	.93	.85	1.00
October 13	1.12	1.22	.95	.87	1.02
October 17	1.15	1.25	.98	.90	1.05
October 20	1.18	1.28	1.01	.93	1.08
November 15	1.16	1.26	.99	.91	1.06
November 16	1.15	1.25	.98	.90	1.05
December 9	1.17	1.27	1.00	.92	1.07
December 19	1.19	1.29	1.02	.94	1.09

In the following table are given the average monthly prices of crude petroleum produced in the various districts of the Appalachian oil regions in the year 1898, in which special prices are paid:

Average monthly prices of Appalachian crude petroleum, per barrel of 42 gallons, in 1898.

Month.	Tiona.	Pennsylvania.	Barnesville.	Corning.	Newcastle.
January	\$0.75	\$0.65	\$0.55	\$0.48	\$0.40
February	.77¾	.67¾	.57¾	.50¾	.42¾
March	.88⅝	.78⅝	.68⅝	.61⅝	.53⅝
April	.83¾	.73¾	.63¾	.56¾	.48¾
May	.92¼	.82¼	.72¼	.65¼	.57¼
June	.97⅛	.87⅛	.77⅛	.70⅛	.62⅛
July	1.03¼	.93¼	.83¼	.76¼	.68¼
August	1.07⅝	.97⅝	.87⅝	.80⅝	.72⅝
September	1.11¾	1.01¾	.91¾	.84¾	.76¾
October	1.23⅛	1.13⅛	1.03⅛	.96⅛	.88⅛
November	1.26⅜	1.16⅜	1.06⅜	.99⅜	.91⅜
December	1.27½	1.17½	1.07½	1.00½	.92½
Average	1.01⅛	.91⅛	.81⅛	.74⅛	.66⅛

Almost the entire Appalachian product of petroleum is sold under the head of Pennsylvania oil, and it commanded the average price of 91⅛ cents per barrel during 1898. The output of Tiona petroleum was 291,585 barrels in 1898, while the yield of the Barnesville, Corning, and Newcastle pools in Ohio did not exceed three quarters of a million barrels.

The following table, taken from the Derrick's Handbook, gives the highest and lowest prices of crude petroleum for every year since 1859. The months during which the highest and lowest prices were attained are likewise shown.

Highest and lowest prices of crude petroleum each year since 1859.

Year.	Highest month.	Price.	Lowest month.	Price.
1859	September	\$20.00	December	\$20.00
1860	January	20.00	December	2.00
1861	January	1.75	December	.10
1862	December	2.50	January	.10
1863	December	4.00	January	2.00
1864	July	14.00	February	3.75
1865	January	10.00	August	4.00
1866	January	5.50	December	1.35
1867	October	4.00	June	1.50
1868	July	5.75	January	1.70
1869	January	7.00	December	4.25
1870	January	4.90	August	2.75
1871	June	5.25	January	3.25
1872	October	4.55	December	2.67½
1873	January	2.75	November	.82½
1874	February	2.25	November	.62½
1875	February	1.82½	January	.75
1876	December	4.23¾	January	1.47½
1877	January	3.69⅜	June	1.53¾
1878	February	1.87½	September	.78¾
1879	December	1.28¾	June	.63⅛
1880	June	1.24⅜	April	.71¼
1881	September	1.01¼	July	.72½
1882	November	1.37	July	.49¼
1883	June	1.24¾	January	.83¼
1884	January	1.15⅝	June	.51¼
1885	October	1.12⅝	January	.68
1886	January	.92¼	August	.59¾
1887	December	.90	July	.54
1888	March	1.00	June	.71⅜
1889	November	1.12½	April	.79½
1890	January	1.07⅝	December	.60¾
1891	February	.81⅜	August	.50
1892	January	.64⅛	October	.50
1893	December	.80	January	.52⅞
1894	December	.95¾	January	.78½
1895	April	2.60	January	.95¼
1896	January	1.50	December	.90
1897	March	.96	October	.65
1898	December	1.19	January	.65

WELL RECORDS IN THE APPALACHIAN OIL FIELD.

The following table shows the total number of wells completed each month in the several districts for 1898:

Total number of wells completed in the Appalachian oil field in 1898, by months and districts.

Month.	Bradford.	Allegany.	Middle.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg and other pools.	Total.
January	19	15	36	38	33	165	21	327
February	17	10	28	21	30	131	18	255
March	13	11	24	53	41	114	18	274
April	25	31	29	39	40	138	27	329
May	30	16	24	67	43	122	28	330
June	42	23	33	63	35	147	21	364
July	45	21	33	60	33	172	26	390
August	47	30	37	82	33	164	24	417
September	55	19	34	75	54	197	41	475
October	78	26	38	84	51	210	43	530
November	61	30	41	104	45	210	41	532
December	56	32	31	86	59	247	58	569
Total	488	264	388	772	497	2,017	366	4,792

The above table does not include the wells drilled in the Franklin lubricating-oil district of Pennsylvania, nor the wells in the Volcano and Burning Springs districts of West Virginia, which produce natural lubricating petroleum.

The following table shows a large falling off in the number of wells drilled in all the districts of the Appalachian field in 1898, as compared with 1897, amounting to a decrease of 1,280 wells, equal to 21 per cent. For the same time the production decreased only 10 per cent, or 3,518,092 barrels.

Total number of wells completed in the Appalachian oil field from 1891 to 1898.

District.	Wells completed.							
	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Bradford	278	37	52	284	578	769	696	488
Allegany	91	21	41	82	258	331	350	264
Middle	331	131	91	215	401	594	481	388
Venango and Clarion	650	131	243	731	1,783	1,614	990	772
Butler and Armstrong.	597	342	298	755	1,292	1,153	802	497
Southwest	1,414	1,230	1,065	1,481	2,364	2,744	2,255	2,017
Macksburg and others.	27	76	190	215	460	619	498	366
Total	3,388	1,968	1,980	3,763	7,136	7,824	6,072	4,792

The following table gives the number of wells drilled in the Appalachian oil field from 1891 to 1898, inclusive, by months. It will be noticed that the greatest number of wells are usually completed in June, July, August, and September, in which months there is generally the largest production.

Number of wells completed in the Appalachian oil field each month from 1891 to 1898, by months and years.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	310	182	135	189	296	580	599	327
February	243	180	99	176	212	555	438	255
March	275	149	143	217	355	542	414	274
April	288	174	146	278	462	614	486	329
May	314	174	196	324	658	729	548	330
June	304	162	228	370	810	793	604	364
July	334	179	219	342	822	739	638	390
August	333	143	163	359	814	640	601	417
September	281	146	179	381	775	644	489	475
October	246	160	154	394	727	624	446	530
November	255	174	144	390	638	682	426	532
December	205	145	174	343	567	682	383	569
Total	3,388	1,968	1,980	3,763	7,136	7,824	6,072	4,792

Of the 4,792 wells drilled in 1898, 1,269 were dry, leaving 3,523 producing wells as compared with 6,072 drilled in 1897, out of which 1,580 were dry, leaving 4,492 producing wells.

In the following table is given the initial daily production of new wells in the Appalachian field in 1898, by districts and months. By initial daily production is meant the production of the well when first drilled into the sand, so as to fully open up the pay streak, and this, in all cases, is nearly the maximum production. These figures do not include any of the production in the lubricating-oil districts of Pennsylvania or West Virginia.

Initial daily production of new wells in the Appalachian oil field in 1898, by months.

[Barrels of 42 gallons.]

Month.	Brad-ford.	Alle-gany.	Mid-dle.	Venan-go and Clar-ion.	Butler and Arm-strong.	South-west district.	Macks-burg.	Total.
January	55	64	611	112	127	8, 133	157	9, 259
February	80	30	300	65	164	4, 559	49	5, 247
March	74	27	94	160	130	6, 804	74	7, 363
April	294	80	123	140	170	5, 680	68	6, 555
May	339	54	124	206	144	6, 249	192	7, 308
June	326	70	237	185	99	4, 650	142	5, 709
July	597	41	293	171	168	4, 214	216	5, 700
August	704	82	272	193	213	6, 743	173	8, 380
September	769	44	241	219	249	7, 008	392	8, 922
October	813	73	186	236	204	5, 665	494	7, 671
November	703	84	221	242	189	6, 733	748	8, 920
December	600	89	238	197	274	5, 924	1, 362	8, 684
Average	446	61	245	177	178	6, 030	339	7, 476

For comparison we give the following statement showing the initial daily production of new wells from 1891 to 1898, and the average production of wells by districts for the same period. If only producing wells were considered the initial daily production would average 25.5 barrels per well for 1898 as compared with 29.6 in 1897.

Initial daily production of new wells in the Appalachian oil field from 1891 to 1898, by districts.

[Barrels of 42 gallons.]

District.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Bradford	1, 596	152	410	2, 296	3, 431	9, 462	7, 037	5, 354
Allegany	481	77	100	326	1, 277	1, 742	1, 332	738
Middle	2, 509	486	744	1, 953	2, 691	5, 968	11, 695	2, 940
Venango and Clarion	3, 736	534	1, 533	3, 815	6, 511	5, 652	3, 311	2, 126
Butler and Armstrong	18, 178	10, 668	6, 345	16, 592	18, 073	13, 725	6, 940	2, 131
Southwest	155, 853	89, 568	76, 633	64, 364	65, 684	74, 081	99, 095	72, 362
Macksburg	371	1, 768	2, 610	2, 698	5, 336	5, 768	3, 663	4, 067
Total	182, 724	103, 253	88, 375	92, 044	103, 003	116, 398	133, 073	89, 718
Average of all districts	26, 103	14, 750	12, 625	13, 149	14, 715	16, 628	19, 010	12, 817

Average daily production of new wells in the Appalachian oil field from 1891 to 1898, by districts.

[Barrels of 42 gallons.]

District.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Bradford	6.1	5.6	8	8	6.8	13.7	12.09	12.60
Allegany	5.8	5.1	2.2	4	5.8	6.1	4.45	3.48
Middle	8.4	5	8.2	9	7.8	12.2	32.58	10
Venango and Clarion	6.9	5.8	6.3	5.2	4.3	4.2	4	3.34
Butler and Armstrong	37.9	43	21.3	22	19.3	17	13.69	7.30
Southwest	148.3	90.7	72	43.5	38.4	39.4	61.36	49.63
Macksburg	28.5	42.1	13.7	12.5	15.9	13.8	12.13	19.74

The above table is remarkable, owing to the great falling off in the average production in the Middle district in 1898 as compared with 1897 and an increase in the Macksburg district, all others showing a decline.

Total daily initial production of new wells in the Appalachian oil field from 1891 to 1898, by months.

[Barrels of 42 gallons.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	13,364	12,249	5,910	8,667	5,938	7,383	9,289	9,259
February	6,618	9,992	6,982	5,914	3,662	7,829	8,492	5,247
March	7,751	8,661	7,650	6,100	6,150	8,842	6,048	7,363
April	7,710	6,751	6,962	7,584	6,388	11,253	8,078	6,555
May	7,875	7,793	8,176	7,430	7,859	11,350	9,471	7,308
June	5,263	9,585	10,815	11,443	9,909	11,825	13,108	5,709
July	6,543	10,669	7,662	9,009	8,786	10,476	13,834	5,700
August	13,536	7,861	8,733	7,691	12,204	7,471	16,983	8,380
September	18,118	6,347	6,640	6,912	14,728	8,216	13,350	8,922
October	46,748	8,833	4,510	7,838	9,916	9,263	13,029	7,671
November	33,660	6,932	6,495	7,507	10,374	10,294	11,502	8,920
December	15,538	7,580	7,840	5,949	7,089	12,196	9,889	8,684
Average	15,227	8,604	7,365	7,670	8,584	9,700	11,089	7,476

In the following table the number of dry holes in the Appalachian field is enumerated for 1898, by months and districts. There were 20 per cent decrease of dry holes drilled in 1898 as compared with 1897, and 17 per cent of decrease in 1897 as compared with 1896.

Total number of dry holes drilled in the Appalachian oil field in 1898.

Month.	Bradford.	Allegany.	Middle.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	9	0	9	9	17	52	12	108
February	4	1	6	5	10	39	10	75
March	4	5	11	10	23	32	10	95
April	5	4	13	8	17	42	16	105
May	3	1	7	16	18	26	16	87
June	4	5	10	10	14	32	8	83
July	6	7	5	14	14	54	13	113
August	6	6	5	18	10	48	10	103
September	3	5	4	9	22	52	18	113
October	9	6	12	10	18	52	11	118
November	5	4	7	16	19	55	15	121
December	5	8	5	11	23	75	21	148
Total	63	52	94	136	205	559	160	1,269

The number of dry holes in the Appalachian field from 1891 to 1898 in the different districts are noted in the following tables:

Number of dry holes drilled in the Appalachian oil field from 1891 to 1898.

District.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Bradford	18	10	8	46	76	78	114	63
Allegany	8	6	22	28	39	46	51	52
Middle	34	35	17	31	58	104	122	94
Venango and Clarion	110	40	56	124	283	261	162	136
Butler and Armstrong	117	94	88	204	354	347	295	205
Southwest	363	243	206	357	653	865	640	559
Macksburg	14	34	46	85	125	200	196	160
Total	664	462	443	875	1,588	1,901	1,580	1,269

In the following table will be found the statement of the number of dry holes drilled in each month from 1891 to 1898, inclusive:

Dry holes drilled in the Appalachian oil field from 1891 to 1898.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	46	37	39	36	76	145	154	108
February	61	36	24	41	55	147	109	75
March	52	38	36	54	87	142	116	95
April	59	40	28	68	110	155	128	105
May	48	48	41	67	119	175	131	87
June	72	33	48	84	170	190	141	83
July	67	43	40	67	181	188	162	113
August.......	66	31	40	80	185	151	158	103
September ...	41	40	43	102	169	148	140	113
October	50	37	35	91	176	133	105	118
November....	59	40	28	100	139	160	122	121
December	43	39	41	85	121	167	114	148
Total...	664	462	443	875	1,588	1,901	1,580	1,269

The following table presents the total number of rigs or derricks in course of construction at the close of each month in each district during 1898. The average for 1896 was 414; for 1897, 297; for 1898, 260:

Rigs building in the Appalachian oil field in 1898.

Month.	Bradford.	Allegany.	Middle.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January..............	17	11	21	23	28	88	9	197
February	16	15	20	22	35	95	8	211
March................	26	14	16	25	33	91	11	216
April................	21	15	19	23	30	77	10	195
May..................	19	14	17	26	29	96	14	215
June	27	12	12	36	33	98	9	227
July	20	9	16	41	33	126	17	262
August...............	36	14	15	26	36	118	10	255
September...........	44	22	18	46	33	130	12	305
October	36	20	17	55	45	104	20	297
November	34	25	23	53	44	150	25	354
December	39	20	19	49	54	148	63	392
Average........	28	16	18	35	36	110	17	260

The following table gives the rigs or derricks building, by districts, since 1891. A large decline in new work will be noticed since 1895:

Rigs building in the Appalachian oil field from 1891 to 1898, by districts.

District.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Bradford	18	1	3	16	47	52	45	28
Allegany	2	1	1	4	14	16	22	16
Middle	9	3	6	16	29	32	23	18
Venango and Clarion	33	10	18	37	95	67	36	35
Butler and Armstrong	38	20	22	49	93	69	40	36
Southwest	79	59	67	96	162	152	112	110
Macksburg	3	13	12	15	26	26	19	17
Total	182	107	129	233	466	414	297	260

In the following table will be found a statement of the number of rigs or derricks building in the Appalachian oil field, by months, from 1891 to 1898 inclusive:

Rigs building in the Appalachian oil field from 1891 to 1898, by months.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	233	110	108	166	270	441	320	197
February	195	132	107	180	353	450	322	211
March	218	111	132	187	380	449	332	216
April	186	100	159	233	457	458	362	195
May	208	108	144	237	599	439	322	215
June	234	89	135	238	564	436	312	227
July	182	96	116	245	576	379	287	262
August	188	74	114	292	490	360	272	255
September	131	98	91	254	486	378	244	305
October	156	108	110	269	464	389	301	297
November	142	130	143	248	472	419	273	354
December	112	122	193	248	476	365	216	392
Average	182	107	129	233	466	414	297	260

In the following statement will be found the number of wells drilling, by districts and months, for 1898, in the Appalachian field:

Wells in process of drilling in the Appalachian oil fields in 1898, by districts and months.

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	15	12	22	15	47	189	11	311
February	8	15	14	30	46	168	7	288
March	19	27	19	21	44	182	11	323
April	15	15	18	41	50	182	12	333
May	30	24	22	26	46	228	10	386
June	25	25	16	41	43	238	15	403
July	27	23	22	40	48	232	13	405
August	43	16	20	38	67	274	20	478
September	42	25	24	42	62	292	21	508
October	42	23	20	63	54	303	30	535
November	43	31	24	72	81	334	35	620
December	39	35	23	62	62	308	60	589
Average	29	23	20	41	54	244	20	431

In the following table will be found a statement of the wells in process of drilling, by districts, yearly since 1891, in the Appalachian field. The year 1895 shows the greatest number:

Number of wells in process of drilling in the Appalachian oil field from 1891 to 1898, by districts.

District.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Bradford	22	3	6	25	54	51	37	29
Allegany	8	2	2	7	24	27	26	23
Middle field	21	10	7	21	39	35	27	20
Venango and Clarion	34	7	16	40	93	80	46	41
Butler and Armstrong	71	44	40	95	162	112	66	54
Southwest	227	166	162	206	313	311	247	244
Macksburg	3	10	13	15	30	33	22	20
Total average	386	242	246	409	715	649	471	431

The following table gives the number of wells drilling, by months, from 1891 to 1898 inclusive, for comparison, over the entire Appalachian field:

Number of wells drilling in the Appalachian oil field from 1891 to 1898, and the average by months.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	407	264	188	269	418	701	514	311
February	410	273	214	282	440	621	433	288
March	401	251	206	330	467	667	462	323
April	387	230	269	345	635	757	477	333
May	380	233	291	410	824	727	521	386
June	407	258	305	430	941	682	571	403
July	420	204	266	498	902	640	546	405
August	406	244	248	484	866	625	463	478
September	397	236	233	489	819	556	464	508
October	386	246	219	469	794	590	415	535
November	351	228	277	451	760	627	401	620
December	286	238	233	456	716	595	384	589
Average.	386	242	246	409	715	649	471	431

The following table shows the wells completed, the initial production, dry holes, wells drilling, and the rigs building, by months, during 1898, in the Bradford, Allegany, Middle, Venango and Clarion, Butler and Armstrong, Southwest and Macksburg fields:

Well record in the Appalachian oil field in 1898.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	327	9,259	108	311	197
February	255	5,247	75	288	211
March	274	7,363	95	323	216
April	329	6,555	105	333	195
May	330	7,308	87	386	215
June	364	5,709	83	403	227
July	390	5,700	113	405	262
August	417	8,380	103	478	255
September	475	8,922	113	508	305
October	530	7,671	118	535	297
November	532	8,920	121	620	354
December	569	8,684	148	589	392
Total	4,792	*a* 7,476	1,269	*a* 431	*a* 260

a Average.

Tables under the head of Ohio give detailed information as to wells drilled and initial daily production in that portion of the Appalachian oil fields known as the Corning, Macksburg, Steubenville, and Marietta districts, and miscellaneous wells in southeastern or southern Ohio, grouped in the previous tables under the head of Macksburg. That portion of the Sistersville pool in southern Ohio is included under the head of the Southwest district.

The remaining portion of the Sistersville pool is in West Virginia and is also a part of the great Southwest district. Detailed information as to the number of wells drilled and initial daily production is given under the head of that State.

OHIO AND STATES OUTSIDE THE APPALACHIAN OIL FIELD.

OHIO.

This State has a part of two fields of petroleum. The Appalachian field extends along its southeastern border from Steubenville and Scio to Corning, this portion being known as the southern or southeastern Ohio field. The Mecca and Belden districts are outliers to the north of this field and produce a small amount of superior natural lubricating petroleum. The other field is known as the Lima field, located in the northwestern portion of the State. Ohio produces more petroleum than any other State.

There was, however, a heavy decline in Ohio's production of petroleum in 1898 as compared with the preceding year, but owing to a higher market the total value of the product for 1898 was greater by nearly a million dollars than that of 1897. In the eastern part of the State a new Berea grit pool was discovered near Scio, in Harrison County, toward the latter part of the year, which was destined to become a factor of considerable importance during 1899. There were seven completed wells in this pool at the close of the year and their productive capacity attracted the general attention of oil operators and encouraged the thorough exploration of that section of the State. On the last of December there were 43 rigs and drilling wells under way in what is known as the Scio pool. The initial well of the Scio pool was completed in August, 1898. It started at about 15 barrels a day from the Berea sand, but was considered of little importance, save merely from a local standpoint.

In the other districts of the southeastern part of the State producing Pennsylvania oil, the Wilson Run development in Washington County appeared most promising at the beginning of the year, but a number of dry holes proved very discouraging and it soon dropped to the rear.

The Jackson Ridge pool, a Keener sand development, in Monroe County, likewise assumed some prominence during the year, but it turned out to be very spotted territory and afforded very little profit to the investors.

The Archers Fork district, below Marietta, was the most active of any of the newer developments of 1898. One well on the Whittekind farm, from the Cow Run sand, started at 60 barrels an hour and for over a week, placed more than 1,000 barrels a day to its credit.

The greater part of the production in southeastern Ohio comes from the Keener and Big Injun sands followed by the Berea sand. There are a number of sands, which locally produce petroleum, extending from Scio to Marietta. In descending order, they are: First, Cow Run sand or Upper Mahoning; second, Cow Run sand or Lower Mahoning, Mendenhall sand, Salt sand, Keener sand, Big Injun sand, Squaw sand, and Berea sand. A little oil has been found in a lower sand opposite St. Mary, West Virginia, in Washington County, that corresponds with the Gordon sand.

Operations in the Lima oil or Trenton rock territory in the northwestern part of the State during 1898 embraced an enormous amount of work, but did not result in the discovery of any new productive areas of great importance. The Children's Home pool south of Lima was probably the most important of the year, but the drilling of nearly 60 wells only resulted in a production of about 600 barrels a day, which was the highest point attained. The Van Buren Township pool in Shelby County received quite a little extension, through a small strike that was made in April near Kettlerville. Another very creditable discovery of the year was in Jackson Township, Allen County, directly east of Lima. This locality was generally regarded as condemned years ago, but in August several wells of the hundred-barrel order were struck, and the new pool received a boom that was increased by other good strikes during the closing months of 1898.

In Wood and Hancock counties operators made a success of deepening many of the old wells and thereby adding considerably to their production. On the western dip of the Lima and Findlay arch a number of wells were drilled deep into the sand and an abundance of salt water was found. These wells were tubed with large tubing and put to pumping continuously. In some instances it required three weeks of continued pumping to exhaust the salt water, which was followed by the oil. Large and lasting wells were secured—the salt water generally diminishing and the oil increasing. In September, a well drilled in old territory on the Coons farm, in Henry Township, Wood County, surprised the trade by starting at 500 barrels a day.

Other noteworthy features of the year were the spots of new developments in the South Lima district, the North Findlay town-lot pool, and the Jackson, Shawnee, and Perry Township districts, in Allen County. Most of the test wells drilled outside of the Lima field proper resulted in failure. A few small wells were drilled in Wyandot, Ottawa, and Putnam counties, but they were so quickly followed with dry holes that it appears unlikely they will ever prove important factors in the production of petroleum.

The total crude petroleum produced in Ohio in 1898 was 18,738,708 barrels. Of this amount 16,590,416 barrels was of the Lima and 2,147,610 of the eastern Pennsylvania variety; the remaining 682 barrels consisted of the valuable and peculiar lubricating product of the Mecca and Belden districts.

The production decreased 2,821,807 barrels, or over 13 per cent from the preceding year. In 1897 the decrease in the Ohio production as compared with 1896 was 2,380,654 barrels, or nearly 10½ per cent. The production of Lima oil in this State was 18,682,677 barrels in 1897 and 20,575,138 barrels in 1896. The production of eastern oil in Ohio was 2,877,193 barrels in 1897 and 3,365,365 barrels in 1896. The average price of Lima oil advanced from 48 cents per barrel in 1897 to 61¾ cents in 1898, a gain of over 28 per cent. The increase in the total valuation of all the oil produced in Ohio in 1898 over 1897 was $972,212, or nearly 9 per cent. The number of wells completed in the Lima oil fields of Ohio was 2,394 in 1898, as compared with 2,486 in 1897, a decrease of 92, or nearly 4 per cent.

During 1898 a large number of natural-gas engines were installed for pumping wells in clusters, many of the oil wells furnishing enough gas to pump a number of other wells. The cheap reliable power furnished by these engines, and also the fact that they require no special attention, will ultimately prove a factor of great importance; because many wells that were too small to pay for pumping by the ordinary methods can be made to pay owing to the cheaper power furnished by the gas engine.

PRODUCTION.

The total amount and value of crude petroleum produced in Ohio in all fields in 1897 and 1898 are shown in the following table:

Total amount and value of crude petroleum produced in Ohio in 1897 and 1898.

District.	1897.			1898.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*		
Lima	18,682,677	$8,967,685	$0.48	16,590,416	$10,244,582	$0.61¾
Eastern	2,877,193	2,262,193	.78⅝	2,147,610	1,957,010	.91⅛
Mecca-Belden	645	3,120	4.84	682	3,618	5.30½
Total.	21,560,515	11,232,998	.52	18,738,708	12,205,210	.65

In the following table will be found the total production of all the crude petroleum in Ohio in 1898, by months, in the several fields. The production in the Mecca-Belden field, being very small, was not divided into monthly production.

Total production of crude petroleum in Ohio in 1898, by months and districts.

[Barrels of 42 gallons.]

Month.	Lima.	Southeastern Ohio.	Mecca-Belden.	Total.
January	1,408,076	179,371	....	1,587,504
February	1,251,149	165,313	....	1,416,519
March	1,409,400	182,591	....	1,592,048
April	1,326,696	179,779	....	1,506,532
May	1,366,758	181,666	....	1,548,481
June	1,336,812	176,993	....	1,513,862
July	1,352,640	163,448	....	1,516,145
August	1,472,428	181,555	....	1,654,040
September	1,399,457	175,779	....	1,575,293
October	1,446,838	180,001	....	1,626,896
November	1,397,247	180,615	....	1,577,918
December	1,422,915	200,499	....	1,623,470
Total	16,590,416	2,147,610	682	18,738,708

The total amount and value of crude petroleum produced in Ohio from 1889 to 1898, inclusive, by districts, are shown in the following table:

Total amount and value of crude petroleum produced in Ohio from 1889 to 1898.

Year.	Lima district.		Southeastern Ohio district.	
	Production.	Value.	Production.	Value.
	Barrels.		*Barrels.*	
1889	12,153,189	$1,822,978	317,037	$340,683
1890	15,014,882	4,504,465	1,108,334	1,127,730
1891	17,315,978	5,281,373	422,883	283,332
1892	15,169,507	5,555,832	1,190,302	662,106
1893	13,646,804	6,448,115	2,601,394	1,664,892
1894	13,607,844	6,531,765	3,183,370	2,670,052
1895	15,850,609	11,372,812	3,693,248	5,018,201
1896	20,575,138	13,723,617	3,365,365	3,966,924
1897	18,682,677	8,967,685	2,877,193	2,262,193
1898	16,590,416	10,244,582	2,147,610	1,957,010

Total amount and value of crude petroleum produced in Ohio from 1889 to 1898—Cont'd.

Year.	Mecca-Belden district.		Total.	
	Production.	Value.	Production.	Value.
	Barrels.		*Barrels.*	
1889	1,240	$10,334	12,471,466	$2,173,995
1890	1,440	12,000	16,124,656	5,644,195
1891	1,440	12,000	17,740,301	5,576,705
1892	3,112	21,101	16,362,921	6,239,039
1893	1,571	11,335	16,249,769	8,124,342
1894	940	4,476	16,792,154	9,206,293
1895	1,376	8,229	19,545,233	16,399,242
1896	666	2,897	23,941,169	17,693,438
1897	645	3,120	21,560,515	11,232,998
1898	682	3,618	18,738,708	12,205,210

In the following table is given the total production of crude petroleum in Ohio for the years 1888 to 1898, by months:

Total production of crude petroleum in Ohio from 1888 to 1898, by months.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1888	444,804	507,686	612,830	656,186	774,267
1889	1,041,655	944,506	1,016,278	1,029,780	1,115,703
1890	948,780	929,810	1,008,933	1,101,773	1,223,241
1891	1,561,039	1,396,474	1,484,045	1,500,142	1,475,339
1892	1,124,194	1,160,634	1,242,936	1,173,952	1,216,416
1893	1,227,363	1,195,698	1,399,648	1,289,982	1,384,090
1894	1,326,282	1,187,891	1,431,894	1,368,268	1,486,678
1895	1,286,468	1,123,784	1,387,882	1,480,228	1,572,718
1896	1,957,875	1,805,698	1,967,188	1,989,262	2,062,582
1897	1,828,136	1,747,124	1,905,148	1,825,884	1,857,766
1898	1,587,504	1,416,519	1,592,048	1,506,532	1,548,481

Year.	June.	July.	August.	September.
1888	889,066	939,287	1,022,009	1,005,422
1889	1,074,384	1,052,430	1,075,008	1,060,982
1890	1,274,209	1,472,974	1,544,291	1,700,227
1891	1,516,362	1,545,298	1,538,210	1,523,826
1892	1,266,712	1,370,135	1,572,657	1,574,336
1893	1,419,758	1,444,572	1,480,285	1,402,213
1894	1,439,144	1,398,304	1,487,528	1,369,409
1895	1,590,936	1,779,452	1,877,470	1,904,985
1896	2,101,507	2,117,849	2,059,532	1,994,503
1897	1,848,213	1,854,656	1,830,399	1,763,199
1898	1,513,862	1,516,145	1,654,040	1,575,293

Total production of crude petroleum in Ohio from 1888 to 1898, by months—Continued.

[Barrels of 42 gallons.]

Year.	October.	November.	December.	Total.
1888	1,064,688	1,017,362	1,077,261	10,010,868
1889	1,048,448	1,030,795	981,497	12,471,466
1890	1,798,413	1,608,883	1,513,122	16,124,656
1891	1,527,490	1,299,737	1,372,339	17,740,301
1892	1,586,173	1,517,198	1,557,578	16,362,921
1893	1,397,125	1,306,883	1,302,152	16,249,769
1894	1,469,457	1,424,926	1,402,373	16,792,154
1895	1,963,297	1,840,501	1,737,512	19,545,233
1896	2,041,301	1,863,720	1,980,152	23,941,169
1897	1,774,937	1,642,421	1,682,632	21,560,515
1898	1,626,896	1,577,918	1,623,470	18,738,708

The total production of Ohio in 1898 decreased 2,821,807 barrels, amounting to 13 per cent, as compared with 1897.

The following table gives the production of petroleum in Ohio from the beginning of operations in that State to the close of 1898:

Production of petroleum in Ohio.

Year.	Barrels.	Year.	Barrels.
Previous to 1876	200,000	1887	5,022,632
1876	31,763	1888	10,010,868
1877	29,888	1889	12,471,466
1878	38,179	1890	16,124,656
1879	29,112	1891	17,740,301
1880	38,940	1892	16,362,921
1881	33,867	1893	16,249,769
1882	39,761	1894	16,792,154
1883	47,632	1895	19,545,233
1884	90,181	1896	23,941,169
1885	661,580	1897	21,560,515
1886	1,782,970	1898	18,738,708

LIMA DISTRICT.

This district is the most important productive area yet discovered in Ohio. The product is characterized by the presence of sulphur compounds, which make it of less value for refining purposes than the eastern or Pennsylvania product.

The Lima district proper lies entirely in northwestern Ohio, covering portions of Wood, Hancock, Allen, Auglaize, Sandusky, Mercer, Van Wert, Seneca, Lucas, and Shelby counties. It produced over 88 per cent of all the oil produced in Ohio in 1898. The first well to produce oil was drilled at Findlay, Hancock County, in the fall of 1884. The Lima oil production comes entirely from the Trenton rock formation.

PRODUCTION.

The following table gives the production of this district, beginning with 1886 and ending in 1898:

Production of petroleum in the Lima (Ohio) district from 1886 to 1898.

Year.	Barrels.	Year.	Barrels.
1886	1,064,025	1893	13,646,804
1887	4,650,375	1894	13,607,844
1888	9,682,683	1895	15,850,609
1889	12,153,189	1896	20,575,138
1890	15,014,882	1897	18,682,677
1891	17,315,978	1898	16,590,416
1892	15,169,507		

In the following table is found the production of petroleum in the Lima (Ohio) field from 1887 to 1898, by months, so far as it has been obtainable:

Production of petroleum in the Lima (Ohio) field from 1887 to 1898.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	131,011	206,026	303,084	352,798	449,062
1888	422,125	479,824	586,781	629,932	745,896
1889	1,016,697	921,185	989,793	1,004,969	1,090,638
1890	911,947	888,978	955,620	1,040,924	1,142,954
1891	1,471,858	1,355,734	1,455,628	1,470,661	1,446,284
1892	1,090,173	1,127,481	1,200,305	1,128,253	1,165,750
1893	1,037,358	985,620	1,161,384	1,072,850	1,179,808
1894	1,116,979	974,091	1,177,837	1,099,452	1,203,229
1895	1,034,489	900,530	1,111,346	1,194,799	1,287,167
1896	1,635,925	1,523,866	1,673,595	1,697,848	1,775,858
1897	1,534,285	1,485,039	1,638,755	1,570,621	1,590,956
1898	1,408,076	1,251,149	1,409,400	1,326,696	1,366,758

Production of petroleum in the Lima (Ohio) field from 1887 to 1898—Continued.

[Barrels of 42 gallons.]

Year.	June.	July.	August.	September.
1887	474, 535	389, 997	490, 862	465, 743
1888	862, 106	905, 218	995, 938	979, 943
1889	1, 050, 269	1, 029, 707	1, 050, 152	1, 038, 072
1890	1, 175, 821	1, 354, 672	1, 411, 998	1, 559, 473
1891	1, 491, 228	1, 514, 607	1, 509, 262	1, 492, 115
1892	1, 210, 523	1, 300, 197	1, 461, 020	1, 422, 534
1893	1, 213, 521	1, 231, 010	1, 258, 289	1, 181, 493
1894	1, 165, 190	1, 131, 081	1, 212, 090	1, 090, 626
1895	1, 300, 058	1, 474, 115	1, 540, 149	1, 527, 085
1896	1, 822, 817	1, 843, 477	1, 789, 341	1, 739, 122
1897	1, 589, 063	1, 608, 730	1, 603, 336	1, 546, 131
1898	1, 336, 812	1, 352, 640	1, 472, 428	1, 399, 457
Year.	**October.**	**November.**	**December.**	**Total.**
1887	444, 941	458, 612	483, 704	4, 650, 375
1888	1, 036, 712	988, 997	1, 049, 211	9, 682, 683
1889	1, 019, 961	997, 825	943, 921	12, 153, 189
1890	1, 660, 069	1, 495, 099	1, 417, 327	15, 014, 882
1891	1, 499, 834	1, 271, 189	1, 337, 578	17, 315, 978
1892	1, 379, 909	1, 328, 548	1, 354, 814	15, 169, 507
1893	1, 154, 641	1, 084, 324	1, 086, 506	13, 646, 804
1894	1, 165, 938	1, 146, 686	1, 124, 644	13, 607, 844
1895	1, 579, 693	1, 494, 985	1, 406, 193	15, 850, 609
1896	1, 770, 493	1, 612, 298	1, 690, 498	20, 575, 138
1897	1, 571, 760	1, 458, 688	1, 485, 313	18, 682, 677
1898	1, 446, 838	1, 397, 247	1, 422, 915	16, 590, 416

WELL RECORDS IN LIMA DISTRICT.

The table below shows the wells completed each month during the year 1898 in the Lima (Ohio) district.

Total number of wells completed in the Lima (Ohio) district in 1898.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Lucas.	Mercer.
January	7	15	23	7	43	18	7
February	12	11	9	1	36	9	5
March	10	16	10	8	26	8	5
April	16	13	10	12	33	14	8
May	16	14	19	9	24	10	5
June	19	15	21	19	50	12	9
July	18	28	23	21	79	13	10
August	26	34	26	36	117	21	11
September	34	28	29	31	116	21	7
October	39	27	38	37	114	16	10
November	41	29	43	51	105	16	9
December	41	9	50	37	94	24	4
Total	279	239	301	269	837	182	90

Month.	Shelby.	Seneca.	Ottawa.	Van Wert.	Miscellaneous.	Total.
January	5	1	2	0	1	129
February	4	0	1	0	0	88
March	3	0	1	1	1	89
April	8	1	1	0	2	118
May	9	2	1	3	2	114
June	12	3	1	0	1	162
July	4	7	0	1	2	206
August	8	12	2	1	3	297
September	4	8	4	2	1	285
October	6	11	1	0	3	302
November	11	10	2	1	1	319
December	10	12	2	0	2	285
Total	84	67	18	9	19	2,394

In the following table it will be observed that the average of the initial daily production of the new wells completed in 1898 was 4,097 barrels per month. This amount multiplied by 12 will give 49,165 as the total initial production. This divided by 2,124, the number of productive wells completed in 1898, gives 23 as the average number of barrels of initial daily production for each paying well drilled in 1898, as compared with 27 barrels in 1897, 21.7 in 1896, and 23 in 1895. The average for 1895 and 1898 is exactly the same. The falling off in initial production reveals the fact that the best of Ohio's oil territory in the northwest has been pretty thoroughly drilled over.

Initial daily production of wells completed in the Lima (Ohio) district in 1898.

[Barrels of 42 gallons.]

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Lucas.	Mercer.
January	55	320	310	75	955	660	200
February	200	215	145	20	745	420	175
March	160	350	120	130	630	365	60
April	320	175	185	110	625	585	180
May	400	320	685	120	635	500	75
June	205	420	285	300	1, 155	335	115
July	350	620	310	375	1, 805	450	165
August	475	575	480	795	2, 850	555	95
September	605	475	730	505	2, 425	710	110
October	1, 295	335	610	630	2, 240	450	130
November	645	385	905	780	2, 095	425	100
December	845	155	675	445	1, 485	475	60
Average	463	362	453	357	1, 471	494	121

Month.	Shelby.	Seneca.	Ottawa.	Van Wert.	Miscellaneous.	Total.
January	125	60	5	0	0	2, 765
February	185	0	0	0	0	2, 105
March	235	0	20	10	5	2, 085
April	345	5	5	0	5	2, 540
May	360	45	30	35	0	3, 205
June	355	35	40	0	5	3, 250
July	80	100	0	15	10	4, 280
August	130	145	25	5	65	6, 195
September	120	120	70	20	10	5, 900
October	190	90	5	0	10	5, 985
November	510	80	80	20	0	6, 025
December	405	210	65	0	10	4, 830
Average	254	74	29	9	10	4, 097

The following table shows that 270 dry holes were completed in 1898 as compared with 384 in 1897 and 550 in 1896. This leaves 2,124 productive wells completed in 1898 as compared with 2,102 in 1897 and 3,908 in 1896. This is an increase of only 22 in number of productive wells completed in 1898. With 2,124 new wells added to the producing list there was still a decline of 2,821,807 barrels in the aggregate yield of Lima petroleum in Ohio during 1898.

Total number of dry holes drilled in the Lima (Ohio) district in 1898.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Lucas.	Mercer.
January	2	3	6	0	6	1	0
February	3	4	1	0	8	1	0
March	2	1	3	0	3	1	0
April	4	3	1	2	5	1	0
May	1	3	1	1	3	0	0
June	3	1	1	0	5	2	2
July	1	5	5	0	7	1	0
August	5	7	2	3	14	2	2
September	4	6	4	0	10	0	2
October	3	4	5	0	8	3	1
November	9	6	4	0	12	1	2
December	6	1	5	3	10	1	1
Total	43	44	38	9	91	14	10

Month.	Shelby.	Seneca.	Ottawa.	Van Wert.	Miscellaneous.	Total.
January	1	0	1	0	1	21
February	0	0	1	0	0	18
March	0	0	0	0	0	10
April	1	0	0	0	1	18
May	1	0	0	1	2	13
June	0	0	0	0	2	16
July	1	0	0	0	1	21
August	2	0	0	0	0	37
September	0	1	0	0	0	27
October	0	0	0	0	1	25
November	0	0	0	0	1	35
December	1	0	0	0	1	29
Total	7	1	2	1	10	270

From the following tables it will be observed that new operations in the Lima (Ohio) field were largely increased during the closing months of the year. There were 124 rigs and 278 drilling wells under way in the Lima (Ohio) oil fields on December 31, 1898, as compared with 82 rigs and 128 drilling wells on December 31, 1897. The average of new rigs built was 109 per month in 1898, 90 in 1897, and 159 per month in 1896.

Total number of rigs or derricks building in the Lima (Ohio) district in 1898.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Lucas.	Mercer.
January	3	11	6	17	30	7	2
February	3	6	4	16	20	7	2
March	2	7	4	18	30	7	5
April	0	1	9	16	34	5	3
May	5	10	8	15	41	5	6
June	11	16	8	16	57	3	7
July	5	7	11	17	62	7	2
August	10	7	9	22	49	6	0
September	12	8	21	20	51	9	5
October	12	13	21	20	65	10	1
November	24	8	27	18	62	15	2
December	18	7	16	14	51	11	1
Average	9	8	12	17	46	8	3

Month.	Shelby.	Seneca.	Ottawa.	Van Wert.	Miscellaneous.	Total.
January	1	0	1	3	0	81
February	0	0	1	3	0	62
March	1	1	1	3	0	79
April	2	0	0	4	1	75
May	2	0	0	3	1	96
June	0	1	0	3	0	122
July	2	3	0	3	1	120
August	0	2	1	2	0	108
September	1	3	0	1	0	131
October	1	0	1	1	1	146
November	4	1	0	3	5	169
December	0	3	2	1	0	124
Average	1	1	1	2	1	109

The following table shows 278 wells drilling at the close of December, 1898, as compared with 128 in 1897. Although so nearly equal for the average per month, more than double the number were drilling in the latter half of 1898 than there was in the first half.

Total number of wells drilling in the Lima (Ohio) district in 1898.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Lucas.	Mercer.
January	9	11	14	1	34	12	6
February	11	11	16	3	22	8	4
March	11	8	17	4	28	11	6
April	12	4	19	8	29	11	4
May	13	6	20	8	27	10	6
June	16	19	23	14	68	12	9
July	16	21	25	17	91	14	12
August	30	23	25	16	90	17	9
September	24	23	33	24	75	15	10
October	31	13	41	31	101	10	6
November	45	16	45	27	108	22	5
December	44	19	49	24	103	16	5
Average	22	14	27	15	65	13	7

Month.	Shelby.	Seneca.	Ottawa.	Van Wert.	Miscellaneous.	Total.
January	4	0	1	0	2	94
February	3	0	1	0	2	81
March	5	1	0	0	3	94
April	7	1	0	1	2	98
May	5	3	0	0	1	99
June	3	6	1	1	2	174
July	5	4	3	1	1	210
August	6	5	2	1	0	224
September	4	8	1	0	0	217
October	5	6	2	0	0	246
November	8	7	2	1	2	288
December	7	5	2	1	3	278
Average	5	4	1	0	2	175

The increase in the wells drilling in the above table, and the increase in the rigs or derricks building in a previous table, show a large gain in operations in the latter half of the year. This is due to the increase in price, the average price being about 43 cents per barrel in January, 1898, 64 cents in July, and 62 cents in December.

Number of wells completed in the Lima (Ohio) district from 1890 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890..	44	62	.....	.....	147	165	224	271	307	319	243	187	1,969
1891..	142	123	129	156	116	143	144	138	157	134	104	88	1,574
1892..	67	82	93	93	93	121	134	166	171	174	147	105	1,446
1893..	100	85	163	135	128	160	152	133	131	120	132	130	1,569
1894..	130	175	179	205	248	230	233	219	204	226	214	209	2,472
1895..	200	158	244	316	412	461	484	519	462	427	470	336	4,489
1896..	328	355	370	432	504	513	396	337	346	279	299	299	4,458
1897..	252	193	210	215	226	211	242	193	216	196	191	141	2,486
1898..	129	88	89	118	114	162	206	297	285	302	319	285	2,394

Initial daily production of new wells in the Lima (Ohio) district from 1890 to 1898, by months.

[Barrels of 42 gallons.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1890	....	....	....	....	....	....	....
1891	5,858	5,474	4,428	6,543	4,411	6,667	8,461
1892	2,853	4,485	3,973	4,665	4,750	8,314	11,648
1893	5,510	4,809	6,241	5,477	6,858	9,701	9,588
1894	3,853	4,211	4,486	5,586	7,291	6,391	5,637
1895	4,432	3,753	5,281	6,208	8,161	9,772	9,011
1896	5,651	6,704	7,885	9,335	9,902	9,670	6,885
1897	4,710	3,600	4,820	4,040	4,175	4,525	5,855
1898	2,765	2,105	2,085	2,540	3,205	3,250	4,280

Year.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1890	18,944	16,309	17,426	13,779	8,424	14,976
1891	8,427	7,855	8,033	5,592	2,989	6,228
1892	14,631	12,908	13,772	7,554	4,907	7,872
1893	5,124	6,752	4,223	4,205	3,275	5,980
1894	5,642	5,020	5,991	10,464	5,539	5,843
1895	10,025	9,175	8,586	9,695	6,284	7,532
1896	6,175	5,640	5,355	5,630	6,171	7,084
1897	6,740	6,283	5,955	4,145	2,975	4,818
1898	6,195	5,900	5,985	6,025	4,830	4,097

Total number of dry holes drilled in the Lima (Ohio) district from 1890 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890..	3	2	.....	.....	4	11	10	23	30	32	37	41	193
1891..	28	27	23	28	14	18	22	14	26	20	17	13	250
1892..	9	9	8	13	10	18	16	18	27	22	18	15	183
1893..	12	15	20	24	18	19	18	12	14	16	13	22	203
1894..	17	41	37	27	32	41	30	34	35	27	28	35	384
1895..	33	19	38	33	66	65	70	48	59	48	49	36	564
1896..	43	44	57	39	55	63	47	35	52	26	42	47	550
1897..	28	28	30	32	31	25	36	26	33	39	43	33	384
1898..	21	18	10	18	13	16	21	37	27	25	35	29	270

Number of wells drilling in the Lima (Ohio) district, at the close of each month, from 1890 to 1898.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1890..	47	59	.....	.....	135	188	237	182	238	294	148	111	164
1891..	90	105	94	82	79	90	90	93	85	88	67	53	85
1892..	61	78	76	51	64	95	101	112	120	114	106	81	88
1893..	72	78	88	92	117	119	103	101	89	102	118	114	99
1894..	120	113	127	138	127	139	117	138	136	136	138	140	131
1895..	132	176	214	269	302	369	397	413	404	435	306	331	312
1896..	327	317	338	368	371	293	282	251	251	240	243	249	294
1897..	217	221	200	187	148	189	160	184	168	178	141	128	177
1898..	94	81	94	98	99	174	210	224	217	246	288	278	175

Wells completed in the Lima (Ohio) district from 1890 to 1898.

Year.	Number.	Dry.	Total productive.
1890	1,969	193	1,776
1891	1,574	250	1,324
1892	1,446	183	1,263
1893	1,569	203	1,356
1894	2,472	384	2,088
1895	4,489	564	3,925
1896	4,458	550	3,908
1897	2,486	384	2,102
1898	2,394	270	2,124

Rigs building in the Lima (Ohio) district from 1890 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1890..	56	69	.....	.....	173	239	248	212	210	194	149	109	166
1891..	120	137	155	117	115	123	137	120	117	106	91	99	120
1892..	95	115	106	112	113	104	128	126	121	112	112	49	108
1893..	62	70	63	58	90	72	52	52	61	76	66	69	66
1894..	60	83	90	88	85	76	68	95	86	92	112	110	87
1895..	114	171	208	245	305	339	317	282	294	264	194	195	244
1896..	205	216	231	201	206	147	130	106	114	120	138	91	159
1897..	94	108	102	97	100	94	76	79	71	85	88	82	90
1898..	81	62	79	75	96	122	120	108	131	146	169	124	109

The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in the Lima (Ohio) district in 1898:

Well record in the Lima (Ohio) district in 1898.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	129	2,765	21	94	81
February	88	2,105	18	81	62
March	89	2,085	10	94	79
April	118	2,540	18	98	75
May	114	3,205	13	99	96
June	162	3,250	16	174	122
July	206	4,280	21	210	120
August	297	6,195	37	224	108
September	285	5,900	27	217	131
October	302	5,985	25	246	146
November	319	6,025	35	288	169
December	285	4,830	29	278	124
Total	2,394	*a* 4,097	270	*a* 175	*a* 109

a Average.

PIPE-LINE RUNS IN THE LIMA-INDIANA FIELD.

The term Lima-Indiana field is used to include all of the petroleum produced in the Lima (Ohio) and the Indiana fields, which embraces all of the Trenton limestone production. In the following table of pipe-line runs it is not possible to separate the petroleum carried out of Ohio from that carried out of Indiana, and therefore the runs and shipments from these States are combined. As has been before mentioned in this report, pipe-line runs are not production. This is especially true of the Lima-Indiana field. The production by States is quite accurately given under that head.

Pipe-line runs, Lima-Indiana field, from 1887 to 1898.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	164, 474	207, 026	303, 084	352, 798	449, 062
1888	359, 860	428, 008	534, 588	587, 043	705, 045
1889	973, 980	800, 828	830, 559	845, 377	932, 067
1890	683, 750	622, 799	676, 175	842, 416	887, 590
1891	1, 241, 154	1, 147, 947	1, 255, 611	1, 202, 583	1, 191, 147
1892	971, 607	1, 008, 069	1, 083, 801	1, 042, 087	1, 064, 478
1893	1, 049, 778	974, 944	1, 163, 641	1, 074, 290	1, 187, 939
1894	1, 265, 267	1, 106, 493	1, 353, 591	1, 295, 619	1, 424, 182
1895	1, 213, 841	1, 029, 385	1, 291, 355	1, 405, 424	1, 540, 972
1896	1, 739, 291	1, 631, 939	1, 795, 745	1, 859, 882	1, 945, 979
1897	1, 547, 658	1, 589, 905	1, 733, 521	1, 647, 997	1, 685, 011
1898	1, 457, 122	1, 275, 150	1, 476, 996	1, 387, 212	1, 406, 450

Year.	June.	July.	August.	September.	October.
1887	474, 535	389, 997	490, 162	465, 743	444, 941
1888	774, 710	896, 034	975, 235	868, 826	939, 468
1889	843, 844	805, 744	968, 449	875, 201	850, 077
1890	916, 289	1, 105, 885	1, 149, 877	1, 289, 577	1, 342, 158
1891	1, 207, 884	1, 236, 291	1, 240, 841	1, 252, 375	1, 257, 986
1892	1, 099, 145	1, 190, 015	1, 346, 949	1, 232, 385	1, 264, 536
1893	1, 245, 880	1, 289, 991	1, 390, 894	1, 315, 933	1, 302, 295
1894	1, 402, 417	1, 366, 310	1, 469, 372	1, 325, 352	1, 405, 042
1895	1, 541, 221	1, 713, 937	1, 752, 150	1, 778, 653	1, 822, 002
1896	2, 026, 387	2, 016, 564	1, 953, 876	1, 883, 814	1, 896, 033
1897	1, 689, 456	1, 702, 339	1, 668, 287	1, 618, 488	1, 649, 170
1898	1, 394, 877	1, 397, 520	1, 528, 979	1, 452, 312	1, 464, 780

Year.	November.	December.	Total.	Average.
1887	458, 613	483, 704	4, 684, 139	390, 345
1888	891, 999	938, 188	8, 899, 004	741, 584
1889	774, 073	755, 553	10, 255, 752	854, 646
1890	1, 215, 960	1, 186, 434	11, 918, 910	993, 243
1891	1, 070, 131	1, 211, 820	14, 515, 770	1, 209, 648
1892	1, 209, 953	1, 244, 712	13, 657, 737	1, 138, 145
1893	1, 230, 658	1, 224, 952	14, 451, 195	1, 204, 266
1894	1, 334, 334	1, 326, 371	16, 074, 350	1, 339, 529
1895	1, 705, 506	1, 621, 184	18, 415, 630	1, 534, 636
1896	1, 681, 715	1, 778, 786	22, 210, 011	1, 850, 834
1897	1, 566, 921	1, 571, 761	19, 670, 514	1, 639, 210
1898	1, 415, 198	1, 472, 301	17, 128, 897	1, 427, 408

SHIPMENTS OF PETROLEUM FROM THE LIMA-INDIANA FIELD.

Shipments represent the demand on the pipe lines, and are generally regarded as indicative of actual consumption. The following tables contain the shipments of the Buckeye pipe lines from the Lima-Indiana districts from 1887 to 1898, inclusive. The shipments for 1898 were the greatest on record, and were 7,323,523 barrels in excess of the runs. The pipe line stocks suffered a decrease of 7,581,887 barrels. During 1897 the runs and shipments were very close together and the stocks were increased 365,871 barrels.

Shipments of crude petroleum from the Lima-Indiana field from 1887 to 1898.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	....	10, 957	32, 613	77, 900	101, 306
1888	81, 569	207, 040	243, 964	210, 725	159, 620
1889	367, 524	862, 807	391, 026	340, 889	309, 238
1890	156, 085	111, 604	123, 125	115, 223	169, 662
1891	968, 887	837, 928	330, 448	336, 854	1, 078, 489
1892	1, 355, 362	1, 346, 541	1, 532, 606	1, 512, 358	1, 427, 753
1893	1, 306, 612	1, 270, 595	1, 390, 646	1, 205, 748	1, 321, 782
1894	1, 199, 752	1, 109, 110	1, 247, 295	1, 210, 391	1, 150, 298
1895	1, 473, 730	1, 289, 686	1, 409, 761	1, 206, 172	1, 212, 061
1896	1, 802, 361	1, 593, 328	1, 618, 117	1, 546, 888	1, 574, 627
1897	1, 672, 838	1, 795, 876	1, 724, 306	1, 585, 187	1, 762, 085
1898	1, 889, 062	1, 944, 249	2, 203, 051	2, 058, 630	2, 015, 854

Year.	June.	July.	August.	September.	October.
1887	104, 440	174, 824	20, 0[illegible]9	30, 944	43, 168
1888	179, 192	227, 707	401, 175	301, 316	370, 378
1889	352, 886	361, 694	464, 325	626, 207	715, 386
1890	700, 422	874, 121	846, 360	813, 817	723, 725
1891	923, 605	997, 681	1, 166, 054	1, 260, 598	1, 408, 343
1892	1, 492, 543	1, 389, 501	1, 342, 949	1, 125, 335	1, 315, 994
1893	1, 235, 843	1, 152, 374	1, 040, 860	1, 038, 819	1, 196, 018
1894	1, 303, 957	1, 023, 316	1, 238, 183	1, 023, 232	1, 198, 801
1895	1, 279, 618	1, 302, 596	1, 298, 502	1, 452, 640	1, 507, 992
1896	1, 667, 914	1, 617, 519	1, 745, 657	1, 702, 721	1, 704, 065
1897	1, 750, 613	1, 841, 908	1, 478, 129	1, 655, 593	1, 591, 449
1898	1, 975, 584	1, 967, 098	2, 223, 759	2, 032, 483	2, 186, 912

Shipments of crude petroleum from the Lima-Indiana field from 1887 to 1898—Continued.

[Barrels of 42 gallons.]

Year.	November.	December.	Total.	Average.
1887	78, 827	76, 327	751, 325	68, 302
1888	287, 934	382, 448	3, 053, 068	254, 422
1889	759, 702	750, 244	5, 801, 928	483, 494
1890	657, 614	907, 548	6, 199, 306	516, 609
1891	1, 391, 400	1, 454, 578	12, 154, 865	1, 012, 905
1892	1, 323, 204	1, 340, 734	16, 504, 880	1, 375, 407
1893	1, 262, 130	1, 230, 216	14, 651, 643	1, 220, 970
1894	1, 285, 861	1, 463, 566	14, 453, 762	1, 204, 480
1895	1, 587, 449	1, 810, 159	16, 830, 366	1, 402, 531
1896	1, 720, 720	1, 727, 549	20, 021, 466	1, 668, 156
1897	1, 353, 321	1, 881, 121	20, 092, 426	1, 674, 369
1898	2, 054, 504	1, 851, 234	24, 452, 420	2, 033, 535

STOCKS OF CRUDE PETROLEUM IN LIMA-INDIANA FIELD.

The following tables represent stocks in iron tanks of the Lima-Indiana fields held by the Buckeye Pipe Line Company at the close of each month from 1887 to 1898. The enormous reduction of stocks during 1898 amounted to over seven and a half million barrels, or nearly one-third of the amount on hand at the beginning of the year. The total net stocks of Lima oil at the close of 1898 were 15,180,892 barrels, as compared with 22,762,779 barrels at the close of 1897. On December 31, 1898, the stock in the eastern oil fields amounted to 11,541,753 barrels, making a total of 26,722,465 barrels of crude oil in iron tanks, as against 33,949,683 barrels on December 31, 1897. The decrease in stocks in the Lima-Indiana field was 7,581,887 barrels, while the increase in the eastern oil stocks was 752,101, making a net decline for the year in both fields of 6,829,786 barrels. There was an increase of stocks in both fields of 1,630,193 barrels during 1897.

Total stocks of crude petroleum in the Lima-Indiana field, at the close of each month, from 1887 to 1898.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	....	847,817	1,118,288	1,393,186	1,740,942
1888	4,367,355	4,588,323	4,949,446	5,367,401	5,980,283
1889	10,415,880	10,852,202	11,288,793	11,792,707	12,413,137
1890	14,104,018	14,180,090	14,241,340	14,153,259	14,298,966
1891	21,233,645	21,537,789	21,957,948	22,319,191	22,424,364
1892	21,692,318	21,350,912	20,896,185	20,425,914	20,062,639
1893	18,355,492	18,059,846	17,877,265	17,747,249	17,616,527
1894	18,565,823	18,566,158	18,675,275	18,763,242	19,041,624
1895	19,898,378	19,642,870	19,524,463	19,723,715	20,052,627
1896	21,431,778	21,473,447	21,651,075	21,964,069	22,335,420
1897	23,174,324	22,968,353	22,977,567	23,040,378	22,963,304
1898	22,280,840	21,611,740	20,885,685	20,215,331	19,605,927

Year.	June.	July.	August.	September.
1887	2,111,037	2,326,211	2,632,828	2,957,900
1888	6,593,165	7,282,088	7,852,705	8,392,493
1889	12,902,628	13,344,795	13,846,765	14,092,706
1890	14,513,553	14,744,004	19,086,736	19,843,950
1891	22,704,034	22,930,048	22,993,496	22,975,470
1892	19,668,894	19,467,900	19,505,399	19,150,058
1893	17,642,117	17,779,733	18,129,767	18,408,814
1894	19,142,598	19,504,651	19,736,628	20,040,748
1895	20,314,230	20,725,571	21,179,219	21,351,757
1896	22,693,894	23,094,851	23,304,312	23,091,525
1897	22,902,147	22,762,578	22,952,736	22,840,818
1898	19,025,220	18,455,642	17,690,914	17,021,263

Year.	October.	November.	December.	Average.
1887	3,359,674	3,739,459	4,148,469	2,397,801
1888	8,920,086	9,499,482	9,810,714	6,966,962
1889	14,224,747	14,554,662	14,105,149	12,819,514
1890	20,442,065	20,967,258	20,971,395	16,795,553
1891	22,722,465	22,375,030	22,103,705	22,456,438
1892	18,800,715	18,687,464	18,604,442	19,859,403
1893	18,527,901	18,499,669	18,497,340	18,095,143
1894	20,246,989	20,295,461	20,158,266	19,394,788
1895	21,565,766	21,683,823	21,494,848	20,596,439
1896	23,290,538	23,251,533	23,302,770	22,573,768
1897	22,858,539	23,072,139	22,762,779	22,939,639
1898	16,299,131	15,559,825	15,180,892	18,652,701

PRICES OF CRUDE PETROLEUM IN THE LIMA-INDIANA FIELD.

In the following table are given the average monthly prices of Lima (Ohio) and Indiana crude petroleum, per barrel of 42 gallons each, in the year 1898:

Average monthly prices of Ohio and Indiana crude petroleum, per barrel of 42 gallons, in 1898.

Month.	North Lima.	South Lima.	Indiana.
	Cents.	*Cents.*	*Cents.*
January	46	41	41
February	$47\frac{1}{4}$	$42\frac{1}{4}$	$42\frac{1}{4}$
March	$57\frac{3}{8}$	$52\frac{3}{8}$	$52\frac{3}{8}$
April	$54\frac{3}{4}$	$49\frac{3}{4}$	$49\frac{3}{4}$
May	$59\frac{1}{8}$	$54\frac{1}{8}$	$54\frac{1}{8}$
June	$62\frac{1}{8}$	$57\frac{1}{8}$	$57\frac{1}{8}$
July	$67\frac{5}{8}$	$62\frac{5}{8}$	$62\frac{5}{8}$
August	$70\frac{5}{8}$	$65\frac{5}{8}$	$65\frac{5}{8}$
September	73	68	68
October	$76\frac{1}{4}$	$71\frac{1}{4}$	$71\frac{1}{4}$
November	$77\frac{1}{2}$	$72\frac{1}{2}$	$72\frac{1}{2}$
December	$78\frac{3}{4}$	$73\frac{3}{4}$	$73\frac{3}{4}$
Average	$64\frac{1}{4}$	$59\frac{1}{4}$	$59\frac{1}{4}$
Average of North and South Lima	$61\frac{3}{4}$		....

In the following table are given the fluctuations in prices for the various grades of Lima oil in 1898. The dates are those on which changes in prices were made.

Fluctuation in prices of Lima (Ohio) and Indiana crude petroleum in 1898.

Date.	North Lima.	South Lima.	Indiana.
January 1	$0.46	$0.41	$0.41
February 16	.47	.42	.42
February 23	.48	.43	.43
February 25	.49	.44	.44
February 26	.50	.45	.45
February 28	.56	.51	.51
March 1	.60	.55	.55
March 8	.59	.54	.54
March 9	.57	.52	.52
March 17	.56	.51	.51
April 2	.55	.50	.50
April 22	.54	.49	.49
May 5	.56	.51	.51
May 6	.58	.53	.53
May 7	.60	.55	.55
May 11	.59	.54	.54
May 19	.60	.55	.55
May 20	.61	.56	.56
June 22	.62	.57	.57
June 24	.64	.59	.59
June 27	.65	.60	.60
June 28	.67	.62	.62
July 11	.68	.63	.63
July 20	.67	.62	.62
July 22	.66	.61	.61
July 25	.67	.62	.62
July 26	.68	.63	.63
July 27	.69	.64	.64
August 15	.70	.65	.65
August 18	.71	.66	.66
August 22	.73	.68	.68
October 4	.74	.69	.69
October 7	.75	.70	.70
October 13	.76	.71	.71
October 17	.77	.72	.72
October 20	.78	.73	.73
November 15	.77	.72	.72
December 9	.78	.73	.73
December 19	.79	.74	.74
December 23	.80	.75	.75

In the following tables will be found the highest, lowest, and average prices of Lima oil for the past twelve years:

Highest, lowest, and average prices of Lima (Ohio) crude petroleum in each year from 1887 to 1898, inclusive.

Year.	Highest.	Lowest.	Average.
1887	$0.15	$0.15	$0.15
1888	.15	.15	.15
1889	.15	.15	.15
1890	.37½	.15	.30
1891	.35	.30	.30½
1892	.37½	.35	.36⅝
1893	*a* .49	*b* .40	.47¼
1894	*a* .55	*b* .47½	.48
1895	*a* 1.27	*b* .50	.71¾
1896	*a* .90	*b* .52	.66¾
1897	*a* .60	*b* .41	.48
1898	*a* .80	*b* .41	.61¾

a North Lima. *b* South Lima.

EASTERN OR SOUTHEASTERN OHIO DISTRICT.

The production of this district includes all of that part of the Appalachian oil field in Ohio, the principal subdivisions of which are known as the Macksburg, Corning, Steubenville, Marietta, Scio, Sistersville, Newcastle, and the Barnesville pools.

The other States that make up the Appalachian field have been discussed under the head of that field.

PRODUCTION.

The production of the southeastern Ohio district for the last fourteen years is given in the following table:

Production of petroleum in the southeastern Ohio district from 1885 to 1898.

Year.	Barrels.	Year.	Barrels.
1885	661,580	1892	1,190,302
1886	703,945	1893	2,601,394
1887	372,257	1894	3,183,370
1888	297,774	1895	3,693,248
1889	317,037	1896	3,365,365
1890	1,108,334	1897	2,877,193
1891	422,883	1898	2,147,610

The highest production of this section of Ohio was in 1895. There was a decrease of 729,583 barrels for 1898 as compared with 1897, and of 488,172 barrels for 1897 as compared with 1896.

In the years prior to 1891 most of the petroleum was produced in the old Macksburg field.

The following table shows the total production of crude petroleum in Southeastern Ohio, by months, beginning with the year 1888 and ending 1898:

Total production of crude petroleum in the Southeastern Ohio district from 1888 to 1898, by months.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.
1888.....	20, 144	25, 327	23, 515	23, 720	25, 837	24, 426	31, 535
1889.....	24, 855	23, 218	26, 382	24, 708	24, 961	24, 011	22, 619
1890.....	36, 713	40, 712	53, 193	60, 729	80, 167	98, 268	118, 182
1891.....	89, 061	40, 620	28, 297	29, 361	28, 935	25, 014	30, 571
1892.....	33, 762	32, 894	42, 371	45, 439	50, 407	55, 930	69, 678
1893.....	189, 874	209, 948	238, 133	217, 001	204, 151	206, 106	213, 431
1894.....	209, 225	213, 721	253, 979	268, 736	283, 371	273, 876	267, 144
1895.....	251, 865	223, 140	276, 422	285, 314	285, 436	290, 763	305, 222
1896.....	321, 895	281, 776	293, 538	291, 358	286, 669	278, 634	274, 317
1897.....	293, 801	262, 035	266, 343	255, 213	266, 760	259, 100	245, 876
1898.....	179, 371	165, 313	182, 591	179, 779	181, 666	176, 993	163, 448

Year.	August.	September.	October.	November.	December.	Total.
1888.....	23, 537	22, 945	25, 442	25, 831	25, 515	297, 774
1889.....	24, 752	22, 807	28, 384	32, 867	37, 473	317, 037
1890.....	132, 173	140, 634	138, 224	113, 664	95, 675	1, 108, 334
1891.....	28, 828	31, 591	27, 536	28, 428	34, 641	422, 883
1892.....	111, 377	151, 543	206, 005	188, 391	202, 505	1, 190, 302
1893.....	221, 865	220, 589	242, 353	222, 428	215, 515	2, 601, 394
1894.....	275, 360	278, 704	303, 441	278, 162	277, 651	3, 183, 370
1895.....	337, 206	377, 785	383, 489	345, 402	331, 204	3, 693, 248
1896.....	270, 135	255, 326	270, 752	251, 367	289, 598	3, 365, 365
1897.....	227, 013	217, 018	203, 127	183, 683	197, 224	2, 877, 193
1898.....	181, 555	175, 779	180, 001	180, 615	200, 499	2, 147, 610

PIPE-LINE RUNS IN THE SOUTHEASTERN OHIO DISTRICT.

In the following tables the pipe-line runs and the shipments from the Macksburg or Southeastern Ohio district are given from 1885 to 1898:

Pipe-line runs in the Southeastern Ohio district from 1885 to 1898.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.
1885..	11, 894	20, 626	27, 066	40, 527	58, 258	64, 982	75, 737
1886..	54, 806	46, 694	58, 795	64, 137	58, 596	65, 379	56, 966
1887..	37, 134	28, 514	33, 995	29, 796	30, 601	29, 586	22, 413
1888..	16, 257	18, 861	17, 283	21, 187	21, 349	21, 511	21, 785
1889..	18, 174	16, 239	19, 676	20, 144	20, 283	18, 536	16, 705
1890..	29, 872	34, 022	45, 362	53, 905	72, 158	90, 827	111, 584
1891..	86, 058	45, 618	23, 055	25, 070	24, 263	21, 689	24, 858
1892..	24, 801	27, 620	39, 010	40, 424	43, 569	50, 007	64, 107
1893..	183, 781	211, 658	235, 177	211, 102	199, 929	146, 626	148, 622
1894..	138, 172	121, 627	150, 095	190, 677	239, 912	228, 267	221, 999
1895..	94, 999	181, 155	220, 883	229, 159	225, 816	227, 643	251, 003
1896..	321, 468	272, 933	296, 565	294, 603	279, 317	283, 385	267, 797
1897..	289, 720	263, 896	284, 298	255, 715	266, 687	257, 925	242, 160
1898..	175, 546	164, 419	184, 451	182, 567	185, 388	174, 768	161, 163

Year.	August.	September.	October.	November.	December.	Total.	Average.
1885..	74, 228	68, 110	63, 619	60, 926	61, 113	627, 086	52, 257
1886..	57, 492	48, 918	46, 937	41, 359	40, 578	640, 657	53, 388
1887..	26, 659	22, 903	20, 458	19, 902	17, 079	319, 040	26, 587
1888..	18, 558	22, 058	18, 809	20, 802	20, 950	239, 410	19, 951
1889..	16, 607	16, 875	21, 555	25, 415	28, 567	238, 776	19, 898
1890..	121, 349	138, 310	129, 717	106, 552	87, 955	1, 021, 613	85, 134
1891..	24, 432	27, 006	23, 428	23, 073	28, 682	377, 232	31, 436
1892..	106, 082	135, 353	212, 470	176, 852	196, 852	1, 117, 147	93, 096
1893..	152, 912	156, 124	149, 773	134, 923	144, 488	2, 075, 115	172, 926
1894..	249, 472	202, 364	220, 557	199, 787	199, 774	2, 362, 703	196, 892
1895..	279, 602	310, 400	322, 439	286, 932	324, 447	2, 954, 478	246, 207
1896..	270, 280	252, 351	267, 337	253, 909	278, 231	3, 338, 176	278, 181
1897..	232, 208	214, 283	202, 847	190, 028	194, 168	2,893, 935	241, 161
1898..	184, 659	171, 760	175, 956	179, 490	197, 904	2, 138, 071	178, 173

SHIPMENTS OF PETROLEUM FROM THE SOUTHEASTERN OHIO DISTRICT.

Shipments of crude petroleum and refined petroleum reduced to crude equivalent from the Southeastern Ohio district from 1886 to 1898.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.
1886..	60,119	42,525	32,277	23,578	28,986	40,211	28,832
1887..	52,065	23,908	17,593	16,558	16,002	17,384	16,504
1888..	40,076	30,045	4,122	14,920	15,275	15,630	9,083
1889..	11,847	16,168	23,939	8,611	9,027	8,934	15,269
1890..	44,306	38,898	35,041	30,975	13,070	22,851	46,394
1891..	54,363	27,160	1,040	2,094	1,060	41,725	820
1892..	2,594	2,200	1,763	1,600	252	37,989	1,834
1893..	7,174	6,556	8,218	5,906	2,338	1,123	1,025
1894..	3,366	3,932	2,874	2,272	1,998	959	2,569
1895..	4,370	3,106	3,154	1,130	869	1,756	583
1896..	4,128	3,116	1,874	1,309	1,026	300	0
1897..	2,948	2,437	2,063	2,776	400	1,645	0
1898..	102	43	101	52	0	56	54

Year.	August.	September.	October.	November.	December.	Total.	Average.
1886..	45,882	47,992	53,156	51,608	49,260	504,426	42,036
1887..	27,719	35,030	37,978	34,508	39,654	334,903	27,909
1888..	6,989	32,698	47,572	47,066	26,940	290,416	24,201
1889..	14,507	22,669	50,447	47,924	47,090	276,432	23,036
1890..	107,175	73,469	50,780	54,540	53,704	578,203	48,184
1891..	2,318	3,283	3,040	2,700	2,236	141,839	11,820
1892..	1,555	2,102	3,773	4,358	6,413	66,463	5,539
1893..	586	1,964	2,524	4,538	2,563	44,515	3,710
1894..	2,309	3,839	4,377	4,264	3,999	36,758	3,063
1895..	1,874	2,124	4,177	6,716	3,332	33,191	2,766
1896..	235	599	3,641	2,560	2,561	21,349	1,779
1897..	1,416	2,323	3,496	3,510	55	23,069	1,922
1898..	47	48	106	58	51	718	60

The above table embraces the crude petroleum delivered to refineries in Parkersburg and Marietta by the Macksburg division of the Buckeye Pipe Line Company. The balance of the shipments was delivered to the trunk lines and included in their monthly statements.

STOCKS OF CRUDE PETROLEUM IN THE SOUTHEASTERN OHIO DISTRICT.

Total stocks of crude petroleum in the Southeastern Ohio district at the close of each month from 1886 to 1898, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.
1886..	324,483	332,322	362,923	407,212	440,329	467,599	468,796
1887..	404,315	408,926	425,325	438,562	453,162	465,363	472,273
1888..	380,551	386,293	400,602	407,086	413,858	420,631	434,573
1889..	363,620	357,527	360,121	364,796	376,052	397,718	387,089
1890..	296,413	291,536	301,856	324,786	388,874	451,851	517,042
1891..	685,120	503,284	480,618	480,364	453,809	433,773	401,358
1892..	461,616	468,861	460,750	462,383	475,768	447,685	457,176
1893..	410,715	418,513	397,127	404,951	407,715	421,222	413,935
1894..	390,977	388,341	379,037	376,883	325,664	294,427	271,801
1895..	172,461	193,935	236,022	242,317	204,030	211,740	184,784
1896..	246,557	290,225	345,405	348,997	324,443	248,799	220,759
1897..	485,986	507,619	522,985	537,636	515,716	523,944	519,334
1898..	438,224	445,137	476,064	476,652	486,206	446,456	613,303

Year.	August.	September.	October.	November.	December.	Average.
1886........	456,621	461,842	437,299	427,950	419,248	417,219
1887........	471,214	459,085	441,563	426,957	404,382	439,261
1888........	444,006	427,797	394,807	365,873	351,128	402,267
1889........	389,189	383,393	354,498	331,939	310,848	364,732
1890........	531,215	596,056	660,573	703,031	698,129	480,113
1891........	378,857	388,855	431,450	461,037	454,232	462,730
1892........	462,306	441,494	434,560	432,283	422,142	452,252
1893........	426,552	443,669	458,692	446,503	415,900	422,124
1894........	241,439	197,660	179,867	152,200	147,318	278,801
1895........	182,209	169,850	192,060	211,591	231,048	202,671
1896........	214,159	217,946	434,786	469,580	465,953	318,967
1897........	541,300	516,498	496,550	456,413	436,844	505,069
1898........	568,233	524,403	520,388	638,755	556,059	515,823

WELL RECORDS OF THE SOUTHEASTERN OR SOUTHERN OHIO DISTRICT.

This part of the Appalachian oil field is included under the head of Pennsylvania oil, and is discussed in the former part of this report. The following tables show the wells completed, number of dry holes, new production, rigs, and drilling wells under way from month to month in 1898. They are incomplete for the reason that a considerable portion of the operations in southeastern Ohio are included under the head of the Southwestern district.

Total number of wells completed in the Southeastern Ohio district in 1898.

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Scio and Jewett.	Miscellaneous.	Total.
January	0	3	12	2	0	4	21
February	1	11	2	2	0	2	18
March	14	0	0	1	0	3	18
April	3	10	1	7	0	6	27
May	2	13	2	8	0	3	28
June	1	7	0	6	0	7	21
July	1	6	3	8	0	8	26
August	4	8	3	5	0	4	24
September	3	10	4	14	0	10	41
October	0	10	2	27	0	4	43
November	6	10	0	19	6	0	41
December	7	4	0	34	8	5	58
Total	42	92	29	133	14	56	366

It will be noticed that toward the latter part of the year 14 wells were drilled in the Scio and Jewett district. Other tables following show 20 rigs building and 23 drilling wells at the close of December, 1898.

Initial daily production of wells completed in the Southeastern Ohio district in 1898.

[Barrels of 42 gallons.]

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Scio and Jewett.	Miscellaneous.	Total.
January	0	5	17	10	0	125	157
February	0	31	13	0	0	5	49
March	34	0	0	0	0	40	74
April	0	13	0	25	0	30	68
May	20	65	0	62	0	45	192
June	20	52	0	40	0	30	142
July	0	50	0	59	0	107	216
August	55	23	15	20	0	60	173
September	25	42	7	73	0	245	392
October	0	122	17	300	0	55	494
November	53	23	0	588	84	0	748
December	25	0	0	1,016	301	20	1,362
Average	19	36	6	183	32	63	339

Total number of dry holes drilled in the Southeastern Ohio district in 1898.

Month.	Corning.	Macks-burg.	Steuben-ville.	Marietta.	Scio and Jewett.	Miscella-neous.	Total.
January	0	2	8	1	0	1	12
February	1	6	0	2	0	1	10
March	9	0	0	1	0	0	10
April	3	7	1	2	0	3	16
May	1	9	2	3	0	1	16
June	0	3	0	3	0	2	8
July	1	5	3	2	0	2	13
August	1	6	1	1	0	1	10
September	1	6	2	6	0	3	18
October	0	2	0	8	0	1	11
November	3	5	0	7	0	0	15
December	4	4	0	11	0	2	21
Total	24	55	17	47	0	17	160

Total number of wells drilling in the Southeastern Ohio district in 1898.

Month.	Corning.	Macks-burg.	Steuben ville.	Marietta.	Scio and Jewett.	Miscella-neous.	Total.
January	0	6	2	1	0	2	11
February	1	3	0	1	0	2	7
March	2	4	0	1	0	4	11
April	1	6	1	2	0	2	12
May	0	2	0	5	0	3	10
June	1	4	3	2	0	5	15
July	1	5	2	2	0	3	13
August	2	4	2	6	0	6	20
September	1	6	2	8	0	4	21
October	4	9	6	9	0	2	30
November	6	9	0	13	2	5	35
December	2	10	0	23	23	2	60
Average	2	6	1	6	2	3	20

Total number of rigs building in the Southeastern Ohio district in 1898.

Month.	Corning.	Macks-burg.	Steuben-ville.	Marietta.	Scio and Jewett.	Miscella-neous.	Total.
January	2	4	0	1	0	2	9
February	2	2	0	1	0	3	8
March	3	3	1	1	0	3	11
April	3	4	1	1	0	1	10
May	3	2	3	2	0	4	14
June	1	4	1	2	0	1	9
July	3	3	0	9	0	2	17
August	1	3	2	4	0	0	10
September	1	3	2	5	0	1	12
October	2	3	1	12	0	2	20
November	3	3	0	13	5	1	25
December	3	7	0	32	20	1	63
Average	2	3	1	7	2	2	17

In the following tables are given the well records in the Southeastern Ohio district from 1891 to 1898:

Number of wells completed in the Southeastern Ohio district from 1891 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	.....	.....	.....	.....	.....	.....	.....	.....	.....	9	10	8	27
1892	7	9	12	7	4	8	5	2	4	2	14	2	76
1893	10	15	13	19	24	15	26	18	21	15	7	7	190
1894	9	6	15	17	17	21	23	18	19	21	22	27	215
1895	25	17	31	37	57	56	50	48	40	41	25	33	460
1896	43	41	43	45	71	49	66	51	50	43	60	57	619
1897	55	30	46	58	63	51	35	44	34	29	22	31	498
1898	21	18	18	27	28	21	26	24	41	43	41	58	366

Initial daily production of new wells in the Southeastern Ohio district from 1891 to 1898, by months.

[Barrels of 42 gallons.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891	.....	.....	.....	.....	.....	.....	.....	.....	.....	36	265	70	124
1892	60	152	393	65	291	25	43	2	0	20	117	0	97
1893	209	168	109	254	350	210	323	398	240	234	37	78	218
1894	143	50	74	172	246	223	262	232	180	468	215	433	225
1895	387	348	680	506	748	465	528	406	398	269	284	317	445
1896	338	359	787	413	554	426	473	300	434	594	592	498	481
1897	499	302	433	361	374	287	158	465	240	170	192	182	305
1898	157	49	74	68	192	142	216	173	392	494	748	1,362	339

Total number of dry holes drilled in the Southeastern Ohio district from 1891 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	5	4	14
1892..	2	3	4	4	4	5	1	0	4	1	4	2	34
1893..	0	2	4	3	8	2	7	3	7	4	4	2	46
1894..	3	2	8	7	5	9	8	8	7	8	11	9	85
1895..	11	3	6	9	9	18	11	14	7	20	5	12	125
1896..	11	15	9	16	31	11	23	19	12	13	24	16	200
1897..	20	10	11	20	26	25	14	22	14	9	12	13	196
1898..	12	10	10	16	16	8	13	10	18	11	15	21	160

Number of wells drilling in the Southeastern Ohio district at the close of each month from 1891 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	14	10	13
1892..	15	15	12	9	14	9	6	6	6	10	7	9	10
1893..	14	10	15	15	13	15	13	19	12	8	9	12	13
1894..	11	4	19	5	17	15	18	18	16	15	19	22	15
1895..	19	21	16	34	32	38	35	41	35	27	33	33	30
1896..	33	22	38	42	27	36	35	26	33	35	40	36	34
1897..	19	27	31	22	21	26	22	25	18	15	21	15	22
1898..	11	7	11	12	10	15	13	20	21	30	35	60	20

Rigs building in the Southeastern Ohio district from 1891 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	20	20	4	15
1892..	18	17	14	13	21	10	8	11	13	16	13	13	14
1893..	16	17	23	11	4	9	12	9	13	9	13	13	12
1894..	9	13	13	9	13	13	18	18	15	27	19	17	15
1895..	16	23	21	26	24	28	25	30	24	24	38	31	26
1896..	38	24	24	30	22	21	23	26	22	30	22	22	25
1897..	25	23	24	25	21	16	18	15	11	19	19	10	19
1898..	9	8	11	10	14	9	17	10	12	20	25	63	17

The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in the southeastern Ohio oil field in 1898:

Well record in the Southeastern Ohio district in 1898.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	21	157	12	11	9
February	18	49	10	7	8
March	18	74	10	11	11
April	27	68	16	12	10
May	28	192	16	10	14
June	21	142	8	15	9
July	26	216	13	13	17
August	24	173	10	20	10
September	41	392	18	21	12
October	43	494	11	30	20
November	41	748	15	35	25
December	58	1, 362	21	60	63
Total	366	*a* 339	160	*a* 20	*a* 17

a Average.

MECCA-BELDEN DISTRICT.

The product of these two fields is used only for lubricating purposes. The oil is black, 28° gravity, with a cold test of about 15° above zero. The wells are not pumped with any regularity, owing to their small production and the handling of a large amount of water. The fields are isolated by many miles from other oil developments and are themselves widely separated. They yield a very fine article of natural lubricating oil, which comes from the Berea sandstone. The Mecca district is near Warren, Ohio, in the northern part of Trumbull County, and the Belden district is in Lorain County, just south of Elyria. The production increased a few barrels the past year, and the price has advanced from an average of $4.35 a barrel in 1896 to $4.84 in 1897 and $5.30½ in 1898.

PRODUCTION.

The following table gives the production of crude petroleum in the Mecca-Belden district in 1898:

Production of crude petroleum in the Mecca-Belden district in 1898.

District.	Barrels of 42 gallons.	Value.	Price per barrel.
Belden, Lorain County	510	$1,879	$3.68
Mecca, Trumbull County	172	1,739	10.11
Total	682	3,618	5.30½

In the following tables are given the production and value and stocks of the crude petroleum in this district from 1892 to 1898:

Production and value of crude petroleum in the Mecca-Belden district of Ohio from 1892 to 1898.

Year.	Belden district, Lorain County.			Mecca district, Trumbull County.			Total.		
	Production.	Value.	Value per barrel.	Production.	Value.	Value per barrel.	Production.	Value.	Value per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
1892	1,732	$9,280	$5.36	1,380	$11,821	$8.57	3,112	$21,101	$6.78
1893	1,120	8,014	7.15	451	3,321	7.36	1,571	11,335	7.21½
1894	740	3,276	4.43	200	1,200	6.00	940	4,476	4.76
1895	833	4,200	5.04	543	4,029	7.42	1,376	8,229	5.98
1896	520	1,848	3.55	146	1,049	7.18	666	2,897	4.35
1897	500	1,972	3.94	145	1,148	7.91½	645	3,120	4.84
1898	510	1,879	3.68	172	1,739	10.11	682	3,618	5.30½

STOCKS OF PETROLEUM IN THE MECCA-BELDEN DISTRICT, OHIO.

Stocks at wells in the Mecca-Belden district of Ohio.

Year ending Dec. 31—	Barrels.	Year ending Dec. 31—	Barrels.
1891	4,048	1895	390
1892	161	1896	70
1893	403	1897	69
1894	225	1898	225

INDIANA.

Indiana's oil development began in 1889, when the first oil produced in the State from the Trenton limestone came from a well drilled near Montpelier, in Blackford County. A small area of oil territory was discovered at Terre Haute the same year, but, although a number of wells were afterwards drilled, the yield of oil was insignificant and it proved of no commercial importance.

Indiana's great oil and gas product is found in the Trenton limestone, just as in the fields of northwestern Ohio. The field as at present developed is an extension of the Lima oil developments in Ohio, and covers portions of Wells, Blackford, Jay, Adams, Grant, Huntington, Wabash, Marion, Miami, Madison, and Delaware counties. The Peru pool, in Miami County, which created considerable excitement in 1897, suffered a collapse in 1898, and the new pools discovered during the year were small and somewhat disappointing.

The total production of Indiana for 1898 was 3,730,907 barrels, which, at an average price of 59.4 cents per barrel, was valued at $2,214,322. Compared with 1897 this was a decrease of 391,449 barrels, or about 9½ per cent, accompanied by a gain of $333,910 in value, or nearly 18 per cent. The year 1897, showed a falling off of 558,376 barrels production, or 11.93 per cent, as compared with 1896. The price, which declined from 63 cents per barrel in 1896 to 45.6 cents in 1897, advanced to 59.4 cents in 1898.

With the comparative failure of the development of the Peru pool, the Broad Ripple district in Washington Township, Marion County, claimed the greatest share of attention. The good wells found in the latter pool were the leading features of interest in this portion of the Indiana oil field at the beginning of the year. The best well drilled at Broad Ripple in January, 1898, started off at 210 barrels per day, and several others were rated at from 50 to 125 barrels. In the following month a well was struck on the Mitchell farm that started at 30 barrels an hour, but it soon settled down to a moderate producer. A little excitement was likewise created in February, owing to the drilling of a well on the Fiddler farm in Licking Township, Blackford County, in the gas territory north of Hartford City. It made a big showing at first and proved the incentive for a great deal of drilling, but in the end was a sad disappointment to all who put their faith and capital into the field.

The little pool at Kellers Station, 8 miles east of Peru, in Noble Township, Wabash County, come to the front in March with two wells that started off at 200 barrels each. A great sensation in the Indiana oil circles was created in March by the waste-gas decision of the State supreme court, whereby oil operators were debarred from drilling in the gas territory. This practically put a stop to oil operations in several districts, and no oil wells have since been drilled in the very promising sections of Madison and Delaware counties. In April the Kellers Station district had a daily production of 500 barrels from 10 wells, but before the close of the year it was pretty thoroughly defined and its daily yield at no time exceeded 800 barrels.

June witnessed a startling find in Jackson Township, Wells County. It was located on the Yountz farm and began producing at the rate of 400 barrels a day. It was in defined territory, however, and added nothing to the area of the field developments. A number of good wells were drilled along the line between Wells and Blackford counties and operators were very active in leasing the available lands for oil purposes. The Dale Farm well, in section 17, Washington Township, Blackford County, was another interesting feature of the Indiana field. It was completed in July and started off at 250 barrels, gradually increasing until it reached 400 barrels a day. The outlook for a large pool of new oil territory appeared very promising. The usual rush of oil producers followed and many wells were drilled, but a duplicate to the Dale "gusher" failed to be secured. A number of ordinary "pumpers" were discovered, but within ninety days operations practically came to a standstill.

The Compton pool, in the center of Jackson Township, Wells County, was opened up in August. The initial well started flowing several hundred barrels of salt water and 50 barrels of oil per day. The surrounding lands were speedily drilled over, but nothing out of the ordinary was the result. The closing months of the year were characterized by the large volume of new operation, but production failed to be materially increased. The efforts to discover new pools in Cass, Hamilton, and Jasper counties all proved unsuccessful. The Jasper County well, at Rensselaer, created a small wave of excitement which subsided very rapidly. The hole was drilled for water and a little oil was found at a depth of 400 feet. The year closed with a good strike on the Baker farm in Erie Township, Miami County, about 4 miles northeast of Peru, marking the discovery of a small area of productive territory similar to that at Kellers Station, in Wabash County.

PRODUCTION.

In the following table will be found a statement of the production of petroleum in Indiana from 1891 to 1898:

Production of petroleum in Indiana from 1891 to 1898.

	1891.	1892.	1893.	1894.
Total production (barrels of 42 gallons)	136, 634	698, 068	2, 335, 293	3, 688, 666
Total value at wells of all oils produced, excluding pipage	$54, 787	$260, 620	$1, 050, 882	$1, 774, 260
Value per barrel	$0. 40	$0. 37	$0. 45	$0. 48
	1895.	**1896.**	**1897.**	**1898.**
Total production (barrels of 42 gallons)	4, 386, 132	4, 680, 732	4, 122, 356	3, 730, 907
Total value at wells of all oils produced, excluding pipage	$2, 811, 444	$2, 954, 411	$1, 880, 412	$2, 214, 322
Value per barrel	$0. 64	$0. 63	$0. 45$\frac{3}{5}$	$0. 59$\frac{2}{5}$

The following is a very complete record of the monthly production, beginning in January, 1891, and closing with December, 1898. It also gives the average monthly production for the same period.

Total production of petroleum in Indiana from 1891 to 1898, by months.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.
1891..	6, 171	5, 981	5, 159	4, 973	5, 757	8, 136	10, 809
1892..	15, 841	18, 946	24, 794	26, 184	31, 033	40, 888	49, 203
1893..	111, 824	96, 025	134, 549	146, 493	186, 939	209, 616	221, 666
1894..	259, 000	232, 107	282, 376	287, 330	321, 502	333, 479	327, 349
1895..	300, 568	230, 559	310, 303	352, 077	397, 001	403, 569	434, 376
1896..	365, 582	341, 743	386, 586	395, 032	417, 963	434, 167	422, 968
1897..	315, 980	309, 867	347, 922	327, 744	346, 515	347, 884	351, 280
1898..	318, 254	273, 900	326, 540	311, 235	312, 448	321, 676	280, 101

Total production of petroleum in Indiana from 1891 to 1898, by months—Continued.

[Barrels of 42 gallons.]

Year.	August.	September.	October.	November.	December.	Total.	Average.
1891..	11,603	16,500	19,029	20,801	21,715	136,634	11,386
1892..	56,109	66,034	95,699	129,270	144,067	698,068	58,172
1893..	248,353	245,615	252,568	245,607	236,038	2,335,293	194,608
1894..	345,031	319,588	339,424	304,030	337,450	3,688,666	307,389
1895..	420,132	409,169	393,153	373,789	361,436	4,386,132	365,511
1896..	407,238	415,675	394,283	337,331	362,164	4,680,732	390,061
1897..	345,856	329,379	372,113	379,896	347,920	4,122,356	343,530
1898..	334,017	327,465	320,730	301,843	302,698	3,730,907	310,909

WELL RECORDS IN THE INDIANA FIELD.

The wells completed in the Indiana oil fields during 1898 were 694 in number. One hundred and fourteen, or about 16 per cent of the total, were destitute of oil in paying quantities. Compared with 1897, there was an increase of 24 in productive wells and a decrease of 16 dry holes. At the close of the year there were 26 rigs and 64 drilling wells in progress, as compared with 12 rigs and 29 drilling wells at the close of 1897. The increase in new operations was over 100 per cent.

Up to January 1, 1898, 5,267 wells had been drilled in the Indiana oil fields. The total at the close of the past year was 5,961. The number of producing wells in the Indiana oil fields at the beginning of the year was 3,850. Adding the number completed in 1898 and deducting 114 dry holes and 169 wells abandoned during the year will give 4,261 as the number producing January 1, 1899.

The productive wells completed in the Indiana fields in 1897 showed a decrease of 467, and the dry holes of 28 from the preceding year. While about 13 per cent of the wells drilled in 1896 were destitute of oil in paying quantities, nearly 20 per cent of the total drilled in 1897 were failures. At the close of 1897 operations had declined to 12 rigs and 29 drilling wells, which was a falling off of 12 rigs and 23 drilling wells from the figures at the close of 1896, or nearly 50 per cent.

There were 685 wells completed in the Indiana oil fields in 1897, and 130 were dry holes. In 1896 the number of wells completed was 1,180, and 158 of them were dry holes. The year 1895 completed 1,267 wells, which was the greatest number yet recorded. The dry holes summed up 166.

The following tables show the total number of wells completed, the initial daily production of the producing wells, the total number of dry holes, and the total number of wells drilling and rigs building in the Indiana oil fields for each month during 1898:

Total number of wells completed in Indiana in 1898, by counties.

Month.	Adams.	Blackford.	Grant.	Huntington.	Jay.	Wells.	Madison.
January	3	3	2	0	3	5	1
February	0	2	0	2	1	3	1
March	0	5	1	1	2	5	0
April	3	5	0	2	9	8	0
May	1	7	2	2	2	5	0
June	1	14	5	4	2	15	0
July	2	13	6	3	4	17	0
August	4	20	8	6	5	24	0
September	5	18	7	1	6	24	0
October	7	18	12	4	5	30	0
November	5	16	13	5	8	36	0
December	6	18	10	4	6	34	0
Total	37	139	66	34	53	206	2

Month.	Miami.	Marion.	Delaware.	Wabash.	Miscellaneous.	Total.
January	8	6	1	7	2	41
February	5	6	1	2	0	23
March	0	9	2	4	0	29
April	1	6	0	8	1	43
May	5	7	0	7	0	38
June	2	6	0	6	0	55
July	3	3	0	2	0	53
August	1	3	0	6	3	80
September	4	2	0	5	0	72
October	2	1	0	3	0	82
November	1	3	0	4	1	92
December	3	3	0	2	0	86
Total	35	55	4	56	7	694

Initial daily production of wells completed in Indiana in 1898, by counties.

[Barrels of 42 gallons.]

Month.	Adams.	Black-ford.	Grant.	Hunting-ton.	Jay.	Wells.	Madison.
January	90	30	15	0	40	95	0
February	0	20	0	40	50	55	10
March	0	30	75	20	90	50	0
April	65	30	0	30	65	140	0
May	25	175	80	110	0	60	0
June	45	225	130	50	60	335	0
July	75	455	250	75	35	390	0
August	85	315	250	105	120	415	0
September	125	170	235	50	75	460	0
October	195	170	345	40	70	630	0
November	80	120	365	170	115	660	0
December	100	155	145	105	80	580	0
Average	74	158	157	66	67	322	1

Month.	Miami.	Marion.	Delaware.	Wabash.	Miscella-neous.	Total.
January	120	190	100	20	10	710
February	35	150	100	40	0	500
March	0	340	110	415	0	1,130
April	100	155	0	490	0	1,075
May	30	210	0	200	0	890
June	40	150	0	210	0	1,245
July	0	80	0	55	0	1,415
August	10	55	0	200	0	1,555
September	20	25	0	95	0	1,255
October	10	60	0	5	0	1,525
November	25	120	0	20	0	1,675
December	75	145	0	5	0	1,390
Average	39	140	26	146	1	1,197

Total number of dry holes drilled in Indiana in 1898, by counties.

Month.	Adams.	Blackford.	Grant.	Huntington.	Jay.	Wells.	Madison.
January	1	1	1	0	1	0	1
February	0	0	0	0	0	0	0
March	0	2	0	0	0	0	0
April	1	2	0	1	5	2	0
May	0	0	0	1	2	1	0
June	0	2	0	2	0	1	0
July	0	2	0	0	1	1	0
August	0	3	0	1	1	2	0
September	0	2	0	0	2	3	0
October	1	2	0	1	0	1	0
November	1	3	1	0	3	3	0
December	0	6	3	0	1	3	0
Total	4	25	5	6	16	17	1

Month.	Miami.	Marion.	Delaware.	Wabash.	Miscellaneous.	Total.
January	2	2	0	5	0	14
February	3	1	0	0	0	4
March	0	0	0	0	0	2
April	0	1	0	0	1	13
May	3	2	0	1	0	10
June	0	0	0	1	0	6
July	3	0	0	0	0	7
August	0	0	0	0	3	10
September	3	0	0	2	0	12
October	1	0	0	2	0	8
November	0	0	0	1	0	12
December	2	0	0	1	0	16
Total	17	6	0	13	4	114

Total number of wells drilling in Indiana in 1898, by counties.

Month.	Adams.	Black-ford.	Grant.	Hunting-ton.	Jay.	Wells.	Madison.
January	1	4	0	2	1	5	0
February	0	6	1	1	4	3	0
March	2	6	1	2	3	8	1
April	0	6	0	2	1	5	1
May	0	7	3	2	1	8	1
June	2	7	4	2	3	11	1
July	2	16	3	4	4	12	1
August	2	13	6	1	3	8	1
September	4	17	8	2	7	22	1
October	7	12	10	4	6	26	0
November	7	22	15	6	5	17	0
December	5	12	14	5	3	16	0
Average	3	11	5	3	3	12	1

Month.	Miami.	Marion.	Delaware.	Wabash.	Miscella-neous.	Total.
January	3	1	3	1	0	21
February	0	5	5	2	0	27
March	1	6	4	1	0	35
April	3	5	4	3	0	30
May	1	3	4	3	0	33
June	2	3	4	1	0	40
July	1	3	4	3	1	54
August	5	1	4	4	0	48
September	3	0	4	2	1	71
October	3	1	0	3	0	72
November	3	2	0	1	0	78
December	7	1	0	1	0	64
Average	3	2	3	2	0	48

Total number of rigs or derricks building in Indiana in 1898, by counties.

Month.	Adams.	Black-ford.	Grant.	Hunting-ton.	Jay.	Wells.	Madison.
January	0	2	0	2	0	3	0
February	0	3	1	1	0	1	0
March	0	1	0	2	2	2	0
April	1	2	1	1	1	5	0
May	1	1	2	4	2	3	0
June	2	6	4	2	3	5	0
July	2	2	4	1	4	7	0
August	1	5	1	1	7	4	0
September	6	8	3	3	3	16	0
October	2	9	6	3	3	16	0
November	2	4	7	3	4	22	0
December	0	2	5	2	5	10	0
Average	1	4	3	2	3	8	0

Month.	Miami.	Marion.	Delaware.	Wabash.	Total.
January	0	4	1	0	12
February	0	3	1	0	10
March	0	2	1	2	12
April	1	3	1	4	20
May	0	3	1	0	17
June	1	1	1	0	25
July	0	1	1	0	22
August	0	1	1	0	21
September	0	1	1	0	41
October	0	2	0	1	42
November	1	1	0	0	44
December	0	2	0	0	26
Average	0	2	1	1	25

In the following tables are given the records of wells completed in the Indiana oil fields from 1891 to 1898:

Number of wells completed in the Indiana oil fields from 1891 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891....	....	.....	.....	.....	.....	.....	6	6	15	15	15	8	65
1892....	11	13	18	13	17	19	17	30	25	52	33	47	295
1893....	20	30	31	36	45	47	47	55	27	72	56	76	542
1894....	90	103	103	80	110	107	84	123	100	107	97	85	1, 189
1895....	61	45	81	111	122	153	132	140	129	106	102	85	1, 267
1896....	76	90	86	136	148	150	113	121	70	58	66	66	1, 180
1897....	41	35	40	47	49	52	60	45	55	89	119	54	686
1898....	41	23	29	43	38	55	53	80	72	82	92	86	694

Initial daily production of new wells in Indiana oil fields from 1891 to 1898, by months.

[Barrels of 42 gallons.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	......	342	1, 020	2, 361	2, 132	1, 557	730	710
February	......	250	913	2, 935	1, 413	1, 875	1, 000	500
March	......	289	2, 805	3, 395	2, 504	2, 090	1, 000	1, 130
April	......	316	4, 135	3, 175	3, 473	2, 825	800	1, 075
May	......	505	3, 155	4, 450	3, 035	3, 149	1, 295	890
June	......	545	5, 595	4, 886	4, 923	3, 115	900	1, 245
July	253	595	3, 880	3, 530	3, 067	2, 332	1, 800	1, 415
August	135	1, 295	4, 184	3, 435	2, 760	2, 650	850	1, 555
September	875	2, 145	2, 055	3, 149	3, 175	1, 700	2, 010	1, 255
October	330	4, 155	3, 442	3, 455	2, 651	1, 515	4, 200	1, 525
November	390	3, 050	2, 305	3, 323	2, 560	1, 400	3, 790	1, 675
December	175	3, 160	2, 968	2, 654	2, 025	1, 100	1, 045	1, 390
Average	360	1, 387	3, 038	3, 396	2, 810	2, 109	1, 618	1, 197

Total number of dry holes drilled in Indiana oil fields from 1891 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891....	....	....	.....	.....	.....	.....	0	2	5	4	3	1	15
1892....	2	6	6	2	3	4	2	3	3	18	6	21	76
1893....	7	10	10	6	14	6	11	9	5	14	10	9	111
1894....	19	14	24	14	13	13	9	21	15	14	8	17	181
1895....	7	4	13	16	22	20	15	23	12	12	9	13	166
1896....	10	13	6	28	26	20	14	19	4	4	6	8	158
1897....	8	9	7	12	5	16	11	9	16	11	18	8	130
1898....	14	4	2	13	9	6	7	10	12	8	13	16	114

Number of wells drilling in the Indiana oil fields at the close of each month from 1891 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891....	....	....	.....	.....	.....	.....	5	13	12	8	4	12	9
1892....	17	15	11	12	13	16	11	16	23	23	26	24	17
1893....	24	19	22	18	20	28	29	45	27	50	36	50	31
1894....	63	71	37	56	60	61	71	64	58	62	62	58	60
1895....	66	52	62	82	112	101	109	110	103	102	78	81	88
1896....	97	80	90	99	99	88	88	52	47	45	43	52	73
1897....	38	35	30	33	35	39	34	29	48	40	45	29	36
1898....	21	27	35	30	33	40	54	48	71	72	78	64	48

Rigs or derricks building in the Indiana oil fields from 1891 to 1898, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891....	....	....	.....	.....	.....	.....	7	2	12	8	6	6	7
1892....	8	18	23	23	17	21	16	15	29	31	39	19	22
1893....	12	15	17	14	17	26	32	28	9	25	27	30	21
1894....	36	39	34	40	35	30	32	35	35	57	38	32	37
1895....	37	50	73	89	102	91	78	69	83	70	61	80	74
1896....	72	50	53	67	79	48	52	33	32	34	42	24	49
1897....	29	36	34	25	29	22	18	23	37	25	19	12	26
1898....	12	10	12	20	17	25	22	21	41	42	44	26	25

The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in Indiana in 1898:

Well record in Indiana in 1898.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	41	710	14	21	12
February	23	500	4	27	10
March	29	1,130	2	35	12
April	43	1,075	13	30	20
May	38	890	9	33	17
June	55	1,245	6	40	25
July	53	1,415	7	54	22
August	80	1,555	10	48	21
September	72	1,255	12	71	41
October	82	1,525	8	72	42
November	92	1,675	13	78	44
December	86	1,390	16	64	26
Total	694	*a* 1,197	114	*a* 48	*a* 25

a Average.

MICHIGAN.

There was a small production in Michigan, at Port Huron, opposite Sarnia, Canada. The petroleum is found in the Corniferous limestone, which has for so many years produced a large amount of petroleum at Petrolia and Oil Springs, in Canada. Numerous deep wells have been drilled into the Trenton limestone, in the southeastern portion of the State, in search of petroleum and gas. Nothing but big flows of salt water have so far been found.

ILLINOIS.

This State continues to produce a dark, heavy oil, from four wells located near Litchfield, Montgomery County. It has a specific gravity of 22° and is used as a lubricant. The wells are from 640 to 670 feet in depth.

The production of petroleum in this State since 1889 has been as follows:

Production of petroleum in Illinois from 1889 to 1898.

Year.	Barrels.	Year.	Barrels.
1889	1,460	1894	300
1890	900	1895	200
1891	675	1896	250
1892	521	1897	500
1893	400	1898	360

MISSOURI.

The crude petroleum produced in Missouri in 1898 was from a well located in Bates County, not far from the town of Merwin. The oil is used for lubricating purposes and for harness oil, and is retailed at 25 cents per gallon. It is found in a porous rock at a depth of 225 feet. This petroleum is of a dark color, very heavy. It possibly comes from near the top of the Mississippian limestone, and is closely related to the oil found in Kansas. Petroleum is also reported to have been found at Braymer, associated with maltha in surface springs.

In the following table is given the production of crude petroleum in Missouri from 1889 to 1898:

Production of petroleum in Missouri from 1889 to 1898.

Year.	Barrels.	Year.	Barrels.
1889	20	1894	8
1890	278	1895	10
1891	25	1896	43
1892	10	1897	19
1893	50	1898	10

KANSAS.

The production of oil in Kansas in 1898 was 71,980 barrels, compared with 81,098 barrels in 1897, showing a decline of 9,118 barrels, or 11.24 per cent. There has been a decreasing production in the State since 1896, when it amounted to 113,571 barrels. The counties producing oil are Wilson and Neosho, toward the southeastern corner of the State. About 300 wells have been drilled in this corner of Kansas since 1892, but only 77 of them are now producing petroleum. There are several wells scattered throughout the oil field that have produced some oil, but their small product and inferior quality, together with their remoteness from lines of transportation, made them unprofitable to operate. There is a great area extending from the extreme west to the southeast corner of the State that has not yet been tested by the drill, but that will probably, at some time in the future, give an increased production in the State. Of the 300 wells before mentioned about 40 gas wells will have to be deducted.

The oil is found in a dark "sugar sand" from 15 to 20 feet in thickness at about 800 feet in depth. The largest cluster of producing wells is located along the river bottom near Neodesha, in Wilson County. The geological position of this sand is near the bottom of what is known as the Cherokee shales. The well records show a series of slate, sand, and limestone from the oil sand to the top. About 300 feet lower, after passing through another series of slate and sand (the lower beds holding salt water generally), the flint beds of the Subcarboniferous limestone is usually found. In this section this formation is known as Mississippian limestone, corresponding to the Subcarboniferous of the Appalachian field. The slate and sands above correspond to our Lower Coal measures, although they hold no coal in this locality, but do so in other localities in the State. The oil sand is in some wells wanting, and in others another sand above holds dark, heavy oil. This section has developed a number of good gas wells, showing a series of moderate anticlinal and synclinal folds in the floor of the lower rocks.

The petroleum is of a dark-green color of about 40° B. gravity. A small but very complete refinery has been built at Neodesha, from which point the pipe lines reach out 3 to 5 miles to the clusters of wells. There is also a large amount of tankage at this place. A very excellent quality of water-white oil is said to be produced from the Kansas petroleum.

A deep well was drilled at Neodesha in 1897, reaching a depth of 2,414 feet. The record below 814 feet, where the usual oil sand was barren, showed a series of sands and slates down to 1,179 feet, where the cap flint of the Mississippian limestone was reached. Then followed limestone, flint, and sandstone until granite was reported at the bottom. At 2,250 feet water with a temperature of over 120° was reported. There are a number of gas wells that show a volume of 4 to 8 million cubic feet in twenty-four hours.

The total product of oil in Kansas, so far as records have been obtained, is as follows:

Production of petroleum in Kansas.

Year.	Barrels.	Year.	Barrels.
1889	500	1894	40,000
1890	1,200	1895	44,430
1891	1,400	1896	113,571
1892	....	1897	81,098
1893	18,000	1898	71,980

The following tables give the total number of wells drilled, the number of dry holes, the number that produced gas, and the number that produced petroleum that were drilled in 1897 and 1898, by counties. In this table it will be noticed that Wilson County contains nearly all the producing oil wells.

The average number of wells producing in 1897 and 1898 is also shown, with the production of petroleum by months in 1898, the production in 1897 and 1898, the average daily production, and the average daily production per well during 1897 and 1898.

Total and average daily production of wells in Kansas in 1897 and 1898.

Production.	1897.	1898.
	Barrels.	*Barrels.*
Production in year	81,097.71	71,979.65
Daily average production	222.18	197.20
Average daily well production	3.58	2.63

Production of crude petroleum in Kansas in 1898, by months.

Month.	Production.	Month.	Production.
	Barrels.		*Barrels.*
January	7,602	August	5,537
February	6,384	September	4,723
March	6,562	October	5,457
April	6,973	November	5,224
May	6,186	December	5,503
June	6,570	Total	71,980
July	5,259		

Wells drilled in Kansas, 1897 and 1898.

County.	Wells.		Dry.		Gas.		Oil.	
	1897.	1898.	1897.	1898.	1897.	1898.	1897.	1898.
Neosho	1	......	......	1	......	......	1	......
Wilson	5	......	1	......	2	3	2	......
Chautauqua	4	......	4	......	......	......	......	......
Total	10	......	5	1	2	3	3	......

Total wells producing at close of years 1897 and 1898.

County.	Gas.		Oil.	
	Dec. 31, 1897.	Dec. 31, 1898.	Dec. 31, 1897.	Dec. 31, 1898.
Neosho	2	1	16	17
Wilson	12	7	54	60
Allen	3	3	....	....
Montgomery	2	....	1	....
Chautauqua	1	....	....	....
Total	20	11	71	77

Average wells producing, 1897 62
Average wells producing, 1898 75

INDIAN TERRITORY.

A number of wells have been drilled in different parts of the Territory, about 27 in all, nearly all of which were drilled previous to 1896. Very little new work has been done. Operations have been brought to a standstill owing to the difficulty in perfecting a title. The title of the oil and minerals remains in trust with the United States Government under the direction of the Secretary of the Interior, who must ratify every lease to make it valid. The amount of 640 acres can only be acquired by a single individual or company. Most of the oil produced is heavy and dark, although some of it shows a gravity of 30° to 38° Baumé.

Owing to the above-mentioned unsettled condition of titles no work has been done during 1898. Nearly all of the former production came from the reservation of the Cherokee Nation. The operations were carried on by the Cherokee Oil and Gas Company, who drilled 16 wells, some 5 miles southwest of Chelsea, from 350 to 1,200 feet in depth. Most of them produced a small amount of dark, heavy oil. One well at Eufaula, near the center of the Territory, is reported to have been drilled 2,780 feet deep, and was dry. In another well, at Muskogee, was found a light-green oil at 1,100 feet of 38° Baumé.

Production of petroleum in Indian Territory from 1891 to 1898.

Year.	Barrels.	Year.	Barrels.
1891	30	1895	37
1892	80	1896	170
1893	10	1897	625
1894	130	1898	None.

TEXAS.

Crude petroleum is produced in four counties in Texas, viz, Navarro, Nacogdoches, Bexar, and Hardin. The first-named county produced 544,620 barrels of light crude petroleum of 38° to 40° Baumé gravity. The other counties furnished 1,450 barrels of heavy, dark, lubricating petroleum ranging from 16° to 26° Baumé.

The total production of crude petroleum in Texas was 546,070 barrels in 1898, as compared with 65,975 barrels in 1897, a gain of 727.5 per cent. None of the other States producing petroleum in any commercial quantity have approached this percentage of increase for many years. Texas is certainly developing a production that will soon rival some of the older States in quantity. The quality is said to stand next to Pennsylvania oil.

There was a total of 374 wells drilled in this field in 1898. Of this number 342 produced oil and 32 were dry. The field was extended but little during 1898, most of the petroleum being found in what was considered developed territory. The whole field is not over 3½ miles long by 1 mile wide. A complete system of pipe lines and a number of large storage tanks have been constructed connecting the field with a modern refinery built at Corsicana during the latter part of 1898. The products of Texas petroleum are said to be good, and a large amount of excellent illuminating oil is secured.

The end of the year brought additional field developments with increased production. In the column of States in 1900 Texas will probably be a sharp competitor for the sixth place in production, now held by California. The geology, depth of wells, and other particulars of the Corsicana field were fully discussed in the 1897 report.

Hardin County produces a heavy oil with good natural lubricating qualities. The wells are about 300 feet in depth and produce 10 to 12 barrels per day. A small refinery has lately been completed at Galveston which will receive a partial supply from this field. In Nacogdoches County a lubricating oil is also produced. The wells are about 300 feet deep and produce from 4 to 15 barrels per day. This oil is of a dark green color of 26° Baumé gravity, 280° F. fire test, 54.4 viscosity, and is said to contain 27 per cent of illuminating petroleum. It contains no sulphur or benzine, but gives off an excellent paraffin at 300° F. A small amount of heavy oil is produced from two wells near San

Antonio, Bexar County. There are several localities in which bitumen is found.

The following table gives a complete record of the total wells drilled during 1898, number of producing, dry, and drilling wells, the gas wells found, wells abandoned, and the drilling rigs. The small number of drilling rigs signifies more than it does in the ordinary oil field. First, because none of the wells are over 1,050 feet deep, and, second, the material covering the oil sand is of a soft clay nature, so that it is more a question of how fast the casing can be put in rather than the number of feet drilled. Ten days is often sufficient to complete a well.

PRODUCTION.

The production of petroleum in Texas since 1889 has been as follows:

Production of petroleum in Texas from 1889 to 1898.

Year.	Barrels.	Year.	Barrels.
1889	48	1894	60
1890	54	1895	50
1891	54	1896	1,450
1892	45	1897	65,975
1893	50	1898	546,070

WELL RECORDS.

The following table shows the number of wells completed, producing, dry, drilling, those producing gas and those abandoned, together with the number of rigs and the production of petroleum in Texas in 1898.

Well record and production of crude petroleum in the Corsicana oil field in 1898, by months.

Month.	Wells.						Rigs.	Production. *c*
	Completed.	Producing.	Dry. *a*	Drilling.	Gas.	Abandoned.		Barrels.
January (*b*)	76	66	10	6			8	13,797
February	11	9	2	19		1	18	20,110
March	25	23	2	17	1		13	21,421
April	32	29	3	6			13	30,276
May	32	31	1	13		1	7	31,007
June	26	24	2	8	1		20	55,677
July	26	26		18			9	56,649
August	39	38	1	11	1		11	58,458
September	29	28	1	14			18	63,138
October	27	23	4	16		3	7	63,227
November	24	23	1	12	1		8	63,777
December	27	22	5	14		2	4	67,083
Total	374	342	32	*d* 13	4	7	*d* 11	544,620

a Includes two artesian wells. *c* Includes local consumption approximated.
b One-half month estimate and covers all previous operations. *d* Average.

WYOMING.

This State has a number of natural petroleum springs scattered at intervals, extending from the southwestern corner to the northeastern corner. This line is crossed by another line of petroleum springs in a general east and west direction, extending for 100 miles near the center of the State.

At several localities wells have been drilled that have generally found oil. There are some 15 distinct pools in which natural oil springs exist, and two localities in which wells have been drilled that have produced petroleum. The great inland valleys and plains, with their ridges and mountain chains extending for many miles with synclinal and anticlinal folds, have, at numerous points, been cut through by streams that have exposed the rocks down to the Subcarboniferous, the Triassic, and the Jurassic, and the individual members of the great Cretaceous formation. There are numerous points at which the rocks of this Cretaceous formation are discharging dark, heavy petroleum, until miniature lakes are formed. At other points they are saturated with it, where they come to the surface. At others natural gas is seen bubbling up in pools of water. All of these facts seem to indicate that Wyoming will one day produce a large amount of petroleum, although many natural difficulties will have to be overcome. The elevation of the State averages about 6,000 feet above tide. The extremes are from 3,000 to 14,000 feet.

The very large areas in this State that are cut off from communication and transportation, the long distance to any large center of population, the abundance of good coal, and the scarcity of good water and timber, together with its comparatively small population, have all been factors that have retarded the development of its petroleum.

There is but one operation in the entire State, and that is near the head of Salt Creek, close to the north line of Natrona County. At this locality six wells owned by the Pennsylvania Oil and Gas Company are producing a dark green oil of natural lubricating qualities, of 24° Baumé gravity. The production is between 18 and 20 barrels per day for the whole group. The petroleum is hauled 50 miles south to Casper, on the Fremont, Elk River and Missouri Valley Railroad, by teams, the oil being loaded into tank wagons, a team of 16 to 18 horses hauling 30 to 35 barrels. The first well was drilled in the Salt Creek pool in 1889. The depth of the six wells now producing runs from 800 to 1,125 feet. Three strings of casing are required to reach the sand. At Casper this petroleum is distilled and a small amount of light products secured. The main product is a very good quality of lubricating oil, which is thoroughly filtered under pressure to remove a fine sharp sand, and finds a market as car and cylinder oil.

Three wells have been drilled on Little Popo Agie Creek, 10 miles south of Lander, Fremont County. These wells were drilled about

1884 and are still producing a dark or black oil of 20° Baumé gravity. All three of them will flow on opening them, and several small pools of this dark heavy oil have been collected. The wells are from 180 to 600 feet in depth. Nothing has been done in the way of disposing of this oil, as it is 150 miles from the nearest station on the Union Pacific Railroad.

In Weston County, near Newcastle, several wells were drilled from four to six years ago. Two of them show an oil similar to the Salt Creek wells in small quantity. So far, it may be said, nothing has been done toward developing this great area.

In the report of 1897 many additional facts will be found.

The following table gives the yearly production for five years, the year 1898 showing a considerable increase over 1897:

Production of petroleum in Wyoming from 1894 to 1898.

Year.	Barrels.
1894	2,369
1895	3,455
1896	2,878
1897	3,650
1898	5,475

COLORADO.

The only field that produces petroleum in this State is the Florence field, in Fremont County, in the valley of the Arkansas River, only 10 miles from the eastern base of the Rocky Mountains and 90 miles west of Denver.

Some 10 miles northwest of Florence was found a natural oil spring many years ago, in the valley of Oil Creek, and it is still flowing in a small way. In March, 1862, this spring was walled up and produced considerable oil; afterwards several shallow wells were put down and more oil secured. A small refinery was erected by a Mr. Cassidy about this time, and the petroleum was refined in a crude way and shipped to Denver and sold. The petroleum found in this locality comes from the Jurassic formation, and underlies the rocks which hold the petroleum in the Florence basin proper. The main basin is saucer-shaped; that is, turned up on all the rim edges. The town of Florence is situated near the center. The greater axis is about 14 miles in length, the course being N. 15° W.; the other axis is but 8 miles in length at right angles.

The more recent strata cover the lowest portion of the basin, which is just south of the town of Florence. In traveling northwest from Florence all the rocks are crossed, but the angles are not high until a good part of the distance toward the rim of the basin is reached. In the northwest all of the groups are passed, extending from the Fox Hills group to the Carboniferous limestone. Passing over the former, the Fort Banton shale, the Dakota, the Triassic, and Jurassic are all seen in their order.

The sloping strata from the rim pitch at a moderate angle, so that the lower members of the Cretaceous are buried several thousand feet in its center. The most productive area, so far as developed, comprises about 10,000 acres to the south of Florence.

The Fox Hills group is considered to be the strata that hold the petroleum deposits, and is reached at about 2,500 feet in the deepest part of the basin. Most of the wells reach this point at from 1,600 to 2,100 feet. The shale or sandy shale, which holds the oil, seems to be deposited in lenticular beds, and some wells get three pays of oil from 200 to 400 feet apart, or one may miss them all. The best wells, and the most lasting, are those that get the oil pay the deepest. It is surprising that any oil finds its way through this sandy shale that can not be detected while drilling through it. The drillers are only aware that they have passed an oil deposit by its showing oil on the tools. Generally two or three strings of casing are necessary to get a well down, as there are portions of the strata that cave badly.

One of the oldest wells in the field, although quite an exception, yielded 200 barrels per day when first struck; it is now eight years old and still producing 60 barrels per day. There are 125 producing wells in this field; the production is about 1,400 barrels per day. The total number of wells drilled is near 500.

At Grand Junction, Mesa County, Colorado, two wells were drilled to a depth of 1,000 feet or more that developed some gas pressure, which was afterward drowned out by a big flow of water found in lower rocks.

The vast areas of Cretaceous and Tertiary rocks in this State would seem to indicate that it will one day furnish a much larger percentage of petroleum than it is now producing.

A large part of the oil produced in this field is refined at Florence. The oil is of a dark green color, amber by transmitted light, and the gravity is about 31° Baumé.

PRODUCTION.

The following table gives the production, by months, during 1896, 1897, and 1898:

Production of crude petroleum in Colorado in 1896, 1897, and 1898, by months.

[Barrels of 42 gallons.]

Month.	Production.		
	1896.	1897.	1898.
January	31,846	26,671	33,327
February	28,699	24,566	32,433
March	29,938	26,039	33,670
April	31,506	23,443	33,132
May	30,911	27,811	33,163
June	30,188	33,707	32,749
July	31,241	40,924	34,643
August	31,453	41,192	37,221
September	30,872	38,233	43,051
October	29,669	35,163	44,749
November	27,909	32,968	44,575
December	27,218	34,217	41,670
Total	361,450	384,934	444,383

In the following table will be found a statement of the production of crude oil in Colorado from 1887 to 1898:

Product of crude oil in Colorado from 1887 to 1898.

Year.	Barrels.	Year.	Barrels.
1887	76,295	1893	594,390
1888	297,612	1894	515,746
1889	316,476	1895	438,232
1890	368,842	1896	361,450
1891	665,482	1897	384,934
1892	824,000	1898	444,383

CALIFORNIA.

No other State producing petroleum has had such an increase in new work during 1898 as California. The new developments at Coalinga, Fresno County, together with that of Los Angeles County and several other sections in the southern and central portions of the State, have demonstrated the probable existence of large areas of profitable petroleum territory and have attracted a large amount of outside capital.

The area of the unaltered strata that in localities holds petroleum is estimated at 40,000 square miles in this State. The developments so far have generally been along the steep flanks of anticlinals in the canyons, where the structure is visible. There are no doubt large areas of productive strata covered up by the alluvium carried down into the plains. Deeper drilling will no doubt develop fields under the conditions of more gentle angles or dips that will be prolific and more lasting.

The occurrence of petroleum and tar, under the condition of oil springs, sand and gravel saturated with bitumen, with large deposits of the same, continue from the northern portion of the State, a few miles back of the Pacific coast, to the southern extremity. There are also many such deposits along the eastern flanks of the Coast Range, as well as in the great central valley in the lower half of the State. The oil varies greatly in gravity and quality. Some localities produce a dark, heavy oil of about 16° Baumé, while other localities produce oil as light as 44° Baumé, very light in color. The heavy oil represents at least two-thirds of the production.

Two million two hundred and fifty-seven thousand two hundred and seven barrels of petroleum were produced in California in 1898 as compared with 1,903,411 barrels in 1897, showing a gain of 353,796 barrels, equal to 18.5 per cent. The average value of the petroleum produced in 1898 is placed at 85 cents per barrel, amounting to $1,917,596, an increase of $204,494 over that of 1897. The price was more uniform throughout the year than formerly.

There was more petroleum produced in California in 1898 than in any previous year, as the following table will show. This State stands next to Indiana in the amount of petroleum produced, and is slightly greater than the number of barrels produced in southeastern Ohio for the same year.

The following table gives the yearly production of petroleum in California from 1876 to 1898, that previous to 1876 being estimated:

Production of petroleum in California.

Year.	Barrels.	Year.	Barrels.
Previous to 1876	175,000	1887	678,572
1876	12,000	1888	690,333
1877	13,000	1889	303,220
1878	15,227	1890	307,360
1879	19,858	1891	323,600
1880	40,552	1892	385,049
1881	99,862	1893	470,179
1882	128,636	1894	705,969
1883	142,857	1895	1,208,482
1884	262,000	1896	1,252,777
1885	325,000	1897	1,903,411
1886	377,145	1898	2,257,207

The production by counties has been estimated as follows for 1898:

Production of petroleum in California in 1898, by counties and districts.

County.	District.	Barrels.
Los Angeles	Los Angeles	1,182,600
Do	Purente	115,000
Do	Whittier	74,000
Do	Santa Fe Oil Springs	10,000
Santa Barbara	Summerland	127,700
Do	Other fields	170,000
Ventura	Santa Paula Canyon	427,700
Fresno	Coalinga	150,000
Total		2,257,000

The following review of the petroleum industry in southern California in 1898 is taken from the Los Angeles Times, and is a fair presentation of the matter:

A review of the petroleum industry in southern California shows continued activity in the Los Angeles oil field and the oil territories of the Puente, Santa Fe Railway Company, the Central Oil Company, in the Puente hills, the oil field of the Pacific Coast Oil Company, near Newhall, and the oil fields of Ventura and Santa Barbara counties. The price of oil has also been more satisfactory than it was during 1896–97, and it is probable that the total output for 1898 will greatly exceed any previous annual output of petroleum in California. During 1898 there has been a marked tendency to exploit new territory. In Los Angeles County three new companies have commenced operations in the Puente hills, and new territory is being developed at three or four places near Newhall. At Los Angeles drilling was actively prosecuted during the first half of 1898 in the eastern extension of our local oil field, but recently little has been done toward extending its limits. There has been some exploitation in the outlying portions of Los Angeles, but the only marked success has been on the Maltman tract, where several comparatively shallow wells have been drilled, which are remunerative. The only really new group of productive wells reported as being drilled in Los Angeles County during 1898 are those of the Home Oil Company, near Whittier.

In Ventura County drilling has been active on both sides of the Santa Clara River. This has resulted in many new and productive wells being added to those already in operation. There have been reported from Ventura County several new wells drilled during 1898. On the south side of the valley of the Santa Clara River numerous new and productive wells have been drilled by the Union Oil Company; also several by the Eureka Oil Company. On the north side of the Santa Clara River the Modello Oil Company has sunk six productive wells near Piru, and there have been sundry developments by the Eureka and other companies in Hopper Canyon. In the Sespe district several new and productive wells are reported to have been sunk. Garbutt & Co. have developed a new and productive territory; also on the Temescal ranch, near Piru, one productive well has been sunk by D. C. Cook, who is about to commence active operations on that ranch.

In Santa Barbara County the principal development has been at and near Summerland, where a line of derricks extends not only along the seashore, but out into the ocean. The Arctic Oil Company is also drilling in the edge of the Santa Ynez Mountains, near the Casitas Creek, and some development has been made by the Occidental Oil Company, about five miles northeast of Summerland.

In Central California the most important event in the petroleum industry during 1898 has been the development of the Coalinga oil fields, in Fresno County, which is proving a valuable addition to our petroleum supply. Concerning the Moody Gulch oil field, in Santa Clara County, we have no data for 1898.

The geological investigations concerning the occurrence of petroleum in California, which have been made by me for the State mining bureau during 1898, have been along a line extending from the Santa Ana Mountains, through the Puente hills, to Los Angeles, along a line extending about 10 miles inland from the seashore between San Diego County and Newport, in Orange County; also throughout certain territory in Ventura County, lying between Piru Creek and the Sespe oil-mining district. The latter was described in the 11th bulletin of the California State mining bureau. It is interesting to note how the probable dimensions and directions assigned to the Los Angeles and the Summerland oil fields in the bulletin referred to have been borne out by recent developments.

ALASKA.

Nothing remains to be added to the report of 1897 on Alaska. Several experts visited this section in 1898 with a view to developing the territory, but so far nothing that indicates development in the near future has been reported.

The report of last year is given below:

Several Alaskan companies have located a large number of mining claims which, under certain conditions, include petroleum. Along the coast of Alaska, northwest of Sitka, beginning near Cape Yakutat, which is 500 miles northwest of Sitka and just west of Mount St. Elias, there are numerous natural springs of oil and water along the flank of the first range of foothills, from a mile to a mile and a half back from the ocean, and extending for 25 miles northwest, in a line parallel to the coast. This range of foothills, whose elevation is from 500 to 600 feet, is cut through by many small streams, and along these streams, near the axis of the range, numerous oil and water springs exist. Seventy-five miles farther west along the coast, between Cape Suckling and Cape Martin, there are also springs showing oil and sulphur water, and still farther inland there are deposits of coal.

There are also some slight indications of oil 75 miles farther west, on the mainland opposite Kachemak Bay, at the mouth of Cook Inlet. All of these rocks are more or less disturbed, and the angles of dip are from 20° to 80°, generally not less than 30°, and have a vertical range extending from the lower Cretaceous into the Tertiary.

The character of the oil is similar in a general way to California petroleum, and ranges from dark green to black in color and from 27° to 35° Baumé in weight. The harbors in this section are poor, and landing is attended with more or less difficulty. The surrounding country is a wilderness.

STATE TESTS.

Refined-petroleum test, State requirements, for illuminating petroleum.

The States which use neither open nor closed testing instruments, and in fact, do not exact any test requirements, are Arizona, California, Colorado, Idaho, Indian Territory, Maryland, Mississippi, Nevada, Oregon, South Carolina, Virginia, Washington, West Virginia.

States which have incorporated within their laws the use of the open Tagliabue fire-test cup, with limits as shown, are as follows:

	Degrees F.
Arkansas, fire test	130
Connecticut, fire test	110
Delaware, fire test	110
Florida, fire test	130
Georgia, fire test	120
Illinois, fire test	150
Kentucky, fire test	130
Louisiana, flash	125
Maine, fire test	120
Massachusetts, fire test	110
Minnesota, fire test	120
Missouri, fire test	150
Montana, flash	110
New Hampshire, fire test	120
New Mexico, fire test	120
Pennsylvania, fire test	110
Rhode Island, fire test	110
Tennessee, flash	120
Texas, fire test	110
Vermont, fire test	110
Wisconsin, fire test	120
Wyoming, fire test	150
States using the closed test cups and limits, as shown:	
Indiana, Indiana, flash	120
Iowa, Elliott, flash	105
Kansas, Foster, flash	110
Michigan, Foster, flash	120
Nebraska, Foster, flash	100
North Carolina, Foster, flash	100
New Jersey, Elliott, flash	100
New York, Elliott, flash	100
North Dakota, Foster, flash	100
Ohio, Foster, flash	120
South Dakota, Foster, flash	105
Utah, Foster, flash	110

FOREIGN COUNTRIES.

CANADA.

Although considerable prospecting was done in the Canadian oil fields during 1898, and a number of promising new pools were developed, the total production was not increased over 50,000 barrels above the previous year.

The discovery of oil in southwestern Ontario was almost contemporaneous with the origin of the petroleum industry in Pennsylvania. Oil was collected from springs and artificial excavations in the soil for many years prior to Colonel Drake's first well on Oil Creek, but no wells were sunk for oil in Canadian soil prior to 1860. The Canadian oil industry may be said to be of the same age as that of the United States, but there the parallel ends. The value of the oil produced has seldom exceeded a million dollars per annum. The wells are shallow and very small, ranging from 375 to 420 feet in depth and averaging about one-fifth of a barrel production daily. There were reported to be about 10,000 wells in the Canadian oil fields producing during 1898, and their average daily yield for the year was only a little above 2,000 barrels. The majority of the wells are controlled by small owners, the 10,000 wells, which are spread over miles of country in southwestern Ontario, being divided among nearly 700 different persons.

The financial condition of the Canadian oil industry has been far from satisfactory for many years, although the market price has generally ruled higher than in the United States, owing to import duties. The Petrolia Topic (published at Petrolia, Ontario) of May 2, 1899, made the following statement:

> We would say as an opinion, well based, that if it were possible to get at figures it would be found that for the past twenty years the profits on the entire Canadian investment in oil have not realized a yearly net profit of over 5 per cent. The monthly production of the different fields to-day is made up as follows: Petrolia, 45,000 barrels; Oil Springs, 11,000 barrels, and Bothwell, 6,000 barrels. With an assurance from the government of noninterference of any kind for, say, five years, we could put our yearly production of crude to 1,000,000 barrels. All we need to be possessed of is confidence, and if well seated on that we will continue to cause "rivers of oil" to flow from the bowels of the earth.

Almost all of the production of petroleum in Canada comes from the Corniferous limestone, and nearly every well is torpedoed before it is put to pumping. A number of wells on Pelee Island, Lake Erie, have found oil in paying quantities in the Clinton limestone. Several deep wells have recently been drilled into the Trenton limestone in Essex County, Ontario, that failed to find anything but a show of oil in the top of that formation and below a big flow of salt water was encountered. In the Gaspé district, near the extreme eastern limit of the Province of Quebec, a number of deep wells have been drilled and some very good petroleum found, but in small quantity. Operations in the way of prospecting continue on the Athabasca and Peace rivers, but without success.

PRODUCTION.

Canada estimates her production of crude petroleum in barrels of 35 imperial gallons; this barrel is almost the exact equivalent of the American barrel of 42 standard gallons. The imperial or Canadian gallon is about one-fifth larger than that of the United States.

The total yield of Canadian oil for 1898, as estimated by the Canadian geological survey from the returns of the refinery inspectors, was 758,391 barrels, valued at $1,061,747. Compared with 1897, this was an increase of 48,534 barrels in amount and $50,201 in value. The average price for the year was $1.40 per barrel, which was 2½ cents below the average for the preceding year.

The number of producing wells in the Canadian oil fields at the close of 1898 was estimated at 10,000.

Another authority, the Imperial Oil Company, of Canada, has made the following statement of the production of crude petroleum in Canada in the year 1898, by districts:

Production of crude petroleum in Canada in 1898, by districts.

[Barrels of 35 imperial gallons, or about 42 standard gallons.]

Petrolia	513, 179
Oil Springs	133, 366
Bothwell	66, 404
Plympton	25, 000
Dawn	5, 923
Euphemia	5, 227
Zone	901
Total	750, 000

The total value of this crude petroleum, f. o. b. at refinery, was $1,080,973.

In addition to the above production a small quantity of crude was produced in the Dutton district in 1898.

Canadian import duties on petroleum.

	Per barrel.
Crude petroleum, $3\frac{1}{5}$ cents per imperial gallon	$1. 12
Illuminating oil, etc., $7\frac{1}{5}$ cents per imperial gallon	2. 52
Lubricating oil, 6 cents per imperial gallon	2. 10

SHIPMENTS.

The following table shows the shipments of crude and refined petroleum, reduced to crude equivalent, from Petrolia and Oil Springs in 1897 and 1898, which represents about 80 per cent of the total production in Canada:

Shipments of crude petroleum and refined petroleum reduced to crude equivalent from Petrolia, Canada, in 1897 and 1898, as furnished by the Petrolia Topic.

[Barrels of 35 imperial gallons.]

Month.	1897.			1898.		
	Crude.	Refined.	Crude equivalent.	Crude.	Refined.	Crude equivalent.
January	17, 883	25, 869	82, 556	15, 778	17, 285	58, 991
February	16, 010	20, 467	67, 178	12, 044	15, 067	49, 712
March	13, 170	15, 920	52, 971	11, 882	13, 240	44, 982
April	13, 014	9, 023	35, 572	9, 934	9, 832	34, 514
May	17, 604	17, 187	60, 572	14, 480	7, 214	32, 515
June	15, 716	15, 710	54, 991	15, 507	8, 464	37, 667
July	12, 656	13, 986	47, 622	12, 505	8, 213	33, 038
August	15, 073	22, 752	71, 953	11, 856	15, 142	49, 711
September	18, 045	34, 122	103, 351	11, 286	21, 239	64, 384
October	17, 123	41, 646	121, 238	9, 508	24, 493	70, 741
November	16, 760	35, 946	106, 625	12, 757	19, 783	62, 215
December	18, 767	25, 396	82, 257	12, 899	20, 061	63, 052
Total	191, 821	278, 024	886, 886	150, 436	180, 033	601, 522

The Canadian barrel has 35 imperial gallons of 277.27 cubic inches, making 9,704.4 cubic inches; the United States barrel has 42 gallons of 231 cubic inches, making 9,702 cubic inches—a very slight difference. The imperial or Canadian gallon is 20 per cent, or one-fifth, larger than the United States gallon.

The following table gives the shipments from the Petrolia oil field by railroad, in gallons, for each month from 1894 to 1898:

Shipments of crude petroleum from the Petrolia (Ontario) oil field from 1894 to 1898.

[Barrels of 35 imperial gallons.]

Month.	1894.	1895.	1896.	1897.	1898.
January	101,570	89,462	83,495	82,556	58,991
February	76,183	83,497	66,797	67,178	49,712
March	60,661	66,943	65,283	52,971	44,982
April	73,463	60,287	71,133	35,572	34,514
May	67,369	64,120	43,386	60,572	32,515
June	57,830	59,982	48,459	54,991	37,667
July	69,586	62,410	60,833	47,622	33,038
August	86,345	78,173	78,518	71,953	49,711
September	109,973	102,309	116,144	103,351	64,384
October	156,163	141,787	129,913	121,238	70,741
November	122,513	101,100	103,834	106,625	62,215
December	97,170	102,115	94,486	82,257	63,052
Total	1,078,826	1,012,185	962,281	886,886	601,522
Shipped by pipe line	10,000				
Total	1,088,826	1,012,185	962,281	886,886	601,522

In the following table is given a statement of production from 1881 to 1898, which is based on calculations furnished by the customs inspection returns, and the values are computed at the average yearly price per barrel.

Canadian oils and naphtha inspected and corresponding quantities of crude oil.

Year.	Refined oils inspected.	Crude equivalent calculated.	Ratio of crude to refined.	Equivalent in barrels of 35 gallons.	Average price per barrel of crude.	Value of crude oil.
	Gallons.	*Gallons.*				
1881..	6, 457, 270	12, 914, 540	100: 50	368, 987	....	....
1882..	6, 135, 782	13, 635, 071	100: 45	389, 573	....	....
1883..	7, 447, 648	16, 550, 328	100: 45	472, 866	....	....
1884..	7, 993, 995	19, 984, 987	100: 40	571, 000	....	....
1885..	8, 225, 882	20, 564, 705	100: 40	587, 563	$0. 82¼	$483, 271
1886..	7, 768, 006	20, 442, 121	100: 38	584, 061	. 90	525, 655
1887..	9, 492, 588	24, 980, 494	100: 38	713, 728	. 78	556, 708
1888..	9, 246, 176	24, 332, 042	100: 38	695, 203	1. 02⅝	713, 695
1889..	9, 472, 476	24, 664, 144	100: 38	704, 690	. 92¾	653, 600
1890..	10, 174, 894	26, 776, 037	100: 38	795, 030	1. 18	902, 734
1891..	10, 065, 463	26, 435, 430	100: 38	755, 298	1. 33¾	1, 010, 211
1892..	10, 370, 707	27, 291, 334	100: 38	779, 753	1. 26¼	984, 438
1893..	10, 618, 804	27, 944, 221	100: 38	798, 406	1. 09½	874, 255
1894..	11, 027, 082	29, 018, 637	100: 38	829, 104	1. 00¾	835, 322
1895..	10, 674, 232	25, 414, 838	100: 42	726, 138	1. 49⅝	1, 086, 738
1896..	10, 684, 284	25, 438, 771	100: 42	726, 822	1. 59	1, 155, 647
1897..	10, 434, 878	24, 844, 995	100: 42	709, 857	1. 42½	1, 011, 546
1898..	11, 148, 348	26, 543, 685	100: 42	758, 391	1. 40	1, 061, 747

The average price paid for oil is given in the following table. Sales at the Petrolia Oil Exchange have ceased, producers now making sales direct to the refiners, who own a considerable part of the production.

Average price and sales of crude petroleum in Canada from 1885 to 1898.

Year.	Price.	Sales.
		Barrels.
1885	$0. 82¼	871, 500
1886	. 90	782, 570
1887	. 78	406, 203
1888	1. 02⅝	516, 007
1889	. 92¾	400, 932
1890	1. 18	394, 924
1891	1. 33¾	377, 453
1892	1. 26¼	165, 315
1893	1. 09½	20, 941
1894	1. 00¾	32, 348
1895	1. 49⅝	9, 755
1896	1. 59	0
1897	1. 42½	0
1898	1. 40	0

Average closing prices for crude oil on Petrolia Oil Exchange.

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	$1.30	$1.29¼	$1.18¼	$1.01¼	$1.16	$1.72	1.50	$1.40
February	1.28½	1.29	1.18¾	1.01	1.19⅞	1.72	1.50	1.40
March	1.31¾	1.27¾	1.19	1.01	1.27	1.72	1.50	1.40
April	1.37	1.26	1.19	.99½	1.55¾	1.72	1.40	1.40
May	1.37½	1.25¾	1.07	.92	1.67¼	1.70	1.40	1.40
June..........	1.37	1.27½	1.07	.92¾	1.52	1.50	1.40	1.40
July	1.33½	1.26½	1.06	.94	1.54¼	1.50	1.40	1.40
August........	1.34¾	1.26	1.05	.96	1.54	1.50	1.40	1.40
September ...	1.35	1.26¼	1.04½	.98	1.55½	1.50	1.40	1.40
October	1.35	1.26¾	1.04	1.06	1.59⅞	1.50	1.40	1.40
November....	1.33¼	1.25	1.04	1.12¼	1.64½	1.50	1.40	1.40
December	1.31½	1.18½	1.02	1.13½	1.72⅜	1.50	1.40	1.40
The year.	1.33¾	1.26¼	1.09½	1.00¾	1.49⅜	1.59	1.42½	1.40

The following statements, furnished by the department of agriculture, Ottawa, show the operations of the refineries in Canada from 1890 to 1898 inclusive:

Production of Canadian oil refineries from 1890 to 1898.

[Imperial gallons.]

Year.	Illuminating oil.		Benzine and naphtha.		Paraffin oils.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
1890...	11,129,277	$1,264,677	636,247	$37,026	446,888	$64,713
1891...	10,427,040	1,170,241	603,971	36,790	622,287	75,772
1892...	10,806,806	1,176,720	793,263	60,130	1,051,163	127,351
1893...	11,100,810	1,073,738	721,192	54,760	1,243,924	116,233
1894...	11,289,741	1,003,973	645,031	54,515	1,282,749	118,053
1895...	10,711,378	1,217,426	642,484	63,026	1,016,039	140,245
1896...	11,207,150	1,251,122	719,453	70,733	1,014,271	132,308
1897...	10,493,449	1,064,130	747,163	71,978	930,490	136,283
1898...	11,804,667	1,189,871	1,229,407	120,651	850,863	114,191

Production of Canadian oil refineries from 1890 to 1898—Continued.

[Imperial gallons.]

Year.	Gas and fuel oils.		Lubricating oils and tar.	
	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*	
1890	4,246,447	$84,752	2,877,388	$130,349
1891	3,373,720	89,267	2,500,000	101,752
1892	6,343,589	202,047	3,177,853	133,336
1893	7,559,489	217,740	1,876,633	92,616
1894	7,323,374	197,193	1,801,174	74,309
1895	6,095,355	218,692	1,698,559	75,578
1896	6,788,353	261,618	1,447,455	77,109
1897	6,723,683	249,615	1,148,847	62,058
1898	6,399,298	245,101	868,957	53,479

Year.	Paraffin wax.		Value of other products.	Total value.
	Quantity.	Value.		
	Pounds.			
1890	913,730	$56,903	....	$1,638,420
1891	741,611	60,687	....	1,534,509
1892	876,570	82,781	....	1,782,365
1893	1,659,167	120,697	....	1,675,784
1894	1,950,172	119,091	....	1,567,134
1895	1,840,021	82,970	$8,300	1,806,237
1896	1,532,670	76,249	7,774	1,876,913
1897	1,805,365	81,191	7,174	1,672,429
1898	2,522,834	101,972	....	1,825,265

The consumption of crude oil at refineries in 1898 was 25,933,807 gallons.

IMPORTS AND EXPORTS.

The Statistical Yearbook of Canada for 1898, issued by the department of agriculture, Ottawa, Canada, gives the following tables, showing the exports and imports of petroleum:

Exports of Canadian petroleum since 1868.

Year ending June 30—	Quantity.	Value.	Year ending June 30—	Quantity.	Value.
	Gallons.			*Gallons.*	
1868.....	46,282	$9,431	1883......	1,422	$368
1869.....	690,553	127,319	1884......	327,563	7,546
1870.....	4,748,557	966,461	1885......	954,966	27,303
1871.....	5,753,678	1,052,870	1886......	260,449	30,957
1872.....	7,897,054	1,341,099	1887......	310,667	11,151
1873.....	9,355,325	1,819,183	1888......	355,501	66,834
1874.....	1,276,641	298,417	1889......	110,470	18,681
1875.....	9,844	1,592	1890......	358,804	15,812
1876.....	14,804	3,363	1891......	436,516	18,726
1877.....	3,926,139	900,542	1892......	440,906	18,217
1878.....	73,590	9,423	1893......	178,101	6,814
1879.....	797,079	97,049	1894......	68,740	2,722
1880.....	10,611	1,059	1895......	63,543	3,572
1881.....	2,456	631	1896......	18,241	2,971
1882.....	662	136	1897......	1,831	230

Exports of crude and refined petroleum.

Year.	Crude.		Refined.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
1881..	....	....	....	....	501	$99
1882..	....	....	....	....	1,119	286
1883..	....	....	....	....	13,283	710
1884..	....	....	....	....	1,098,090	30,168
1885..	....	....	....	....	337,967	10,562
1886..	....	....	....	....	241,716	9,855
1887..	....	....	....	....	473,559	13,831
1888..	....	....	....	....	196,602	74,542
1889..	....	....	....	....	235,855	10,777
1890..	....	....	....	....	420,492	18,154
1891..	446,770	$18,471	585	$104	447,355	18,575
1892..	310,387	12,945	1,146	100	311,533	13,045
1893..	107,719	3,696	2,196	394	109,915	4,090
1894..	53,985	2,773	5,297	513	59,282	3,286
1895..	22,831	1,044	10,237	2,023	33,068	3,067
1896..	601	101	7,489	999	8,090	1,100
1897..	....	....	342	49	342	49
1898..	96	4	12,735	3,001	12,831	3,005

The following table gives the figures of domestic inspected and foreign imported oil since 1882, showing the total quantity of oil consumed in Canada during the period:

Total consumption, Canadian and American oil, 1882 to 1898.

Year ended June 30—	Canadian.	American.	Total.
	Gallons.	*Gallons.*	*Gallons.*
1882	5,910,787	3,026,186	8,936,973
1883	6,970,550	3,088,414	10,058,964
1884	7,656,011	3,148,920	10,804,931
1885	7,661,617	3,813,379	11,474,996
1886	8,149,472	3,803,724	11,953,196
1887	8,243,962	4,309,397	12,553,359
1888	9,545,895	4,493,924	14,039,819
1889	9,462,834	4,723,698	14,186,532
1890	10,121,210	5,075,650	15,196,860
1891	10,270,827	5,321,524	15,592,351
1892	10,238,426	5,793,636	16,032,062
1893	10,683,806	6,249,946	16,933,752
1894	10,825,350	6,666,323	17,491,673
1895	10,928,894	6,752,425	17,681,319
1896	10,530,339	5,804,067	16,334,406
1897	10,502,872	5,665,204	16,168,076
1898	10,796,847	6,880,734	17,677,581

Total amount of oil inspected, Canadian and imported.

Year.	Canadian.	Imported.	Total.	Canadian.	Imported.
	Gallons.	*Gallons.*	*Gallons.*	*Per cent.*	*Per cent.*
1892	10,370,707	2,601,946	12,972,653	79.9	20.1
1893	10,618,804	4,520,392	15,139,196	70.1	29.9
1894	11,027,082	5,705,787	16,732,869	65.9	34.1
1895	10,674,232	5,677,381	16,351,613	65.3	34.7
1896	10,684,284	6,106,032	16,790,316	63.6	36.4
1897	10,434,878	6,628,361	17,063,239	61.2	38.8
1898	11,148,348	6,833,061	17,981,409	62.0	38.0

STATISTICS OF REFINERIES.

In the following table is presented the production of the Canadian oil refineries for 1898:

Production of Canadian oil refineries, 1898.

Product.	Amount.	Value.
Illuminating oils ....gallons..	11,804,667	$1,189,871
Benzine and naphtha..................do....	1,229,407	120,651
Paraffin oils..........................do....	850,863	114,191
Gas and fuel oils.......................do....	6,399,298	245,101
Lubricating oils and tar.................do....	868,957	53,479
Paraffin wax ....pounds..	2,522,834	101,972
Total	....	1,825,265

The consumption of crude oil was 25,933,807 gallons, or 740,966 barrels.

Since the producer received for his oil $1,061,747 during the year the margin of difference in favor of the manufactured article was but $763,518, out of which must be paid expenses of refining, marketing, etc., leaving in the end a net profit that must have been but a small return on the investment.

NEWFOUNDLAND.

The oil regions of Newfoundland lie along the west coast, beginning at St. Georges Bay and extending a little east of north for 125 miles along the seacoast with a general average of about 10 miles. Most of this strip is a comparatively level country, especially the northern half, the eastern terminus being a chain of mountains. The surface is cut into by the streams and bays; there are also numerous lakes or ponds.

There are many fine bays and anchorages along the coast line toward the south end of this section, but toward the north they are poor and far apart.

The petroleum found in this section is said to come from the Quebec group. If this is the case, it is the lowest oil horizon of any field so far developed. This group contains rocks that underlie the Chazy limestone, which in turn underlies the Trenton limestone. In the formation holding the oil there is a series of thin bedded slates, sandstone, and limestone at highly inclined angles.

There are three points at which test wells have been drilled; nearly all of them have found some oil. There are also a number of natural springs scattered along the coast. At the extreme south of the field so far developed, on a narrow projecting point bounding the west portion of Port au Port Bay, there were four wells, drilled in 1898. Three of these struck oil at from 136 to 680 feet in moderate quantities. The shallow well is said to have produced ten barrels per day for a month. The color of this oil is dark amber, the gravity 33° Baumé, and seems to have good lubricating qualities.

Another well was drilled about 1887 at St. Pauls, 25 miles above Bonne Bay, to a depth of 1,700 feet, that produced a green oil of 35.5° Baumé gravity. At Parsons Pond three wells have been put down. Two were drilled in 1897—one 1,450 feet and the other 1,000 feet. Both of these wells found oil. One of the wells was shot, but the amount of oil produced is uncertain. Both, however, produced some oil, which has a dark green color and a specific gravity of 36.5° Baumé. Several companies have been formed to operate these fields. Much of the stock and bonds are reported to have been sold to English capitalists. The locality of this field at tide water makes it particularly interesting.

CUBA.

The existence of petroleum and asphalt deposits in Cuba has been known for a long time. The products are used largely for fuel and lighting purposes at San Juan, and in the province of Santa Clara petroleum has been struck at a depth of 285 feet, the oil having a specific gravity of 0.754. Another well, 175 feet deep, has been obtained at Lagomates, in the province of Matanzas. A mile from the coast, in the same province, there is an extensive occurrence of shale and asphalt, and a similar deposit is found near the harbor of Cardenas, in the province of Havana. Throughout the whole district, near the harbor, there are enormous deposits of asphalt, having a thickness of 70 feet. This asphalt realizes a price of from $80 to $120 per ton in New York. Extensive deposits of asphalt are also found in other districts, a deposit in Pinar del Rio, not far from Havana, having a thickness of 18 feet. The deposits at Canas Tomasita, in the district of Pinar del Rio, are 105 feet in thickness, and about 300 tons have been obtained there. Especially pure asphalt is found near Vuelta, and the exports to the United States are steadily increasing in amount. The asphalt is used largely in Cuba in the manufacture of illuminating gas.

On the Motembo estate, province of Santa Clara, at a location named San Juan, borings were made in 1881, which resulted in discovering, at a depth of 95 meters, a deposit of naphtha of extraordinary purity, colorless, transparent as water, inflammable, leaving no residue after combustion, and of a density of 0.754, which congealed at a temperature of 85° C., dissolved asphaltum and the resins, and which was so volatile that its vapor at ordinary temperature could be utilized as illuminating gas. Nevertheless, this well was abandoned after the workings had reached a depth of 290 meters, although the supply continued at that depth.

A well similar to that of Motembo was discovered at Lagumillas, province of Matanzas, from which, out of a source at a depth of 25 meters (82 feet) there flowed a supply of 70 liters (18½ gallons) per day. This also has never been further explored or worked.

PERU.

Little progress was made in the developments of the Peruvian oil fields during 1898. The production of the Zorritos district shows a very small gain over that of the preceding year. The oil produced belongs to the asphaltum series, and only a very inferior illuminating oil can be manufactured from it. There are three companies operating in Peru, viz, The London Pacific (British); Faustino G. Piaggio (Italian), and Compagnie Français (French). According to the report of the British vice-consul, Mr. Rowland H. East, of Payta, Peru, the property of the London Pacific Company is very extensive, covering an area of nearly 600 square miles. It is 30 miles in length, northwest and southeast, and 20 miles in breadth from the seacoast eastward.

The region selected for the extraction of the crude oil by sinking wells is called "Negritos," latitude 4° 40′ south and longitude 81° 17′ 30″ west of Greenwich, or 6½ miles southeast of Talara, and 11¾ miles west of the district called "Brea," where the asphaltum was first discovered by the indigenes through its oozing to the surface. Its geological formation, verified from surface indications, and the wells sunk, some of them bored, and others deepened lately to 900 feet, proves beyond a doubt that the production is not that of surface filtrations, but due to an established formation. The inclination of the strata is considerable, in some cases 45°, and dips in an eastwardly direction, i. e., inland, so that owing to the slope of the ground, should there be only one oil level, the further inland the wells are sunk the deeper they will have to be bored to tap it, but should there prove to be more than one oil level it may be obtained at different places at a more or less uniform depth from the surface.

Within this region, which at present embraces a distance of about 1¾ miles in length, north and south, and about 1 mile from the seabeach inland, 60 wells have been sunk, some of which have already given out, and a number of others yield an insufficient quantity, but in the opinion of the experts now employed in sinking new wells, if the old ones were cleaned out and deepened the product would double itself.

The London company has a pipe line 6½ miles long, which conveys the oil along the seabeach to a 15,000-barrel tank at Talara, from whence it can be loaded on vessels by gravity. The production of this company is estimated at from 800 to 1,000 tons per month.

The property of the Faustino Piaggio Company is situated at a point called "Zorritos," a considerable distance north of Talara. It embraces an area of 2,160,000 square meters, and has been in operation since 1864, from which time up to date 100 wells have been sunk, all of which have been productive. There are at present only 20 yielding, which, according to data furnished by the owner, produce 10,000 gallons, or about 250 barrels a day.

The property of the Compagnie Français is situated near the port of Grau, and comprises an area of 2,200,000 square meters, and its capital has been augmented from 2,000,000 to 3,000,000 francs. It is still in its infancy, as work was only commenced in the early part of 1897. They have erected machinery, workshops, accommodation for employees, deposit tanks, and a refinery for kerosene, which will be shortly finished. So far they have only sunk 6 wells.

The following are the percentages of products derived from the petroleum:

Products derived from Peruvian petroleum.

	Per cent.
Benzine	10
Kerosene	30
Residuum or fuel oil	50
Loss	10
Total	100

Mr. H. Tweddle, who has just returned from Peru (April, 1899), gives the following information:

The position of the Peruvian petroleum fields has not improved during the past two years.

The most northerly part of the field has been worked for several years past by a French company, generally with unsuccessful results. They have, of course, obtained some oil, but certainly not enough to repay them. They have a tank steamer of rather large capacity, the *Madeleine*, which has been idle or employed in other work than conveying petroleum the most part of the time. Lately, I understand, they have put a limited amount of refined oil on the Peruvian market. The next field to the southward is worked by a Mr. Piaggio on about the same scale that it has been for many years past. Most of his oil reaches the market as refined, and is generally used along the coast. It was reported that Mr. Piaggio had the intention of bringing out a small tank steamer, so as to enter the field of supplying fuel oil to the Callao market, but I do not know whether the steamer has arrived or not.

The southern field around Talara is being worked by an English company, the London and Pacific Petroleum Company, Limited, who have also a tank steamer which is generally used to carry fuel oil (residuum) to Callao, and also distribute the small amount of refined oil they manufacture.

The only place where fuel oil is used to any extent is at Callao, where there are three terminal deposits (one belonging to each of the above companies). Here and at Lima the fuel oil is used in a number of small factories and shops, and was up to lately generally used by the railroad and the Casapalca Smelting Works. During the last year the supply was rather low, and I understand some of the consumers were unable to get as much as they required. Generally speaking, I do not think the sales of fuel oil would amount to over 1,000 tons a month, if that.

I am informed that but little development work has been done in the last few years, and no large wells have been struck. It is probable that but little progress will be made in the work for sometime, owing to the fact that a rainy season is now in progress on the northern Peruvian coast. (The first they have had since 1890.)

These rainy seasons are generally seven years apart, but when they do come they are torrential, with the result that agriculture and cattle raising take a great impetus. (Rainy seasons are there known as "fat years" or "years of plenty.") Labor, of course, is in great demand, prices rise, and what trading there is becomes much more brisk. The effect on the petroleum industry, however, is the opposite, as the heavy rains generally do a great deal of damage, washing away pipe lines, choking wells, etc.; consequently it is to be presumed that the production of oil will diminish instead of increase.

Attempts have been made during the past two years to form companies with Peruvian capital to open up the petroleum deposits, but so far with no results.

The tax on importing crude oil into Peru has been greatly diminished with the view, as I was told, of asking the United States to rescind the import tax which was placed on crude oil about 1894. This will, however, make but little change, owing to the fact that the position of the Peruvian oil fields is a peculiar one. Peruvian crude oil contains only a small proportion of "refined," and that not of a very good quality. On the other hand, it has a very large proportion of very volatile oils, benzine, etc., and the residuum (say 50 per cent to 60 per cent) is an excellent lubricating or fuel oil.

The native manufactured kerosene will not have a large sale outside of Peru, where it is protected by a heavy import duty, not only on account of its quality, but the tins and cases can not be manufactured in Peru so cheaply as in the United States, for the simple reason that the tin has to be imported from England, and pays a duty, and the lumber for the boxes comes from the United States, and no "drawback" is allowed by the Peruvian Government when these articles are exported.

Moreover, the Peruvian market for petroleum or any of its products is a limited one. Probably not more than 3,000 tons monthly could be sold in the country. This would be equal to about 1,000 barrels a day, and when this amount is reached it would be difficult to find a foreign market until the probable consumers were guaranteed a sure and steady supply of a very large quantity, and thus it seems that a far larger capital would have to be invested for transportation, storage, and generally in developing the petroleum fields.

The following statement of the production of petroleum in the Zorritos oil field of Peru has been furnished by Mr. Faustino G. Piaggio, who is operating in that field:

Production of petroleum in Zorritos oil field of Peru in years 1896, 1897, and 1898.

Year.	Crude petroleum.	Refined.	Lubricating oil.	Benzine.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*
1896	1,996,520	608,900	896,450	4,650
1897	2,874,980	959,645	964,680	7,940
1898	2,880,000	600,000	1,250,000	8,350

During the year 1898 there were shipped from Zorritos 9,239 tons of products of petroleum. These products were not classified in the custom-house. It is judged that not more than 2,000 tons were crude and residuum, the balance being kerosene.

In the following table a statement is given of the shipments of crude petroleum and its products from Talara, Peru, in 1898:

Shipments of petroleum and its products from Talara, Peru, in 1898.

Month.	Kerosene.	Benzine.	Crude petroleum.	Brea.	Residuum.
	Imp. galls.	*Imp. galls.*	*Tons.*	*Pounds*	*Tons.*
February	84,000	100	853	15,000	
April	66,600	1,500	800		600
June	91,000	1,000	300	19,500	1,150
September	55,230		200		800
October	30,000		840		
November			800		100
December	18,500		330		460
Total	345,330	2,600	4,123	34,500	3,110

All these products were shipped to home ports, none going to west-coast republics.

RUSSIA.

An exhaustive account of the Russian oil fields was given in the report on the production of petroleum for 1897, and it is unnecessary to repeat it here.

Developments continued very actively in 1898, and the influx of a large amount of foreign capital had a highly favorable effect upon the industry. The average daily production of the Russian oil fields in 1898 was over 20,000 barrels a day greater than that in 1897, and for the first time in the history of the business the Russian output of petroleum exceeded that of the United States. The increased production was gained from an increase in the number of wells, as the average output of all the wells in the field has declined from 226 barrels a day in 1896 to 211 in 1897 and to 199 in 1898. A peculiarity of the Russian oil wells has been the constancy with which their production could be maintained by simply drilling them deeper. The first weakening of the wells was observed in 1897, and as it increased in 1898, it gives the falling off an appearance of permanency. This would indicate that the future supply of Russian oil must come from extending the area of the old territory or the discovery of new. The enormous supplies of the Apsheron Peninsula are at last showing signs of exhaustion.

Mr. J. C. Chambers, in his annual report on the Russian oil industry, says:

The average daily production in 1897 increased over that of 1896 about 12,000 barrels, by the completion of 209 wells, i. e., about 60 barrels per well; the increase in 1898 from the completion of 258 wells was about 20,000 barrels, or about 80 barrels per well. This would apparently refute any idea of a falling off in the production of the wells without the explanation that in 1898 one well produced about 4,000,000 barrels in less than two months, making about 11,000 barrels per day for the whole year. Consequently, if this phenomenally large well be eliminated, the increase in 1898 from the other 257 wells completed was only about 10,000 barrels, or not more than 40 barrels per well.

The large well mentioned was located in the Bibi-Eibat district, which district is at present not more than 500 acres in area. It is an old section and has had some big wells, and many which, although they could not be called large, were exceedingly good wells for their owners, from depths less than 1,000 feet; but in the last three years the drilling has steadily deepened, the average depth having been 1,169 feet in 1896, 1,420 feet in 1897, and 1,595 feet in 1898. In 1898, 10 wells in this district produced over 7,000,000 barrels from depths between 1,400 and 1,500 feet; and the inference seems reasonable that although the territory is by no means exhausted, as is evinced by the many good pumping wells, the gas at the depth mentioned is no longer sufficiently strong to produce large flowing wells, and that, consequently, unless deeper strata rich in oil and gas be found, the district has seen its best days.

Of the 10 wells alluded to as having produced 7,000,000 barrels last year, 3 produced 6,000,000 barrels, or more than 16,000 barrels per day. Eliminating these 3 wells, the increase last year for the other 255 wells is left at only about 4,000 barrels per day.

I call attention to these facts simply that the statistics may be properly understood, as I believe they mean that unless deeper and equally rich strata be found in this district, or other rich territory be found to replace it, it will require much more drilling in the future than in the past to materially increase the Baku production.

The gross production of crude petroleum in Russia, at Baku, was 60,597,544 barrels in 1898, as compared with 54,744,303 barrels in 1897 and 49,633,252 barrels in 1896. The increase in the past year was 5,853,241 barrels, or about 10.7 per cent. The gross increase for 1897 over 1896 was 5,110,151 barrels, or a gain of 10.3 per cent. If to this production is added the yield of the Grosni and other districts, which was estimated at 1,800,000 barrels in 1898 and 2,350,000 barrels in 1897, it will make the total production in Russia in round numbers 62,397,544 barrels in 1898 and 57,100,000 barrels in 1897.

Improvement in the quality of Russian refined oil is noted by most foreign correspondents, but there is still room for a great diversity of opinion on the subject. The European markets have been filled with the cheaper articles of the Russian refineries, but the United States has continued to find room for all the oil it was able to ship abroad and at advanced prices. The Russian producers devote their energies to a large extent in supplying the demand for fuel oil, which is constantly increasing in the East, and little attention is devoted to manufacturing a good article of refined oil. Besides, only from 26 to 30 per cent of the Russian product is available for illuminating purposes, while some of the petroleum obtained in the United States will run from 75 to 90 per cent and the general average is from 65 to 70 per cent of refined oil, while one barrel of crude petroleum in this country represents at least 90 per cent of marketable products a barrel of Russian petroleum yields from 33 to 36 per cent.

The crude oil produced at Baku has been deteriorating for the past four years, and the percentage of illuminating oil obtained is gradually growing smaller. The percentage of refined oil has declined at the Baku refineries as follows: 1895, 26.5 per cent; 1896, 24 per cent; 1897, 22.3 per cent; 1898, 20.5 per cent. This indicates a loss of 6 per cent in the past four years. Little change has been noted in the percentage of lubricating oil, while the residuals have increased from 50.2 per cent in 1895 to 54.4 per cent in 1898. This would indicate that the Baku production was growing heavier in gravity. The same complaint has been made against Russian crude oil by the Austrian refineries at Fiume and Trieste, which formerly depended largely for their supply of crude petroleum upon the Baku oil fields. Purchasers of Baku crude now stipulate a specific gravity of 28° and even 27° Baumé, while a few years ago they insisted upon a weight of 30°. The specific gravity of the residuum has decreased from 26° to 23° to 25°. Prices of refined oil rule low. A great deal of crude is shipped directly from the wells as residuum, instead of having the lighter products taken out before being employed for fuel purposes, which is a most dangerous practice. With low-priced refined and high-priced residuum only sufficient illuminating distillate is removed to bring the residuum up to the proper specific gravity. This shows that Russian refined is considered by the refiners themselves as a by-product, and that they recognize the fact that the proper market for their oil is for fuel purposes. Whatever is obtained for the refined is looked upon as mostly clear profit. The producers simply arrange the process of distillation to suit the market.

RUSSIAN OIL FOR FUEL.

As the greater portion of the Russian oil product enters into consumption as fuel oil, the system of manufacture generally employed at Baku will prove of interest. After leaving the well the oil is run into shallow basins dug in the ground, and remains there for a time, in order to allow the sand to settle to the bottom. If left too long, its valuable lighter constituents evaporate and it soon becomes useless for anything save burning for fuel. It is next pumped into iron tanks and finds its way through pipes to the refineries. These are now of modern construction and well adapted in every way for the distillation of crude petroleum. The oil, on its arrival at the refinery, is pumped into large iron stills and raised to any temperature desired by superheated steam, introduced in pipes. The most volatile substances, the benzine and gasoline, are first taken off and then the kerosene, usually of a specific gravity between 0.780 and 0.860. The remainder is called astatki, petroleum refuse, or residuum. This last product is a dark viscous fluid, not much more inflammable than vegetable oil and less so than coal. As a steam producer it has no rival, and the demand for this purpose is constantly on the increase. Nothing else is burned on the railways of central Asia, the Caucasus, and southern Russia, and on the Black Sea, the Caspian Sea, and the Volga River steamers, together with innumerable industrial works that are springing into existence throughout Russia. In the railways which employ this residuum, or astatki, for fuel the locomotive tenders are provided with iron astatki tanks, and from them the fuel oil is fed to the furnaces of the locomotive through pipes, and is sprayed into the fire box by means of a steam jet or compressed air.

An English writer, who has studied the use of Russian petroleum refuse for fuel purposes at close range, says:

> Numerous are the systems of feeding furnaces with astatki, and indeed every engineer has his own pet apparatus. The principle of all is that of the Root blower. A current of air or steam, carrying with it the fuel in minute subdivisions, is forced at high pressure through a nozzle, called a "pulverizer," into the fire box of the boiler to be heated. The result is an intensely yellow-white roaring flame. In the apparatus of the latest type the value of astatki as compared with coal as a steam raiser is as 2½ to 1. The former sells at Baku at 10s. 6d. per ton, and when the pipe line connecting Baku with Batoum is completed, it will be delivered at the steamer's side in the Black Sea at a price with which coal can not compete. But the advantages of astatki do not end with its cheapness. Engines burning it require no army of stokers, for all that is necessary in the largest is a man to regulate the supply by taps. There is no smoke, litter, or dust. Many a passenger by ocean steamer will bless the day when astatki supplants coal, and the stokers who are almost roasted alive in tropical waters will have still greater reason to be thankful for the revolution.

It is estimated that the railways of Russia consume about 65,000,000 poods per annum of this liquid fuel astatki, which is very nearly equivalent to 8,000,000 barrels of 42 gallons each. The price averaged nearly 60 cents a barrel in 1898. It represents an outlay of $4,800,000.

THE RUSSIAN PIPE LINE.

Slow progress has been made on the pipe line between Michailov and Batoum, destined to convey the product of the Baku petroleum field to the Black Sea. As long ago as March 3, 1890, the Russian Government granted the concession authorizing the construction of this line. The carrying out of the scheme was allowed to languish until the winter of 1895–96, when the oil trade suffered enormous losses through the railway being washed away and the petroleum industry almost came to a standstill. It was then decided to begin at once to build a pipe line connecting Michailov and Batoum, which section suffers most from floods and severe storms. It was stipulated that the pipe must be of Russian manufacture, and on May 23, 1896, the state council approved the estimate of 5,105,000 rubles (about $625,000) for it.

Russian engineers began to plan the line, but it was nearly a year before they presented their drawings and before the first portion of the pipe arrived. The total length of this portion of the line was 144 miles. The pipe was to be 8 inches in diameter, and pump stations were to be erected at Michailov, Samtredi, and Soupsa, which were respectively 92, 30, and 30 miles from each other. The pipes were tested to stand a pressure of 120 atmospheres, it is said, but the Russian manufacturers failed to fulfill their contracts, and a vast amount of time and labor has been spent in endeavoring to manufacture pipes that will stand the required pressure without leaking. Pumps for these pump stations have been furnished by a United States manufacturer. At Batoum the pumping station will have four pumps, of which two are of the Blach system and two of the Worthington compound system, with special arrangement. From the stations two 8-inch pipes are carried along the breakwater, and from the main pipe branches they will be carried from the various factories to the docks. All arrangements are made in such a manner that within fifteen hours a tank steamer of 4,000 tons capacity can be completely filled, while at the same time oil can be pumped into the tanks of local exporters.

It is doubtful if the line will be completed and ready for use before the close of 1899.

Of this pipe line Mr. Chambers's report has the following:

It will naturally seem to the American familiar with pipe-line construction that three years is a rather long time for the construction of 145 miles of 8-inch pipe along the line of a railway where distribution of pipe is extremely easy, but their judgment is based upon a knowledge of how such work is done in the United States. No one here would express surprise that the work has not been done more rapidly.

It seems that the delay in this undertaking is entirely due to the difficulty in getting pipe. About three years ago an American-Russian company was organized for the manufacture in Russia of iron of every description from the ore which the company was to mine. This company secured the contract for the pipe for this line, or at least 125 miles of it, which was to be delivered before December 31, 1897, and in order to fulfill this contract they secured a pipe mill from an American manufacturer and sufficient skilled workmen to run it. This mill was established in the south of Russia, and two years ago this month it commenced making pipe, but so much of it was rejected by the inspectors that I believe even now they have about 50 miles yet to deliver. I think the work of constructing the line is not pushed because of the uncertainty of the delivery of the pipe. The line might easily be completed in two or three months if the pipe were on hand.

The object in constructing this pipe line is to add to the transportation capacity of the railway, as the refined (the line is for this class of oil only) will be brought by rail to Michailov, a distance of about 415 miles from Baku, and from there piped to Batoum. As before mentioned, the line is 8-inch and the pumps are of the most approved American pattern, made in the United States under the inspection of a Russian engineer especially for this line. One set of the pumps—i. e., for one pumping station—has already been delivered and the others are en route, so that there is no detention because of the pumps. The first pumping station will be at Michailov, by which the refined oil will be forced, over an elevation of 500 to 600 feet, a distance of 77 miles to the station of Samtredi, a fall of probably 2,000 feet from the summit. From Samtredi there is not much of a fall to Batoum. It is gradual, and there are no elevations to overcome, but about halfway between Samtredi and Batoum there will be still another station. How much this line will increase the transportation capacity of the railway seems to be an open question here. It may, however, reduce the cost.

THE RUSSIAN OIL FIELDS.

The entire production at Baku comes from a remarkably small area, although geological investigations show that there are over 16,000 acres that must be considered as petroliferous land. Only about 10 per cent of this area has been thoroughly explored in the vicinity of Baku. The geological committee at Tiflis has reported that the following new districts are rich in petroleum deposits: All the area lying between Saboountchy and Surachina on the line to Sichi; also Kasanaur near Lake Benkshar; all the fields near Bailoff Bay and the entire district from Lake Masasirski to Ordjaudag hill and also the south side of Lake Masasirski to the Beuk-dag hill, and lastly the territory southeast of the village of Fatma.

Baku is a modern city of 120,000 people. In 1866 it contained but two refineries and land could be had for almost nothing. There are now over 100 works. The shops are poor and pavements miserable. Oil is burned in street lamps, although natural gas might be utilized for street illumination with little trouble. The oil belt is at least 18 miles in length and 2 miles in breadth. Most of the territory worked at present is at Balakhany and Bibi-Eibat, at the northeast and southwest extremities of the belt. It is reasonable to suppose that the intervening area is equally as rich as that already developed. The hills near Puta, the first station on the railway west of Baku, are likewise rich in petroleum deposits. The lands are owned by Tartars and Armenians, who decline to sell outright, but are ready to grant perpetual leases to anyone obtaining concessions from the Government, at one-third royalty.

PRICE OF RUSSIAN OIL.

Mr. Chambers's report contains the following information in regard to the price of the Russian petroleum:

In my report on the trade for 1897 I stated that the price of crude oil at the refineries had reached 42 cents per barrel at the end of the year. At that time that price seemed much too high to continue a great while, as the production was rapidly increasing and reached the unprecedented average of over 217,000 barrels per day in February, 1898. Notwithstanding this enormous gain in production and a continuous increase throughout the year, the price of crude oil steadily advanced until it reached 55 cents per barrel about the close of the Volga navigation season, and has practically not receded from that figure, although from the end of October to the middle of March there is practically no shipment of residuum, and the shipment of other products is limited by the export demand and the capacity of the railway to Batoum. At present, with the opening of Volga navigation at least a month off, there have been no sales of crude oil for future delivery reported for some time. Some sales for immediate delivery are daily reported at about the highest price named, viz, 55 cents per barrel, and the newspapers report the market to be very firm, which I can understand, for in previous years at this season all sales, or the most of them, were for oil to be delivered throughout the season of Volga navigation, as buying spot crude oil means holding it some time before it can be realized on; consequently, the season delivery price is always higher than spot oil prices.

This state of affairs undoubtedly explains the great increase and energy in drilling. There is no doubt that increased depth raises the cost of crude oil, but such advance in cost is insignificant in comparison with the increase in the price of crude oil. I stated in a previous report that the highest estimate of the cost of producing crude oil which I had heard was 4 copecks per pood, or about 17 cents per barrel, and this cost, plus the most liberal allowance for increase because of deeper drilling, certainly leaves a sufficiently wide margin for profit to induce the greatest energy in drilling; besides, there is always the chance of a big flowing well, one of which in a year will materially reduce the producer's cost of crude oil, and consequently greatly increase his profits. But taking the average well—i. e., about 200 barrels per day—at present prices the income is not less than $100 per day, and at that rate it does not take many days to get the cost of the well back. Where there are never any absolute failures and the average well will pay for itself in four or five months, it is not remarkable that every man who can get money or credit is plunging into the producing business.

PRODUCTION.

The total production of crude petroleum in the Apsheron Peninsula and the shipments of the chief petroleum products from Baku from 1880 to 1898 have been as follows:

Total production of crude petroleum on the Apsheron Peninsula and shipments of petroleum products from Baku from 1880 to 1898.

[Barrels.]

Year.	Production.	Shipments from Baku.					
		Illuminating.	Lubricating.	Other products.	Residuum.	Crude oil.	Total.
1880......	3,055,247	976,933	....	....	867,416		1,844,349
1881......	4,889,640	1,564,337	....	....	1,136,228		2,700,565
1882......	6,111,740	1,650,207	37,335	....	2,200,276		3,887,818
1883......	7,333,838	1,833,149	139,384	....	2,297,347		4,269,880
1884......	11,002,624	2,689,365	182,941	....	3,569,226	....	6,441,532
1885......	14,179,833	3,666,297	195,386	....	4,144,185		8,005,868
1886......	18,336,463	4,278,591	207,831	....	4,424,198		8,910,620
1887......	20,170,856	5,378,729	281,257	....	5,072,582		10,732,568
1888......	23,471,270	6,111,739	317,348	....	7,150,897		13,579,984
1889......	25,060,496	7,469,438	415,648	....	10,831,296	550,122	19,266,504
1890......	29,217,126	8,227,384	562,347	....	11,858,191	855,745	21,503,667
1891......	35,206,905	9,046,454	623,472	....	12,640,386	1,454,969	23,765,281
1892......	36,430,248	9,608,801	696,821	....	14,254,280	1,466,993	26,026,895
1893......	41,198,085	10,501,222	709,046	....	17,542,787	1,577,018	30,330,073
1894......	37,811,773	8,704,156	782,396	....	23,667,482	2,102,690	35,256,724
1895......	47,713,983	9,898,288	825,489	130,465	22,050,232	1,849,780	34,754,254
1896......	49,633,252	10,569,670	1,084,095	123,753	22,616,271	3,117,898	37,511,687
1897......	54,744,303	11,042,054	1,114,180	144,988	27,106,357	2,896,333	42,303,912
1898......	60,597,544	11,569,804	1,273,961	177,262	29,628,484	5,365,770	48,015,281

The above table gives the production and shipments of refined products and residuum from Baku. A part of the refined products and the residuum goes to inland ports by way of the Caspian Sea and the Volga River. The larger portion is shipped by rail to Batoum, on the Black Sea, and from there distributed. The average price of illuminating petroleum free on board at Batoum is quoted at 38 copecks per pood, equal to $1.80 per barrel (8.18 poods = 1 barrel; 36.112 pounds = 1 pood; 0.582 cents = 1 copeck).

Two distinct statements in regard to the production of Russian crude petroleum are given. One is known as "total production," which includes not only the crude, collected and refined, or sold as fuel oil, but also an estimate of the oil wasted or not collected, as well also as that used for fuel for pumping the wells. The second statement shows "profitable production;" that is, the amount of crude oil put into tanks or reservoirs.

The "profitable production" for the last eleven years is shown in the following table:

"Profitable production" of crude petroleum in the Apsheron Peninsula from 1888 to 1898.

[Barrels of 42 gallons.]

Year.	Production.	Year.	Production.
1888	22, 249, 389	1894	36, 375, 428
1889	23, 502, 163	1895	46, 140, 174
1890	27, 660, 953	1896	47, 220, 633
1891	33, 565, 819	1897	51, 645, 568
1892	35, 026, 144	1898	59, 409, 357
1893	39, 703, 304		

The divisions of this "profitable production" among the four subfields on the Apsheron Peninsula are as follows:

"Profitable production" of the several fields of the Apsheron Peninsula from 1889 to 1898.

[Barrels.]

Year.	Balakhany.	Saboontchy.	Romany.	Bibi-Eibat.	Total.
1889	8, 424, 364	12, 905, 012	....	2, 172, 787	23, 502, 163
1890	7, 742, 995	17, 525, 134	189, 022	2, 203, 802	27, 660, 953
1891	9, 067, 861	19, 992, 359	1, 585, 342	2, 920, 257	33, 565, 819
1892	7, 025, 973	18, 916, 516	5, 017, 286	4, 066, 369	35, 026, 144
1893	7, 070, 101	17, 883, 692	8, 943, 313	5, 806, 198	39, 703, 304
1894	7, 217, 054	17, 485, 232	7, 542, 922	4, 130, 220	36, 375, 428
1895	8, 258, 961	18, 500, 196	13, 619, 639	5, 761, 378	46, 140, 174
1896	10, 470, 315	18, 664, 322	9, 546, 250	8, 539, 746	47, 220, 633
1897	11, 774, 479	20, 406, 918	11, 821, 815	7, 642, 356	51, 645, 568
1898	12, 921, 001	22, 396, 000	12, 292, 016	11, 800, 340	59, 409, 357

WELLS AND THEIR PRODUCTION.

There are two classes of wells producing oil: Flowing and bucketing. By bucketing it is understood that, owing to the loose sand that continually comes into the well with the oil, the American system of pumping, with rods, cups, and working barrel, is impracticable, as the sharp sand soon cuts the cups. The substitute is a long pipe or bailer that goes inside of the casing, with a valve in the bottom, and connected to a small wire rope passing over the crown pulley. This rope is also connected with a drum driven by power. The bailer is hoisted to the surface, where the valve is opened automatically and the oil and water are discharged in a trough leading to a reservoir. The bailer is then allowed to descend, to be filled again.

Flowing wells are the well-known Baku fountains, some of which have given, and continue to give, say, 100,000 poods per day, or about 10,000 barrels; several of these fountains are credited with producing 60,000 barrels per day.

The production of crude petroleum from pumping (bucketing) and flowing wells for the last ten years has been as follows:

Production of crude oil from pumping and flowing wells in Baku from 1888 to 1898.

[Barrels.]

Year.	Pumping.	Flowing.
1888	13, 325, 184	8, 924, 205
1889	18, 300, 733	5, 201, 430
1890	21, 589, 242	6, 071, 711
1891	28, 777, 506	4, 788, 313
1892	25, 765, 482	9, 260, 662
1893	26, 352, 714	13, 350, 590
1894	28, 814, 428	7, 561, 000
1895	32, 350, 809	13, 789, 365
1896	36, 586, 526	10, 634, 107
1897	40, 784, 321	10, 861, 247
1898	45, 577, 083	13, 832, 274

The profitable production from pumping and flowing wells for years 1892 to 1898 is given in the following table, by fields:

Production of crude petroleum from pumping wells, 1892 to 1898.

[Barrels of 42 gallons.]

Year.	Balakhany.	Saboontchy.	Romany.	Bibi-Eibat.	Total.
1892	7, 025, 973	14, 234, 073	2, 558, 238	1, 947, 198	25, 765, 482
1893	7, 041, 496	14, 465, 119	3, 560, 680	1, 285, 419	26, 352, 714
1894	7, 217, 054	16, 245, 868	4, 221, 278	1, 130, 228	28, 814, 428
1895	8, 258, 961	16, 227, 824	5, 254, 480	2, 609, 544	32, 350, 809
1896	10, 452, 222	16, 938, 528	7, 021, 311	2, 174, 465	36, 586, 526
1897	11, 773, 063	18, 521, 553	8, 105, 441	2, 384, 264	40, 784, 321
1898	12, 742, 529	19, 908, 639	8, 450, 123	4, 475, 792	45, 577, 083

Production of crude petroleum from flowing wells, 1892 to 1898.

[Barrels of 42 gallons.]

Year.	Balakhany.	Sabooutchy.	Romany.	Bibi-Eibat.	Total.
1892	....	4,682,443	2,459,048	2,119,171	9,260,662
1893	28,605	3,418,573	5,382,633	4,520,779	13,350,590
1894	....	1,239,364	3,321,644	2,999,992	7,561,000
1895	....	2,272,372	8,365,159	3,151,834	13,789,365
1896	18,093	1,725,794	2,524,939	6,365,281	10,634,107
1897	....	1,883,602	3,718,302	5,259,343	10,861,247
1898	171,200	2,494,916	3,840,319	7,325,839	13,832,274

The greatest number of wells that produced crude petroleum at any time during the years named was as follows:

Greatest number of producing wells at any time on the Apsheron Peninsula from 1888 to 1898.

Year.	Wells.	Year.	Wells.
1888	239	1894	532
1889	278	1895	604
1890	356	1896	734
1891	458	1897	917
1892	448	1898	1,146
1893	458		

The statement of the number of producing wells from 1893 to 1898, by months, is as follows:

Average number of producing wells in Baku from 1893 to 1898, by months.

Month.	Number of wells.					
	1893.	1894.	1895.	1896.	1897.	1898.
January	322	322	434	501	599	732
February	326	337	434	508	598	747
March	332	347	437	511	614	768
April	323	355	455	536	626	755
May	325	366	451	540	643	764
June	310	369	450	547	658	791
July	307	373	460	566	668	809
August	294	400	475	575	677	806
September	298	413	496	597	688	828
October	310	420	497	606	713	863
November	316	425	504	614	697	869
December	322	440	500	620	702	905
Greatest number	458	532	604	734	917	1,146

The above table gives the average number of wells in operation during each month. The total represents the greatest number of wells opened during the year in Baku.

The number of wells drilling during each month from 1892 to 1898, and the number worked upon during the years 1895 to 1898, are given in the following tables:

Average number of wells drilling in Baku from 1892 to 1898, by months.

Month.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	141	62	59	80	137	226	278
February	131	57	60	86	141	209	295
March	127	69	62	86	145	222	306
April	117	64	72	78	150	218	306
May	94	69	81	86	152	227	323
June	84	73	79	89	159	236	334
July	44	69	75	100	152	250	339
August	45	64	73	109	152	273	360
September	52	58	73	116	164	279	361
October	45	59	69	122	194	287	390
November	50	58	71	133	200	291	435
December	58	59	75	142	208	281	432
Greatest number	200	175	204	270	387	544	706

The year 1898, as shown in the above table, indicates great activity in the field work at Baku.

Number of wells completed in Baku from 1895 to 1898.

Month.	1895.	1896.	1897.	1898.
January	5	13	14	30
February	8	11	11	16
March	7	7	11	18
April	10	8	18	29
May	6	6	25	6
June	5	14	25	18
July	9	11	18	24
August	11	10	20	19
September	8	16	12	26
October	8	16	22	24
November	6	10	16	25
December	11	11	17	23
Total	94	133	209	258

The following table shows the average daily production of crude petroleum in the Baku field in 1897 and 1898, taken from the consular report of Mr. James C. Chambers. The average daily production for the United States in 1898 was 151,683 barrels, as compared with 159,615 barrels in the Baku field:

Average daily production of Baku fields in 1897 and 1898.

[Barrels of 42 gallons.]

Month.	Flowing wells.		Pumping wells.		Total.	
	1897.	1898.	1897.	1898.	1897.	1898.
January	46, 070	59, 365	102, 350	113, 156	148, 420	172, 521
February	60, 621	103, 963	97, 682	113, 729	158, 303	217, 692
March	25, 793	23, 861	102, 324	118, 589	128, 117	142, 450
April	28, 985	33, 493	109, 556	117, 576	138, 541	151, 069
May	21, 670	24, 127	108, 504	123, 670	130, 174	147, 797
June	31, 535	16, 020	110, 714	126, 297	142, 249	142, 317
Six months.	35, 428	42, 680	105, 254	118, 882	140, 682	161, 562
July	20, 020	30, 015	110, 016	122, 197	130, 036	152, 212
August	10, 509	22, 933	113, 145	119, 624	123, 654	142, 557
September	18, 500	29, 764	114, 858	125, 737	133, 358	155, 501
October	12, 929	40, 212	121, 873	130, 063	134, 802	170, 275
November	52, 700	27, 960	118, 680	129, 378	171, 389	157, 338
December	21, 472	37, 797	109, 054	128, 398	130, 526	166, 195
Year	28, 935	37, 202	109, 956	122, 413	138, 891	159, 615

In the following table is given a statement of the greatest number of wells drilling at any time during each of the years from 1889 to 1898, together with the total number of wells drilled deeper, and the total length, in sagenes, of all wells drilled:

Total number of wells drilling, number of wells drilled deeper, and length of wells drilled in Baku from 1889 to 1898.

Year.	Total number of wells drilling.	Total number of wells drilled deeper.	Total length, in sagenes, of wells drilled.
1889	121	28	6, 500
1890	231	50	14, 810
1891	292	87	19, 980
1892	200	111	11, 670
1893	175	103	10, 980
1894	204	101	12, 859
1895	270	131	20, 864
1896	387	172	28, 126
1897	544	225	39, 847
1898	706	216	63, 516

1 sagene = 7 feet.

The number of new wells drilled on the Apsheron Peninsula in 1898 was 456.

WELL RECORDS AT BAKU.

As reported by Mr. Chambers, the following tables give the number of wells completed, average depth, and average daily product in 1897 and 1898, by fields and months:

Number of wells completed in Baku in 1897 and 1898, with average depth and average daily product, by fields and months.

BALAKHANY-SABOOUTCHY.

Month.	1897.			1898.		
	Wells.	Average depth.	Average daily product.	Wells.	Average depth.	Average daily product.
		Feet.	*Barrels.*		*Feet.*	*Barrels.*
January	11	825	2,401	22	725	270
February	9	806	226	14	752	207
March	11	1,115	372	16	918	602
April	15	936	401	24	837	248
May	23	747	411	5	890	623
June	19	747	238	15	819	319
July	17	784	338	20	873	568
August	14	865	310	18	933	203
September	10	830	306	24	801	255
October	15	825	251	21	917	226
November	15	780	276	23	902	436
December	16	657	273	20	880	259
Year	175	815	451	222	845	331

ROMANY.

January	2	1,134	265	6	1,453	160
February				1	1,440	3,600
March				1	1,638	73
April	3	266	2,759	2	1,153	281
May	1	1,372	360	1	1,292	5,040
June	4	1,204	420	1	1,652	254
July				2	1,425	260
August	5	1,431	480	1	1,624	2,447
September	2	1,617	598	1	1,295	4,000
October	4	905	440	2	1,306	464
November	1	1,316	304	1	1,540	213
December				2	1,673	163
Year	22	1,118	750	21	1,448	902

Number of wells completed in Baku in 1897 and 1898, with average depth and average daily product, by fields and months—Continued.

BIBI-EIBAT.

Month.	1897.			1898.		
	Wells.	Average depth.	Average daily product.	Wells.	Average depth.	Average daily product.
		Feet.	*Barrels.*		*Feet.*	*Barrels.*
January	1	1,463	1,192	2	1,596	29,094
February	2	1,335	460	1	1,495	2,062
March	......	......	......	1	1,495	2,836
April	......	......	......	3	1,484	1,001
May	1	1,456	1,284	......	......	......
June	2	1,442	32,797	2	1,673	339
July	1	1,095	1,666	2	1,517	979
August	1	1,512	600	......	......	......
September	......	......	......	1	1,750	240
October	3	1,617	1,347	1	1,827	100
November	......	......	......	1	1,554	6,880
December	1	964	264	1	1,694	273
Year	12	1,420	6,282	15	1,595	5,075

TOTAL.

Month.	1897 Wells.	1897 Average depth.	1897 Average daily product.	1898 Wells.	1898 Average depth.	1898 Average daily product.
January	14	912	380	30	931	2,522
February	11	898	278	16	861	460
March	11	1,115	372	18	988	781
April	18	816	787	29	925	329
May	25	798	436	6	958	902
June	25	875	1,839	18	960	304
July	18	800	395	24	972	579
August	20	1,025	380	19	970	321
September	12	962	367	26	857	420
October	22	955	375	24	987	248
November	16	814	276	25	954	538
December	17	675	273	23	985	249
Year	209	880	813	258	937	653

Mr. Chambers gives the following as the number of wells producing, flowing, and drilling in Baku in 1897 and 1898, by fields and months:

Number of wells producing, flowing, and drilling in Baku in 1897 and 1898.

NUMBER OF WELLS PRODUCING.

Month.	Balakhany-Sabooutchy.		Romany.		Bibi-Eibat.		Total.	
	1897.	1898.	1897.	1898.	1897.	1898.	1897.	1898.
January	502	619	72	82	25	31	599	732
February	500	639	73	82	25	26	598	747
March	516	659	73	76	25	33	614	768
April	527	644	75	79	24	32	626	755
May	540	642	78	84	25	38	643	764
June	554	670	81	81	23	40	658	791
July	561	683	78	86	29	40	668	809
August	567	690	83	83	27	33	677	806
September	589	706	79	84	20	38	688	828
October	601	736	82	86	30	41	713	863
November	591	740	78	90	28	39	697	869
December	599	770	77	93	26	42	702	905
Average for year	......	......	......	......	......	......	657	803

NUMBER OF FLOWING WELLS.

Month.	Balakhany-Sabooutchy. 1897.	Balakhany-Sabooutchy. 1898.	Romany. 1897.	Romany. 1898.	Bibi-Eibat. 1897.	Bibi-Eibat. 1898.	Total. 1897.	Total. 1898.
January	2	2	5	4	2	3	9	9
February	4	1	5	6	4	4	13	11
March	2	3	5	4	4	4	11	11
April	1	4	5	3	1	1	7	10
May	3	1	2	5	3	4	8	10
June	2	4	1	5	4	5	7	14
July	2	5	......	5	4	5	6	15
August	3	6	1	5	2	4	6	15
September	2	6	4	6	2	3	8	15
October	1	5	3	5	4	3	8	13
November	3	3	3	7	3	4	9	14
December	1	9	1	4	3	1	5	14
Average for year	......	......	......	......	......	......	8	13

Number of wells producing, flowing, and drilling in Baku in 1897 and 1898—Continued.

NUMBER OF WELLS STARTED DRILLING.

Month.	Balakhany-Saboutchy.		Romany.		Bibi-Eibat.		Total.	
	1897.	1898.	1897.	1898.	1897.	1898.	1897.	1898.
January	18	23	5	5	1	......	24	28
February	7	27	......	3	1	......	8	30
March	19	30	3	2	......	2	22	34
April	13	21	6	3	......	......	19	24
May	22	25	3	3	......	1	31	29
June	34	34	......	2	......	......	34	36
July	27	35	......	1	2	......	29	36
August	37	30	1	5	......	......	38	35
September	28	32	2	2	......	......	30	34
October	25	48	1	3	......	3	26	54
November	17	71	3	2	1	2	31	75
December	19	34	2	7	......	......	21	41
Total	272	410	26	38	5	8	303	456

SHIPMENTS FROM BAKU AND FROM BATOUM.

The following tables contain the shipments of petroleum and its products from Baku, by months, during 1898, and the total shipments for 1897, in gallons of the United States standard, and from Batoum, by countries, taken from the consular report of Mr. James C. Chambers, of Batoum:

Shipments of all petroleum products from Baku in 1898.

Month.	Illuminating.	Lubricating.	Residuum.	Crude.	Total.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
January	25, 825, 000	3, 120, 000	5, 635, 000	4, 810, 000	39, 390, 000
February	28, 095, 000	2, 565, 000	9, 820, 000	7, 550, 000	48, 030, 000
March	35, 235, 000	5, 455, 000	46, 165, 000	21, 355, 000	108, 210, 000
April	46, 250, 000	3, 555, 000	135, 050, 000	20, 645, 000	205, 500, 000
May	44, 890, 000	6, 280, 000	174, 420, 000	49, 565, 000	275, 155, 000
June	44, 665, 000	5, 505, 000	162, 450, 000	48, 100, 000	260, 720, 000
July	50, 995, 000	4, 625, 000	221, 025, 000	7, 010, 000	283, 655, 000
August	47, 740, 000	5, 800, 000	192, 100, 000	20, 555, 000	266, 195, 000
September	43, 225, 000	4, 765, 000	166, 355, 000	19, 885, 000	234, 230, 000
October	41, 075, 000	4, 255, 000	83, 465, 000	9, 880, 000	138, 675, 000
November	33, 995, 000	3, 140, 000	7, 165, 000	4, 360, 000	48, 660, 000
December	31, 215, 000	3, 040, 000	8, 155, 000	5, 745, 000	48, 155, 000
Total	473, 205, 000	52, 105, 000	1, 211, 805, 000	219, 460, 000	1, 956, 575, 000
1897	458, 035, 000	45, 860, 000	1, 127, 100, 000	130, 045, 000	1, 761, 040, 000

Shipments of petroleum products from Batoum in 1897 and 1898.

[United States gallons.]

To—	Crude and residuum.		Lubricating oils.		Illuminating distillate.
	1898.	1897.	1898.	1897.	1898.
Austria-Hungary	176,850	205,190	2,985,615	2,850,120	11,176,665
Africa	....	....	....	....	....
Belgium	3,723,720	3,546,595	8,047,315	8,086,275	159,490
Bulgaria	27,450	700	46,150	58,850	....
China and Cochin China	....	....	....	....	....
Egypt	20,450	6,750	114,550	140,600	....
France	2,373,630	1,637,395	9,338,175	6,699,545	14,864,665
Germany	2,020,955	1,236,865	10,601,800	8,518,810	78,305
Great Britain	2,634,475	2,116,810	5,830,140	4,725,945	4,321,665
India	89,050	....	100,000	1,000	....
Italy	1,056,340	1,843,840	316,750	559,800	....
Japan	....	....	....	....	....
Java	....	....	....	....	....
Malta	....	....	....	....	....
Netherlands	....	....	5,000	100,000	....
Philippine Islands	....	....	....	....	....
Roumania	1,000	4,100	142,550	233,500	....
Spain	491,850	320,655	246,845	759,445	....
Suez Canal (*a*)	20,500	....	10,000	....	....
Turkey	72,850	73,450	79,400	130,700	....
Other countries	1,000	....	15,250	4,500	....
Total exports	12,710,120	10,992,350	37,879,540	32,869,090	30,600,790
Russia	754,745	255,470	1,965,200	1,143,555	72,450
Total shipments	13,464,865	11,247,820	39,844,740	34,012,645	30,673,240

a Suez Canal shipments were in bulk to points unknown here. The illuminating distillate to Great Britain was gas oil.

Shipments of petroleum products from Batoum in 1897 and 1898—Continued.

[United States gallons.]

To—	Illuminating distillate.	Refined oil.		Total.	
	1897.	1898.	1897.	1898.	1897.
Austria-Hungary	12, 381, 270	4, 705, 470	2, 826, 530	19, 044, 600	18, 263, 110
Africa	....	1, 217, 200	1, 140, 360	1, 217, 200	1, 140, 360
Belgium	233, 185	8, 106, 380	1, 879, 690	20, 036, 905	13, 745, 745
Bulgaria	....	2, 270, 040	6, 939, 730	2, 343, 640	6, 999, 280
China and Cochin China	....	9, 834, 880	19, 406, 270	9, 834, 880	19, 406, 270
Egypt	....	13, 153, 390	11, 001, 690	13, 288, 390	11, 149, 040
France	12, 855, 135	1, 639, 775	856, 270	28, 216, 245	22, 048, 345
Germany	97, 000	7, 910, 465	7, 257, 905	20, 611, 525	17, 110, 580
Great Britain	13, 646, 660	41, 572, 465	23, 485, 345	54, 358, 745	43, 974, 760
India	....	39, 488, 950	34, 984, 880	39, 678, 000	34, 985, 880
Italy	....	7, 567, 680	5, 862, 220	8, 940, 780	8, 265, 860
Japan	....	2, 718, 800	6, 142, 140	2, 718, 800	6, 142, 140
Java	....	5, 198, 840	1, 362, 250	5, 198, 840	1, 362, 250
Malta	....	1, 475, 835	1, 674, 415	1, 475, 835	1, 674, 415
Netherlands	....	2, 071, 805	....	2, 076, 805	100, 000
Philippine Islands	....	1, 668, 280	1, 626, 000	1, 668, 280	1, 626, 000
Roumania	....	423, 200	515, 470	566, 750	753, 070
Spain	....	....	....	738, 695	1, 080, 100
Suez Canal (*a*)	....	55, 730, 190	56, 402, 320	55, 760, 690	56, 402, 320
Turkey	....	28, 730, 005	33, 336, 325	28, 882, 255	33, 540, 475
Other countries	....	685, 100	511, 170	701, 350	515, 670
Total exports	39, 213, 250	236, 168, 750	217, 210, 980	317, 359, 200	300, 285, 670
Russia	33, 700	27, 596, 940	31, 438, 865	30, 389, 335	32, 871, 590
Total shipments	39, 246, 950	263, 765, 690	248, 649, 845	347, 748, 535	333, 157, 260

a Suez Canal shipments were in bulk to points unknown here. The illuminating distillate to Great Britain was gas oil.

STOCKS AT BAKU.

The following table gives the stocks of crude petroleum at the wells and refineries, and the total stocks of illuminating, lubricating, and residuum at Baku at the close of 1896, 1897, and 1898, taken from the report of Mr. Chambers:

Stocks of all products at Baku December 31, 1896, 1897, and 1898.

Product.	1896.	1897.	1898.
Crude:	*Barrels.*	*Barrels.*	*Barrels.*
At wells	764, 690	592, 547	859, 584
At refineries	2, 636, 524	1, 840, 212	1, 462, 344
Total	3, 401, 214	2, 432, 759	2, 321, 928
	Gallons.	*Gallons.*	*Gallons.*
Illuminating oils	71, 785, 020	67, 274, 980	51, 805, 615
Lubricating oils	6, 920, 180	9, 610, 725	11, 605, 275
Residuum	238, 460, 315	263, 532, 270	265, 121, 885

Regarding the Grosni oil field in 1898, Mr. Chambers writes as follows:

The Grosni field has exhibited no redeeming features in the past year. Notwithstanding considerable drilling, there has been no increase, but actually a decrease in the production, as will be seen from the following statistics for 1897 and the first ten months of 1898:

Petroleum product from the Grosni field.

Company.	1897.	1898 (ten months).
	Barrels.	*Barrels.*
Akhverdoff Company	1, 980, 000	1, 178, 269
Maximoff Company	420, 000	216, 484
Moscow Company	276, 000	162, 166
Dnieper Company	78, 000	116, 061
Total	2, 754, 000	1, 672, 980

The barrels hold 42 gallons. Of the nine firms drilling in this field, the above four were the only ones which had any product. The figures show a falling off of about 2,000 barrels per day, notwithstanding the fact that there were 18 wells producing on October 31, against only 12 at the beginning of the year. The following is a comparison of the work in the field at the close of 1897 and 1898:

Operations in the Grosni oil field in 1897 and 1898.

Description.	December 31—	
	1897.	1898.
Wells producing	12	26
Wells idle	7	13
Wells drilling	24	24
Wells drilling deeper	3	1
New derricks	6	10

Big wells have been reported from Grosni several times during the year, but they were either overestimated or very short lived, for the production shows no signs of them.

The outlook is certainly not more promising than it was last year, for some wells have been drilled to more than 2,000 feet without a sign of oil, and many other wells which are drilling are much deeper than those which produced most of the oil in the past.

The production was sold chiefly for fuel, as it yields much less of illuminants than Baku oil and deteriorates more rapidly from exposure in open reservoirs, requiring not more than a few weeks of such exposure to destroy it for illuminating purposes and to make it quite as heavy as the Baku standard for residuum. There are two modern refineries at Grosni, but as less than 1,500,000 gallons of refined oil have been shipped from there during the year it seems that they did not work much of the time. The refined mentioned was received at Novorossisk and from there exported to England early in this year. The only export from Novorossisk in 1898 was a small lot of refined, which had been in tank there for so long that it was only fit for distillate and was given away in order to clear the tanks. It amounted to about 52,000 gallons and went to Fiume.

There is a small refinery at Novorossisk, belonging to people who have some wells in the vicinity which produce a very heavy oil. They also receive Grosni crude, which they run wholly for residuum. The small amount of refined which they produce is sold locally and at the small seaports in the vicinity, while the residuum goes principally to Odessa for fuel.

AUSTRIA-HUNGARY.

GALICIA.

Petroleum in Galicia was discovered in quantity early in the sixties, when rich oil wells were struck in the eastern part of the province. Later on productive wells were found at Boryslaw and Drohobits in central Galicia. N. J. Pantguchoff, a Russian authority, furnished the following facts in regard to the Galician oil industry to a Russian trade journal:

At the present time most of the Galician oil is produced at Gorlice, Mariampol, Krosno, and Ustryki, situated in the western part. The Canadian drilling method, introduced by McGarvey, is now generally in use. The oil industry in Galicia is protected on the part of the Austro-Hungarian Government by high import duties and other privileges. The total production in 1896 amounted to 289,100 tons, and almost covered the home consumption. The yield of the crude in illuminating oil ranges between 50 and 60 per cent, but it could, if desired, certainly be increased to 65 per cent. The price of illuminating oil in Austria depends upon or follows the price of the Russian distillate, which is imported from Batoum by way of Fiume. For the past year it has ruled rather steadily at $12 per barrel at Vienna. This figure covers the cost of the crude material, but not the cost of refining, which, as also the profit, is covered by the sale of benzine and heavy distillates. The best appointed and largest refineries of Galicia are those at Djedits, Mariampol, and Petchenizyn. The latest apparatus for continuous distillation is in use here.

As it is the chief desire to obtain the largest possible yield in illuminating oil, all the Galician refineries work with vertical stills and very high (7 feet) condensers. In order to accomplish a disintegration that is as far reaching as possible, the condensers are provided with two drain pipes, one at the top, the other at the bottom, both being arranged in the immediate vicinity of the stills. The lower pipe can be shut off at will, so that the condensed vapor has to flow back into the still. The crude oil is worked up according to the following schedule: All fractions from 0.800 to 0.880 specific gravity are used for illuminating oil. The distillate running from 0.880 to 0.900 is again distilled, and afterwards worked up to 10 per cent of benzine, 10 per cent of illuminating oil, 30 per cent of "mercantile" oil, which is a low grade of illuminating oil, and 50 per cent of lubricating oil. The principal petroleum products in the market are: "Parlor or Kaiser" oil, specific gravity 0.800 to 0.805, flash point 25° to 28° C.; "Standard" petroleum, specific gravity 0.805 to 0.815, flash point 21° to 23°, and mercantile oil, specific gravity 0.820 to 0.830, flash point 3° to 5° C.

Galician crude oil is partly dark brown, partly light brown to orange in color. Its gravity in east Galicia is 0.830 to 0.868; in central Galicia, 0.844 to 0.855; in west Galicia, 0.846 to 0.859. It generally consists of paraffins, with some naphthenes and phenols. The crude of west Galicia contains little paraffin, its composition being very similar to that of the Russian oil, and making it especially adapted for the manufacture of lubricating oil. The oil in the east is high in paraffin, and therefore less suited for lubricating purposes.

The statistics of production and consumption of Galician oil presented herewith cover the years 1896 and 1897. The following tables give the production of oil in Galicia by districts and by months for 1897:

Production of crude petroleum in Galicia in 1897, by fields.

Fields.	Meter centners.	Barrels of 42 gallons.
Nowy Sacz, Gorlice, Biecz	352, 751	253, 646
Skolyszyn, Jaslo, Krosno, Sanok	597, 507	429, 637
Zagórz, Olszanica, Chyrów, Sambor	149, 866	107, 761
Drohobycz, Boryslaw, Krechowice	1, 892, 964	1, 361, 136
Stanislawów, Nadwórna, Kolomyja	103, 175	74, 188
Total	3, 096, 263	2, 226, 368

Production of crude petroleum in Galicia in 1897, by months.

Month.	Meter centners.	Barrels of 42 gallons.	Month.	Meter centners.	Barrels of 42 gallons.
January	250,000	179,763	August	277,590	199,601
February	248,000	178,324	September	268,420	193,007
March	240,000	172,572	October	276,890	199,098
April	236,630	170,149	November	267,220	192,144
May	238,780	171,695	December	264,400	190,117
June	260,083	187,013	Total	3,096,263	2,226,368
July	268,250	192,885			

Production of crude petroleum in Galicia in 1896, by fields.

Fields.	1896.	
	Meter centners.	Barrels of 42 gallons.
Marcinkowice, Gorlice, Zagórzany	291,300	209,459
Skolyszyn, Jaslo, Krosno	788,600	567,043
Rymanów, Sanok	14,200	10,211
Olszanica, Ustrzyki, Chyrów, Sambor	130,300	93,692
Drohobycz, Boryslaw, Skole, Krechowice	2,047,950	1,472,578
Stanislawów, Nadwórna, Kolomyja	125,300	90,097
Total	3,397,650	2,443,080

In the following table is given a statement of the production of crude petroleum in Galicia from 1886 to 1897, inclusive, as ascertained by the Statistical Bureau of the Galizischer Landes-Petroleum-Verein, Lemberg, and which it has kindly furnished for this report.

Production of crude petroleum in Galicia from 1886 to 1897.

Year.	Meter centners.	Barrels of 42 gallons.	Year.	Meter centners.	Barrels of 42 gallons.
1886	425,400	305,884	1892	898,713	646,220
1887	478,176	343,832	1893	963,312	692,669
1888	648,824	466,537	1894	1,320,000	949,146
1889	716,595	515,268	1895	2,020,720	1,452,999
1890	916,504	659,012	1896	3,397,650	2,443,080
1891	877,174	630,732	1897	3,096,263	2,226,368

Stocks of crude petroleum in the Galician oil field at the close of the years 1895, 1896, and 1897, by districts.

[Metric centners.]

District.	Stock in tanks, Dec. 31—			Pipe lines.	
	1895.	1896.	1897.	No.	Length.
					Kilos.
Bodaki, Pagorzyna, Przegonina, Pstrażne, Rozdzielle, Rychwald	109, 330	308, 069	321, 000	3	26. 5
Ladzin, Grabownica, Mrukowa-Piel-grzymka, Moderówka, Zmigród (Lysagóra)	102, 100	117, 630	223, 640	7	52. 5
Domaradz, Rymanów, Stróże wielkie	700	1, 040	5, 860	....	....
Tyrawczyn	31, 450	57, 620	59, 995	3	18. 7
Kropiwnik nad Stryjem, Truskawiec	306, 730	803, 440	986, 070	4	54. 6
Jablonica, Mlodiatyn	21, 340	22, 030	31, 540	....	....
Total	571, 340	1, 309, 829	1, 628, 105	17	152. 3

The following equivalents of value, weight, and length are given:

1 florin or gulden = 40 cents.
1 metric ton = 2,204.62 pounds.
1 metric ton = 7.1905 barrels of crude petroleum of 42 gallons.
1 metric centner } = 100 kilos (220.462 pounds).
1 quintal....... }
1 kilo = 2.20462 pounds.
1 gallon refined petroleum = 6.6 pounds.
1 gallon crude petroleum = 7.3 pounds.
1 quintal or 1 metric centner of refined petroleum = 0.795317 barrel of 42 gallons.
1 quintal or 1 metric centner of crude petroleum = 0.71905 barrel of 42 gallons.
1 kilometer = 3,280.89 feet = .6213 of 1 mile.

The following tables were given in "Naphtha," an Austrian publication, by Dr. Stanislaus Olszewski, secretary of Galizischen Landes Petroleum Vereines, of Lemberg:

Exports of crude petroleum and its products from Austria-Hungary from 1895 to 1898 inclusive.

Quality of oil.	1895.		1896.	
	Metric centners.	Barrels.	Metric centners.	Barrels.
Crude petroleum	14, 543	10, 457	18, 147	13, 049
Refined petroleum	39, 545	31, 451	231, 062	183, 768
Lubricating oil	3, 065	2, 438	3, 131	2, 490
Benzine	86, 263	68, 606	182, 833	145, 410
Ozokerite	50, 539	....	57, 215	....
Kerosene	23, 821	18, 938	23, 552	18, 724

Exports of crude petroleum and its products from Austria-Hungary from 1895 to 1898, inclusive—Continued.

Quality of oil.	1897.		1898.	
	Metric centners.	Barrels.	Metric centners.	Barrels.
Crude petroleum	16,004	11,508	10,761	7,738
Refined petroleum	130,824	104,047	30,617	24,350
Lubricating oil	13,373	10,636	22,243	17,690
Benzine	210,535	167,438	226,817	180,391
Ozokerite	51,525	....	44,621	....
Kerosene	13,305	10,577	14,224	11,308

Of the total, there were exported in 1897 and 1898, the following:

Total exports of crude petroleum and its products from Austria-Hungary in 1897 and 1898, by countries to which exported.

Quality of oil.	Exported to—	Quantity.	
		1897.	1898.
		Metric centners.	*Metric centners.*
Crude petroleum	Italy	6,776	3,410
	Germany	6,179	2,227
	Trieste	2,939	....
	Switzerland	2,756	5,077
Refined petroleum	Germany	78,937	5,110
	Switzerland	45,879	8,079
	Trieste	2,939	....
	Netherlands	1,146	8,255
	Belgium	716	8,262
	Italy	690	502
Lubricating oil	Switzerland	5,244	10,622
	Germany	4,580	7,970
	Italy	1,530	2,140
	Servia	1,416	766
Benzine	Germany	170,066	190,789
	Switzerland	16,223	21,494
	Bremen	6,161	....
	Trieste	4,405	6,446
	Hamburg	3,650	728
	England	2,964	....
	Italy	2,606	4,403
	France	2,370	1,770
	Belgium	....	691
	Servia	....	132

Total exports of crude petroleum and its products from Austria-Hungary in 1897 and 1898, by countries to which exported—Continued.

Quality of oil.	Exported to—	Quantity.	
		1897.	1898.
		Metric centners.	*Metric centners.*
Ozokerite	Germany	34,210	34,532
	Russia	14,139	6,189
	France	1,865	2,052
	Hamburg		604
Kerosene	Trieste	4,917	5,615
	Italy	1,287	1,000
	Hamburg	1,279	1,150
	Russia	1,110	1,065
	Germany	756	1,503
	France	488	
	United States	419	206
	India	426	322
	Spain	296	499
	England	273	289
	Switzerland		371
	Turkey		512
	Greece		208

The following equivalents of value and weight are given:

1 florin or gulden = 40 cents.
1 metric ton = 2,204.62 pounds.
1 metric ton = 7.1905 barrels of crude petroleum of 42 gallons.
1 metric centner } = 100 kilos (220.462 pounds).
1 quintal....... }
1 kilo = 2.20462 pounds.
1 gallon refined petroleum = 6.6 pounds.
1 gallon crude petroleum = 7.3 pounds.
1 quintal or 1 metric centner of refined petroleum = 0.795317 barrel of 42 gallons.
1 quintal or 1 metric centner of crude petroleum = 0.71905 barrel of 42 gallons.
1 kilometer = 3,280.89 feet = .6213 of 1 mile.

Imports of crude petroleum and its products to Austria-Hungary from 1895 to 1898, inclusive.

Quality of oil.	1895.		1896.	
	Metric centners.	Barrels.	Metric centners.	Barrels.
Crude petroleum, heavy, specific gravity more than 0.830	987,099	709,774	520,526	374,284
Crude petroleum *a*	156,094	112,239	157,029	112,912
Crude petroleum, light, specific gravity 0.830 and less	61,599	44,293	12,573	9,041
Refined petroleum, heavy, dark, specific gravity more than 0.880	25,716	20,452	27,881	22,174
Refined petroleum, heavy, bright, specific gravity more than 0.880	31,566	25,105	31,969	25,425
Lubricating oils, specific gravity more than 0.880	65,149	51,814	74,766	59,463
Refined petroleum, light, specific gravity 0.880 and less	46,325	36,843	44,800	35,630
Crude paraffin	33,589	....	29,424	....
Refined paraffin	23,366	....	28,842	....

Quality of oil.	1897.		1898.	
	Metric centners.	Barrels.	Metric centners.	Barrels.
Crude petroleum, heavy, specific gravity more than 0.830	480,386	345,422	359,960	258,829
Crude petroleum *a*	188,574	135,594	202,187	145,383
Crude petroleum, light, specific gravity 0.830 and less	36,759	26,432	30,757	22,116
Refined petroleum, heavy, dark, specific gravity more than 0.880	52,900	42,072	66,805	53,131
Refined petroleum, heavy, bright, specific gravity more than 0.880	30,264	24,069	12,753	10,143
Lubricating oils, specific gravity more than 0.880	80,470	63,999	99,250	78,935
Refined petroleum, light, specific gravity 0.880 and less	48,852	38,853	44,088	35,064
Crude paraffin	26,710	....	16,952	....
Refined paraffin	44,230	....	53,719	....

a From Roumania, duty paid, 63 kroner per metric centners.

Of the total imported in 1897 and 1898, the following table shows the qualities and quantities received and the countries from which imported:

Quality of oil imported into Austria-Hungary in 1897 and 1898, and countries from which imported.

Quality of oil.	Imported from—	Quantity. 1897.	Quantity. 1898.
		Metric centners.	*Metric centners.*
Crude petroleum, heavy, specific gravity more than 0.830.	Russia	478, 261	319, 077
	Roumania	2, 080	40, 670
	Germany		85
Crude petroleum *a*	Roumania	188, 574	202, 187
Crude petroleum, light, specific gravity 0.830 and less.	United States	36, 759	30, 757
Refined petroleum, heavy, dark, specific gravity more than 0.880.	Russia	47, 514	52, 179
	United States	5, 007	14, 419
Refined petroleum, heavy, bright, specific gravity more than 0.880.	Russia	29, 661	12, 565
	United States	834	
	Germany	111	
	England	88	
Lubricating oils, specific gravity more than 0.880.	United States	37, 907	39, 706
	Russia	36, 712	51, 330
	Germany	2, 054	2, 014
	Hamburg	1, 441	
	Roumania	532	798
	Turkey	438	
	England	323	
	Switzerland		368
Refined petroleum, light, specific gravity 0.880 and less.	United States	43, 987	39, 706
	Germany	1, 734	2, 014
	Italy	1, 200	
	America	798	
	Roumania		798
	Switzerland		368
	Belgium		267
	England		197
Crude paraffin	United States	23, 501	15, 039
	Germany	1, 424	1, 098
	Belgium	780	316
	England	661	372
Refined paraffin	United States	26, 385	38, 228
	England	12, 749	11, 645
	Germany	4, 277	3, 268
	Italy	274	
	Belgium		373

a Specific gravity not reported.

Statistics of the consumption of refined petroleum in Austria-Hungary from 1888 to 1897.

[Metric centners.]

Year.	Production of refineries.			Total production.	Imported from foreign countries.	Total consumption of Austria-Hungary.	Increase in consumption.
	Galicia and Bukovina.	Other provinces of Austria.	Hungary and Bosnia.				
							Per cent.
1888	406, 447	237, 703	756, 257	1, 400, 407	72, 816	1, 473, 223	....
1889	428, 147	243, 595	778, 996	1, 450, 732	78, 253	1, 528, 991	3. 68
1890	400, 611	324, 921	767, 195	1, 492, 727	75, 445	1, 568, 172	2. 55
1891	413, 486	396, 307	814, 960	1, 624, 758	79, 676	1, 704, 429	8. 73
1892	408, 506	446, 008	801, 849	1, 656, 364	50, 161	1, 706, 524	. 11
1893	408, 297	534, 915	787, 329	1, 730, 541	43, 870	1, 774, 411	3. 98
1894	442, 616	616, 167	861, 615	1, 920, 398	48, 968	1, 969, 366	10. 90
1895	482, 798	582, 964	898, 648	1, 964, 410	46, 325	2, 010, 735	2. 13
1896	573, 338	530, 304	960, 488	2, 064, 130	44, 800	2, 108, 930	4. 87
1897	563, 605	769, 945	821, 827	2, 145, 377	48, 852	2, 194, 229	4. 30

Number of refineries in Austria-Hungary.

Country.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Galicia and Bukovina	51	50	44	44	40	39	42	47	50	55
Other provinces of Austria	7	6	7	7	7	7	7	6	6	7
Hungary and Siebenburgen	11	11	10	10	10	7	10	15	15	14
Bosnia and Herzegovina	.....	.....	.....	.....	.....	.....	.....	1	1	1
Total	69	67	61	61	57	53	59	69	72	77

ROUMANIA.

The production of Roumanian oil for 1898 showed about 25 per cent gain over that of the previous year, and was the greatest recorded in the history of the field. Still the entire yield only amounted to 2,100 barrels per day, and there was a general complaint of overproduction at that, and prices ruled very low. There was considerable activity in the share market of Roumanian oil companies, and a great many properties changed hands. The principal investors are foreign syndicates, composed of British, Dutch, and Belgian capitalists. A British consular report says:

Unfortunately, owing to overproduction and difficulty of transport, there being no pipe line from the petroleum centers to the Danube or the Black Sea, and a scarcity of tank cars, the prices of crude oil have been very low. The present prices of the Bustenar quality, which may fairly be taken as a criterion, are 1.35 francs and 1.50 francs per 100 kilograms, free at wells. Poiana qualities are being sold at 1.75

francs to 1.90 francs per 100 kilograms (40 to 50 cents per barrel). The borings at Campina belonging to the Steana Company have proved fairly successful, and it is thought this district has a good future before it.

At Bustenar the Steana Company has decided to shut down several of the borings, owing to unsatisfactory results. At Recea the Steana and Dutch Companies are working hard sinking borings, and up to the present the position looks promising.

The wells owned by Mr. Fowler at Bustenar have been connected with his tanks at Gageni by pipe line. The railway has opened a new station at Gageni, and this will to a great extent relieve the congestion at Plopeni. An English syndicate is reported to have purchased the Berca-Paclele property in the Buzen district, and it is confidently believed that this property when developed will give excellent results.

In Moldavia little or nothing has been done, but the Government has put down one or two borings on some of its lands in this province and is getting fairly good results.

The future of the petroleum trade in Roumania will depend to a large extent upon the laying of a main pipe line from, say, Ploesti or Campina to Galatz, Braila, Giurgevo, or Kustendjie, and it is the opinion of many people that such a line would prove a remunerative speculation.

According to this report, there has been a great falling off in the price of crude petroleum in Roumania in 1898 as compared to 1897, when the lowest price quoted was 78 cents.

The greater part of the production in this country continues to be hoisted out of shafts and pits in the most primitive manner. There are vast areas of undeveloped territory along the flanks of the Carpathian Mountains, and possibly south of the Danube, that will at some time in the future produce petroleum in large quantities.

The Government is averse to private companies controlling a pipe line, or one would long since have been laid by private capital. The estimated cost of a pipe line from Ploesti to Kustendjie is about $2,250,000. The line would generally be carried through on the public roads or alongside the railway lines crossing the Danube in the vicinity of Cernavoda bridge.

It is claimed that the Roumanian petroleum has the same specific gravity as American oil, but with a higher flash point. The Steana Company, which is now controlled by British capitalists, is trying to find an outlet for Roumanian petroleum in Germany. The Hungarian Government now proposes a tax of 2 shillings per ton on all exported through the Iron Gates, and if it is placed in effect it will have serious consequences upon the future of the industry.

According to the Consular Reports, "One point which has hitherto militated against the interests of foreign syndicates, and, indeed, of all those interested in the petroleum lands of Roumania, has been that of the difficulty of ascertaining the boundaries of the several properties, but it is hoped, now that the Government proposes to make a survey of the country, that this difficulty will be overcome. It must, however, be borne in mind that this will take some time to do. The railways are now using petroleum in many of their locomotives, and the number of engines burning petroleum is likely to increase largely. At Bucharest many of the manufacturers have discarded coal and wood in favor of petroleum. All the petroleum introduced into Roumania through the Danube is of Russian origin. The total import amounted to 12,285,620 kilograms, being a decrease of 359,323 kilograms in comparison with the previous year. Beyond what was brought to Sulina in bulk, a limited supply was unshipped in cases, amounting in number to 1,785, a decrease of 16,515 below the number imported in 1897."

The following statement, furnished by the Imperial and Royal Austro-Hungarian consulate in Plojest, gives the production of crude petroleum in Roumania in 1896, 1897, and 1898:

Production of crude petroleum in Roumania in 1896, 1897, and 1898.

[Tank carloads of 100 metric centners.]

Locality.	Production.		
	1896.	1897.	1898.
Baicoi	250	250	340
Glodeni	1,365	350	1,925
Campina	300	1,460	2,650
Dolftana and Bustenari	2,960	3,830	2,730
Ochisori and Matitza	178	150	160
Sarata (Buzeu) / Tega	902	700	1,185
Other localities	1,602	1,200	1,667
Total	7,557	7,940	10,657

One metric centner is equal to 100 kilograms, or 220,462 pounds; this multiplied by 100 (as above) gives 22,046.2 pounds; and as a barrel of crude petroleum between 31° and 32° weighs 305 pounds, this amount divided into 22,046.2 gives 72 barrels to each carload of 100 metric centners. This would make a product of 767,304 barrels during 1898, or about 2,100 barrels a day. The increase in production over 1897 was 196,418 barrels, or about 25 per cent, and the product was 570,886 barrels in 1897 as compared with 543,348 barrels in 1896, a gain of about 5 per cent.

In the following table will be found the production of crude petroleum in the principal districts in Roumania from 1874 to 1898 inclusive:

Production of crude petroleum in Roumania from 1874 to 1898.

Year.	District.				Total.	
	Prahova.	Buzeu.	Bacau.	Dimbovitza.	Tank cars.	Barrels (42 U. S. gallons).
1874	155	780	220	280	1,435	103,176.5
1875	160	820	230	300	1,510	108,569
1876	150	760	280	320	1,510	108,569
1877	180	760	250	320	1,510	108,569
1878	210	750	250	300	1,510	108,569
1879	250	700	280	300	1,530	110,007
1880	290	710	300	290	1,590	114,321
1881	350	740	300	300	1,690	121,511
1882	540	700	310	350	1,900	136,610
1883	570	700	320	350	1,940	139,486
1884	1,560	700	300	370	2,930	210,667
1885	1,350	700	300	340	2,690	193,411
1886	880	750	290	425	2,345	168,605.5
1887	950	800	280	500	2,530	181,907
1888	890	840	360	950	3,040	218,576
1889	950	1,010	380	1,800	4,140	297,666
1890	1,030	1,100	600	2,600	5,330	383,227
1891	1,150	1,050	790	3,800	6,790	488,201
1892	1,600	1,100	850	4,700	8,250	593,175
1893	1,700	950	1,300	3,500	7,450	535,655
1894	2,600	925	1,650	1,880	7,055	507,254.5
1895	3,714	904	1,838	1,544	8,000	575,200
1896	3,688	902	1,602	1,365	7,557	543,348
1897	5,690	700	1,200	350	7,940	570,886
1898	5,880	1,185	1,667	1,925	10,657	767,304

GERMANY.

Germany's production of crude petroleum has been steadily increasing during the past four years, but is still of insignificant proportions. The total output for 1898 was equivalent to 183,424 barrels, which is only a little over 500 barrels a day. The gain over 1897 was 17,602 barrels, which is an increase of 10.6 per cent. Germany's oil product is well protected by import duties, and the German producers have been encouraged to enlarge their petroleum operations by the stimulus of good prices. The price realized in 1898 was the equivalent of $2.06 per American barrel as compared with $2.02 in 1897 and $1.96 per barrel in 1896. Almost the entire production of Germany comes from the

Pechelbronn district in Alsace-Lorraine. The oil is very dark in color and of 28° Baumé gravity. It contains considerable water, and the percentage of illuminating oil to be obtained from it averages from 25 to 30 per cent.

The Hanover oil districts, which are a long distance to the northeast of Pechelbronn, near the towns of Wertze and Oelheim, produced 18,102 barrels of crude petroleum in 1898, and 18,493 barrels in 1897. This represents a falling off of 391 barrels for the year.

Dutch capitalists have recently engaged in the work of developing the petroleum district of Altkirch in Upper Alsace, and very flattering results have been reported. They are said to have discovered a thick stratum of bituminous shale, at a depth of 900 feet, and the petroleum indications were regarded as highly satisfactory.

In 1897 Germany imported 114,583,356 gallons of illuminating oil and 6,877,196 gallons of lubricating oil, making a total of 121,460,552 gallons, equal to 2,892,000 barrels, as compared with 3,500,000 gallons, equal to 83,300 barrels of illuminating and lubricating oils, estimated to have been produced in Germany. The home production is $2\frac{5}{6}$ per cent, or 1 barrel produced to 35 barrels imported from the United States. In 1897 Germany also imported from Russia 7,257,905 gallons of illuminating petroleum, 8,518,810 gallons of lubricating petroleum, and 1,236,865 gallons of crude and distillate, making a total of 405,100 barrels. She also imported from Austria-Hungary 194,820 barrels of illuminating, lubricating, and crude petroleum in 1897.

The production of petroleum in Germany from 1890 to 1898 is shown in the following table:

Production of petroleum in Germany from 1890 to 1898, inclusive.

Year.	Production.	
	Metric tons. (a)	Barrels (42 gallons).
1890	15,226	108,295
1891	15,315	108,927
1892	14,257	103,323
1893	13,974	99,395
1894	17,232	122,563
1895	17,051	121,277
1896	20,395	145,061
1897	23,303	165,743
1898	25,789	183,424

a One ton crude = 7.1126 barrels.

The following table shows the production and value of petroleum in the German Empire from 1894 to 1898, by States:

Production and value of petroleum in the German Empire from 1894 to 1898.

State.	Quantity.		Value.	
	Metric tons.	Barrels.	Marks.	Dollars.
1894.				
Alsace-Lorraine	15,632	111,183	813,284	195,188
Prussia	1,600	11,380	159,163	38,199
Total	17,232	122,563	972,447	233,387
1895.				
Alsace-Lorraine	15,439	109,812	776,671	186,401
Prussia	1,612	11,465	185,784	44,588
Total	17,051	121,277	962,455	230,989
1896.				
Alsace-Lorraine	18,883	134,310	1,001,042	240,250
Prussia	1,512	10,751	187,469	44,993
Total	20,395	145,061	1,188,511	285,243
1897.				
Alsace-Lorraine	20,703	147,250	1,104,291	264,918
Prussia	2,600	18,493	292,153	70,229
Total	23,303	165,743	1,396,444	335,147
1898.				
Alsace-Lorraine, Bavaria	23,244	165,322	1,296,157	311,078
Prussia	2,545	18,102	282,051	67,692
Total	25,789	183,424	1,578,208	378,770

Production of crude petroleum in Prussia in 1898, by districts.

District.	Quantity.	Value.	Number of workmen employed.
	Metric tons.	*Marks.*	
Hildesheim	805	112,450	55
Luneburg	1,740	169,601	62
Total	2,545	282,051	117

In the following table is given a statement of the imports of petroleum into Germany from the United States from 1891 to 1898:

Imports of petroleum into Germany from the United States from 1891 to 1898.

Year.	Crude.	Refined.		
		Naphthas.	Illuminating.	Lubricating.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*
1891	3,107,137	3,227,106	162,187,071	4,186,225
1892	5,247,209	3,471,652	133,417,314	4,512,639
1893	4,182,963	4,127,354	119,277,484	3,798,953
1894	4,877,593	4,278,757	86,388,785	5,637,471
1895	3,966,870	4,900,028	100,829,413	5,378,398
1896	817,212	2,814,217	121,841,266	5,990,561
1897	2,430,249	2,800,883	114,583,356	6,877,196
1898	3,585,777	6,135,309	137,981,137	8,086,776

ITALY.

The statistics for 1898 could not be secured at the time of the closing of this report. There has been a steady decline in the production of petroleum since 1894. The decline in production in 1897 as compared with 1896 was 30 per cent. The price is quoted at $6.84 per barrel, which ought to stimulate the search for the crude petroleum. This high price is due in part to the high excise duty of 10 lires ($1.93) per 100 kilos (220 pounds), amounting to $2.25 per barrel. There is also an import duty of 48 lires per 100 kilos, amounting to $11.50 per barrel for refined petroleum. There was exported from the United States to Italy 20,677,000 gallons in 1898 as compared with 25,800,000 gallons in 1897.

There are numerous springs of petroleum in Italy, and some of them produce petroleum as light as refined illuminating oil, that can be burned in the lamps without refining. There is considerable difficulty in drilling wells, owing to the inclined strata. The strata consist usually of a tough clay that caves badly. The inclined harder strata deflect the drill, and a crooked hole is the result. Only 8 wells were producing in 1897. There are a number of pits furnishing petroleum, scattered along the north slope of the Apennines, near the Stafforia River.

The mining laws of Italy are different in the different States. The minerals of all kinds belong to the Government, which grants temporary rights to parties willing to prospect. Should sufficient petroleum be found, the parties are then entitled to a definite royal concession. It is surprising that only so small an amount is produced in this country. The following tables are very full and extend back over thirty-seven years.

From the volumes of Rivista del Servizio Minerário the following statements are extracted regarding the production of crude and refined petroleum in this country:

Production of crude petroleum in Italy from 1860 to 1897.

Year.	Number of wells in operation.	Quantity.		Value.				Number of workmen employed.
		Metric tons.	United States barrels.	Unit value.		Total value.		
				Lire.	Dollars.	Lire.	Dollars.	
1860....	3	5	36	800.00	21.44	4,400	772	5
1861....	3	4	29	800.00	21.31	3,200	618	8
1862....	4	4	29	800.00	21.31	3,200	618	9
1863....	7	8	58	800.00	21.29	6,400	1,235	18
1864....	7	10	72	800.00	21.41	8,000	1,544	32
1865....	10	315	2,265	209.52	5.62	66,000	12,738	70
1866....	12	138	992	269.86	7.24	37,240	7,187	57
1867....	11	110	791	349.10	9.37	38,400	7,411	58
1868....	9	51	367	435.29	11.67	22,200	4,285	52
1869....	8	20	144	800.00	21.65	16,000	3,118	45
1870....	6	12	86	800.00	21.55	9,600	1,853	30
1871....	6	38	273	263.16	7.07	10,000	1,930	40
1872....	6	46	331	208.69	5.60	9,600	1,853	36
1873....	5	65	467	172.31	4.63	11,200	2,162	35
1874....	4	84	604	152.38	4.00	12,800	2,470	37
1875....	3	113	812	138.05	3.70	15,600	3,011	38
1876....	3	402	2,890	123.38	3.31	49,600	9,573	72
1877....	2	408	2,934	132.35	3.55	54,000	10,422	45
1878....	4	602	4,328	102.99	2.76	62,000	11,966	98
1879....	4	402	2,890	124.37	3.34	50,000	9,650	70
1880....	2	283	2,035	313.05	8.40	88,595	17,099	24
1881....	2	172	1,237	445.00	11.94	76,540	14,772	24
1882....	4	183	1,316	474.55	11.97	86,844	15,761	121
1883....	5	225	1,618	259.49	6.96	58,387	11,269	92
1884....	6	397	2,854	341.18	9.16	135,452	26,142	110
1885....	6	270	1,941	407.65	10.92	110,066	21,243	136
1886....	7	219	1,575	416.11	11.16	91,130	17,588	145
1887....	7	208	1,497	368.84	9.76	76,720	14,614	135
1888....	5	174	1,251	319.71	8.58	55,630	10,737	75
1889....	7	177	1,273	288.13	7.73	51,000	9,843	70
1890....	9	417	2,998	289.21	7.77	120,603	23,276	177
1891....	10	1,155	8,305	301.38	8.09	348,100	67,183	251
1892....	7	2,548	18,321	296.11	7.95	754,500	145,619	267
1893....	8	2,652	19,068	299.80	8.05	795,050	153,445	130
1894....	9	2,854	20,520	296.88	7.97	847,260	163,521	194
1895....	6	3,594	25,841	258.90	6.95	930,496	179,586	134
1896....	9	2,524	18,149	255.34	6.85	644,468	124,383	222
1897....	8	1,932	13,892	255.33	6.84	492,288	95,010	245

7.1905 barrels in 1 metric ton of crude.
7.955 barrels in 1 metric ton of refined.
1 lire=19.3 cents.

Production of crude petroleum in Italy in 1895, by districts.

Mining district.	Number of wells.	Production. Quantity. Metric tons.	Barrels of 42 gallons.	Value. Per ton.	Per barrel.	Total.		Number of laborers.
				Lire.		*Lire.*		
Emilia	3	3,532	25,395	260.00	$6.98	918,320	$177,236	114
Roma	3	62	446	196.71	5.27	12,176	2,350	20
Total	6	3,594	25,841	258.90	6.95	930,496	179,586	134

Production of crude petroleum in Italy in 1896, by districts.

Mining district.	Province.	Number of wells.	Production. Quantity. Metric tons.	Barrels of 42 gallons.	Value. Per ton.	Per barrel.	Total.		Number of laborers.
					Lire.		*Lire.*		
Bologna	....	1	1	7	250.00	$7.00	250	$48	222
Milano	Parma	5	61	439	273.00	7.34	16,682	3,220	
	Piacenza	2	2,388	17,171	260.00	6.98	620,896	119,833	
Roma	Chieti	1	74	532	89.73	2.41	6,640	1,282	
Total	....	9	2,524	18,149	255.34	6.85	644,468	124,383	222

Production of crude petroleum in Italy in 1897, by districts.

Mining district.	Province.	Number of works in operation.	Quantity. Metric tons.	Barrels of 42 gallons.	Value. Per ton.	Per barrel.	Total.		Number of laborers.
					Lire.		*Lire.*		
Milano	Parma	5	80	575	260.00	$6.98	20,800	$4,014	245
	Piacenza	2	1,791	12,878	260.00	6.98	465,660	89,872	
Roma	Chieti	1	61	439	95.44	2.56	5,822	1,124	
Total	....	8	1,932	13,892	255.33	6.84	492,282	95,010	245

Production of refined petroleum in Italy from 1890 to 1897.

Year.	Number of works.	Quantity. Metric tons.	Quantity. Barrels of 42 gallons.	Value. Per ton.	Value. Per barrel.	Value. Total.		Number of laborers.
				Lire.		*Lire.*		
1890	4	350	2,784	600.00	$14.56	210,000	$40,530	44
1891	4	813	6,467	457.86	11.11	372,242	71,843	55
1892	5	1,573	12,513	491.08	11.91	772,474	149,087	65
1893	4	2,613	20,786	494.98	12.01	1,293,380	249,622	57
1894	2	1,640	13,046	590.00	14.31	967,600	186,747	34
1895	3	4,191	33,339	526.07	12.76	2,204,764	425,519	61
1896	3	2,734	21,749	541.60	13.14	1,480,737	285,782	34
1897	12	3,392	26,983	412.05	10.00	1,397,667	269,750	90

Production of refined petroleum, benzine, and gasoline in Italy in 1895, by districts.

Mining district.	Province.	Number of works in operation.	Production. Quantity. Metric tons.	Production. Quantity. Barrels of 42 gallons.	Production. Value. Per ton.	Production. Value. Per barrel.	Production. Value. Total.		Number of laborers.
					Lire.		*Lire.*		
Milano	Parma; Piacenza	2	4,185	33,291	526.03	$12.76	2,201,464	$424,883	50
Roma	Chieti	1	6	48	550.00	13.27	3,300	637	11
Total.		3	4,191	33,339	526.07	12.76	2,204,764	425,520	61

Production of refined petroleum in Italy in 1896, by districts.

Mining district.	Province.	Number of works.	Kind of product.	Production. Quantity. Metric tons.	Production. Quantity. Barrels of 42 gallons.	Production. Value. Per ton.	Production. Value. Per barrel.	Production. Value. Total.		Number of laborers.
						Lire.		*Lire.*		
Milano	Parma	1	Refined	1,883.7	14,985	560.09	$13.59	1,055,037	$203,622	30
	Piacenza	1	Benzine	828.5	6,591	500.00	12.13	414,250	79,950	
			Heavy oil.	2.5	20	400.00	9.65	1,000	193	
Roma	Chieti	1	Refined	19.0	151	550.00	13.35	10,450	2,017	4
Total.		3		2,733.7	21,747	541.66	13.14	1,480,737	285,782	34

Production of refined petroleum in Italy in 1897, by districts.

Mining district.	Province.	Number of works.	Kind of product.	Production: Quantity. Metric tons.	Production: Quantity. Barrels of 42 gallons.	Production: Value. Per ton.	Production: Value. Per barrel.	Production: Value. Total.		Number of laborers.
						Lire.		*Lire.*		
Carrara	Genova	1	Heavy oil	12	95	300.00	$7.00	3,600	$695	4
Milano	Milano	1	Light oil	1,390	11,057	559.90	13.58	778,297	150,211	10
	Parma	1	Benzine	395	3,142	502.20	12.17	198,150	38,242	6
	Piacenza	1	Heavy oil	583	4,638	170.90	4.15	99,720	19,246	24
Napoli	Napoli	1	Light oil	24	191	550.00	13.28	13,200	2,548	4
			Heavy oil	143	1,138	300.00	7.28	42,900	8,280	
Roma	Roma	1	Light oil	17	135	550.00	13.37	9,350	1,805	10
	Chieti	1	Heavy oil	35	278	192.20	5.07	7,300	1,409	
Torino	Alessandria, Torino	5	Light oil	29	231	550.00	13.28	15,950	3,078	32
			Heavy oil	764	6,078	300.00	7.28	229,200	44,236	
Total		12		3,392	26,983	412.05	10.00	1,397,667	269,750	90

Quantity of petroleum imported to Italy from 1864 to 1897.

Year.	Metric tons.	Barrels.	Year.	Metric tons.	Barrels.
1864	1,214	9,657	1881	59,571	473,887
1865	8,398	66,734	1882	61,500	489,233
1866	12,362	98,340	1883	67,630	537,997
1867	18,551	147,573	1884	73,693	586,228
1868	35,396	281,575	1885	92,713	737,532
1869	29,526	234,879	1886	71,268	566,937
1870	38,354	305,106	1887	75,411	599,895
1871	42,791	340,402	1888	69,861	555,744
1872	41,555	330,570	1889	71,331	567,438
1873	34,401	273,660	1890	71,178	566,221
1874	43,881	349,073	1891	72,547	577,111
1875	45,199	359,558	1892	74,487	592,544
1876	43,793	348,373	1893	74,963	596,331
1877	36,795	292,004	1894	74,174	590,054
1878	60,330	479,925	1895	68,617	545,848
1879	58,560	465,845	1896	70,217	558,576
1880	57,571	457,977	1897	68,973	548,680

The refined petroleum imported to Italy in 1897 was from the United States, Russia, and Austria-Hungary. In 1897 there were imported from the United States, 24,525,066 gallons of illuminating oil, and 1,550,688 gallons of lubricating oil; and in 1898 there were imported from the United States 18,705,089 gallons of illuminating oil, and 1,970,890 gallons of lubricating oil.

GREAT BRITAIN.

There is a small petroleum product near Alfreton, in Derbyshire, England, which is of sufficient importance to be included in the official returns. Exudations of petroleum from the Carboniferous limestone have been known for many years, and as long ago as 1847 Mr. James Young commenced the manufacture of products from the petroleum deposits at Redding's colliery, in Derbyshire.

PRODUCTION AND VALUE.

The mineral statistics of the United Kingdom give the production of petroleum from 1886 to 1897 as follows:

Production of petroleum in Derbyshire, England, from 1886 to 1897.

Year.	Tons (2,240 pounds).	Barrels (42 gallons).
1886	43	314
1887	66	482
1888	35	256
1889	30	219
1890	35	256
1891	100	731
1892	218	1,594
1893	260	1,900
1894	49	358
1895	15	110
1896	12	88
1897	12	88

Value of 49 long tons in 1894, £92=$448.
Value of 15 long tons in 1895, £28=$136.
Value of 12 long tons in each year, 1896 and 1897, £29=$141.

THE SCOTCH SHALE-OIL INDUSTRY.

The quantity and value of oil shale produced in Great Britain from 1890 to 1897 are shown in the following table. Most of the oil shale is mined in Scotland.

Production and value of oil shale in Great Britain from 1890 to 1897.

Year.	Production.	Value.
	Tons.	
1890	2, 212, 250	£608, 369
1891	2, 361, 119	707, 177
1892	2, 089, 937	522, 484
1893	1, 956, 520	489, 130
1894	1, 986, 385	496, 596
1895	2, 246, 865	561, 716
1896	2, 419, 525	604, 881
1897	2, 223, 745	555, 936

At one time the Scotch mineral-oil industry assumed large proportions and was a very profitable source of revenue, but of late years it has declined in importance, owing to the low prices of the illuminating oils supplied by American and Russian refineries. The number of companies engaged in the business has decreased and the aggregate value of their products seldom exceeds $3,000,000 per annum. A ton of bituminous shale yields very nearly an American barrel of petroleum distillate, and its cost is very close to the value of an American barrel of crude oil laid down in Scotland. The majority of the petroleum shale mines are located in Midlothian and Linlithgow, near Edinburgh, the Scottish capital. A hundred gallons of crude shale oil obtained by simple distillation of the bituminous rock yields about 30 gallons of fair illuminating oil, 16 gallons of heavy oil, 14 gallons of paraffin scale, 8 gallons of lighter oils, and 5 gallons of petroleum spirits, while the residue is tar and coke, suitable only for fuel purposes. Each ton of shale likewise yields about 50 pounds of sulphate of ammonia.

During 1898 the condition of the Scotch mineral-oil industry was materially improved and several companies were enabled to declare small dividends on their capital stock. The Broxburn Company reported a profit of 6 per cent on its preference shares and 8½ per cent on common stock; at the same time $60,000 was written off as depreciation and its reserve fund remained untouched. The statement of the Oakbank Oil Company showed a net profit of $55,000, and a 5 per cent dividend was declared. The Pumpherston Oil Company published a report showing an apparent profit of $105,000, but a large amount of it was applied to making good past losses and depreciations and the payment of interest. A dividend of 6 per cent was paid on the preference shares and the directors regarded the year's business as satisfactory. In their annual report the directors say:

The prices realized for most of the company's products during the year have been higher than those obtained during the previous year. The market for the two most important products of this company, sulphate of ammonia and solid paraffin, are at present in a more healthy state than they have been for several years, and the current prices show a substantial advance over the average prices realized for the past year.

Other companies, however, were unable to make such favorable reports. Several of them suffered heavy losses and their stocks were greatly depreciated in value. Several works were closed down for greater or less periods during the year. The increased economies in production and the fair profits out of sulphate of ammonia were swept away by the lowering value of other products. The Youngs company made a very unsatisfactory showing; its deficit amounts to over $40,000. The Holmes company reported a shrinkage of over $30,000 in its two last balancings, while the Clippens company confessed a loss of $70,000. The latter portion of the year proved more favorable and the year closed with very fair prospects for the industry in 1899. It will be noticed that the value of the oil shale produced in 1897 was much below that of 1896 or 1895.

IMPORTS INTO THE UNITED KINGDOM.

The following table gives the total importation of petroleum and its products into the United Kingdom from the United States and Russia for 1896, 1897, and 1898:

Total imports of petroleum oil (in barrels, or their equivalent) to England in 1896, 1897, and 1898.

Port.	1896.		1897.		1898.	
	American.	Russian.	American.	Russian.	American.	Russian.
London	1,335,840	522,773	1,422,263	412,610	1,630,687	611,824
Liverpool	663,109	258,527	684,121	368,462	887,489	387,519
Bristol	427,366	....	391,519	....	439,129	....
Hull	340,295	15,540	321,802	12,922	332,862	....
Clyde	58,292	....	51,144	50	54,740	....
Dublin	105,105	....	103,040	....	56,887	....
Other ports	65,089	50,437	115,198	....	65,708	....
Total	2,995,096	847,277	3,089,087	794,044	3,467,502	999,343
Total	3,842,373		3,883,131		4,466,845	

In addition to the above, there were imported of residuum (chiefly described as "distilled") 84,144 barrels into London, 26,067 barrels into Liverpool, and 18,346 barrels into Bristol.

Imports of refined petroleum from America and Russia to Great Britain.

Year.	From America.	From Russia.	Total.
	Barrels.	*Barrels.*	*Barrels.*
1883	1,329,004	502	1,329,506
1884	927,919	17,078	944,997
1885	1,367,720	70,149	1,437,869
1886	1,363,801	46,814	1,410,615
1887	1,444,350	188,461	1,632,811
1888	1,286,148	549,126	1,835,274
1889	1,355,590	771,227	2,126,817
1890	1,357,122	787,529	2,144,651
1891	1,647,772	830,863	2,478,635
1892	1,711,089	807,600	2,518,689
1893	2,209,619	743,094	2,952,713
1894	2,736,236	578,115	3,314,351
1895	2,730,009	602,900	3,332,909
1896	2,992,709	633,971	3,626,680
1897	2,755,486	494,278	3,249,764
1898	2,843,541	915,354	3,758,895

SUMATRA.

A large amount of capital has been invested in the development of the oil fields of Sumatra, but the results of the past year have been far from encouraging. The production shows a considerable increase over the previous year, but the efforts to extend the producing fields have not been very successful. The older wells decline very rapidly and drilling new ones is hampered by government restrictions. A foreign consular report, issued the latter end of the year, says:

For some time rumors have been afloat that the Sumatra oil companies were not as easy in their minds as they had been, and that the wells were running dry more quickly than new ones could be bored. No one seems to know exactly how much truth there is in all this, and many believe that it is merely a movement of insiders on the Amsterdam Stock Exchange to depress the stocks of these companies, with a view of buying in more and thereby tightening their control. If that be their object, it has certainly succeeded; for, whereas the shares of the Royal Company (Koninklijke Maatschappij) were at one time as high as 1,040 per cent premium, they are now very little over 200 per cent premium, and there is every prospect of a further decline. There is no doubt that many of the wells are running dry at an alarming rate. This in itself would not be so very important, as there is much new territory, practically half Sumatra, which has not been worked, and which gives every indication of being good oil country; but the trouble is that the Dutch have neither capital nor men enough to go ahead, and they will not permit foreigners to help them out.

American oil experts are not permitted by the Dutch laws to work in the Tamiang concession, although it is freely admitted that there are not enough Dutch experts competent to do the work. The alleged reason is that Tamiang being a so-called dangerous district, the Dutch are afraid that if any foreigners should get killed by rebels there, their respective governments would make troublesome reclamations. This, however, does not explain their hostility to foreign capital, which is absolutely necessary if the Dutch are to do anything with Sumatra, Borneo, and New Guinea.

Last year, on a capital of 8,000,000 guilders ($3,200,000), the directors of the Royal Company paid a dividend of 56 per cent, which was practically all the cash they had in the treasury at the time; and that, too, in spite of the fact that they knew their wells were running dry, and should have kept back every cent they had for the purpose of opening up new wells and more territory. Desperate as the situation will soon become, the Dutch Government will not permit either foreigners or foreign capital to take a hand. The same policy holds good with regard to coal and mining concessions in Borneo and the Celebes. The Dutch are neither numerous nor rich enough to develop them themselves, and will not let anyone else do it for them. The situation, therefore, is full of encouragement for America. The Russian oil has been nearly driven out of the market, and if the wells now being worked in Sumatra run dry, the Dutch policy will not permit new ones to be opened.

Mr. E. S. Stephens, of Bradford, an expert driller, who spent eighteen months in drilling wells for the Bombay-Burmah Trading Company, was not favorably impressed with the future of the country for oil-producing purposes. The territory now producing oil is being rapidly drowned out by salt water. He says:

The Royal Dutch Company, which has been operating extensively in the region around Berandon, has met with poor success. When the wells were first drilled plenty of oil was found and with sufficient gas to make the wells flow freely. As the supply of oil became gradually exhausted it was replaced by salt water, and in a short time the wells were rendered useless. About six months ago the Royal Dutch Company had a monthly production of 18,000 barrels of oil, but in about a month the output of its wells was reduced to 6,000 barrels. The Royal Dutch Company built a refinery at Berandon, but owing to the decreased production of the wells the refinery remains idle, and unless new territory is opened it will probably be a dead loss to its owners. The Bombay-Burmah Company will soon cease operations on the island of Sumatra, for the present at least, but is now bringing in some good producers on the islands of Java and Borneo. The manner of drilling in the vicinity of Langkat, Sumatra, has changed somewhat since the first days of that development. Hollow tools are now used. A water pressure of 90 pounds, forced through the tools, brings the mud to the top of the hole, and no bailer is required. The wells are drilled to a depth of about 900 feet. No rock is found, and all the driller has to contend with is mud. The holes are started with 10-inch pipe, and usually end at the bottom with pipe of 4¼ inches diameter. Two drillers are assigned to each well, and they work eight hours daily. The last 14 wells drilled by the Royal Dutch Company were of no value. Oil was found, but on account of salt water the wells would not flow, and no way has yet been devised for pumping them.

On the other hand, in some of the Chinese ports Sumatra oil has become a formidable competitor and is said to be driving the Russian and American illuminating oil out of the market. At Samshni, 2,000 gallons of Sumatra oil were imported in 1897 and 159,000 gallons in 1898, while the imports of American oil fell from 82,000 to 19,000 gallons. The American oil is preferred by the Chinese, but the Sumatran is much cheaper and finds a readier sale among this economical people.

In May of the current year the British consul at Fuchau, China, reported as follows:

The keen competition of the Royal Dutch Petroleum Company's "crown" or Langkat oil brought prices down to the lowest figure ever quoted, and this oil from its cheapness seemed destined to drive American and Russian kerosene out of the market, especially as preparations were made at Pagoda anchorage to build tanks in order to import it in bulk, and a steam sawmill started at Fuchau to supply the cases. Toward the end of the year, however, rumors, which were afterwards verified, spread that the Langkat wells showed serious signs of running dry, at least for the time being; supplies thence slackened off and prices went up with a bound. During the year the tank steamer Sabine Rickmers thrice brought full cargoes of Russian oil. The oil is tinned on board by Chinese, who can, under favorable conditions, fill 1,500 tins per hour. The Shell Transport and Trading Company's establishment on the north bank of the Min, at Fuchau, can turn out at least 2,000 tins per diem.

PRODUCTION.

We are indebted to Mr. Adrian Stoop, of the Dordtsche Petroleum Maatschappij, for the following table, giving the production of refined petroleum in Sumatra from 1893 to 1898, inclusive:

Production of refined petroleum in Sumatra, 1893 to 1898.

Year.	Production.		
	Cases.	Liters.	Gallons.
1893	401,370	14,449,320	3,812,238
1894	1,042,943	37,545,948	9,919,670
1895	1,334,249	48,032,964	12,690,347
1896	1,851,512	66,654,432	17,610,154
1897	4,564,987	164,339,532	43,418,635
1898	5,503,694	198,132,984	52,346,891

1 liter = 0.946 quart.
3.785 liters = 1 United States gallon.
1 case = 36 liters = 9.51 gallons.

The following statement, translated from the official government report of the Dutch East Indies by Mr. Theodore H. Johnson, of Washington, D. C., gives the production of refined petroleum in the island of Sumatra during each quarter of the year 1897 and for the first two quarters of 1898.

Production of refined petroleum in Sumatra in 1897 and first half of 1898.

Year.	Production.		
	Cases.	Liters.	Gallons.
1897.			
First quarter	787,048	28,333,728	7,485,794
Second quarter	1,015,680	36,564,480	9,660,365
Third quarter	1,219,820	43,913,520	11,601,987
Fourth quarter	1,542,439	55,527,804	14,670,489
Total	4,564,987	164,339,532	43,418,635
1898.			
First quarter	1,810,000	65,160,000	17,215,324
Second quarter	2,050,500	73,818,000	19,502,774
Total	3,860,500	138,978,000	36,718,098

1 liter = 0.946 quart; 1 United States gallon = 3.785 liters.

The report shows that the production since 1896 has been continually increasing. Although the large production of 2,050,500 cases in the second quarter of 1898 shows a great increase—more than double—over the production of the corresponding quarter in the preceding year, there was a deplorable falling off in the production in the last month of the quarter, the output by months being reported as follows: April, 740,000 cases; May, 839,000 cases; June, 471,500 cases.

JAVA.

Little was done in the way of developing the petroleum industry in Java during 1898, and the production shows only a small increase over that of 1897. The expectations for a large increase were not realized, as the gain for the year was only 8,960 barrels, or about 1¾ per cent. But the consumption of petroleum in Java likewise declined and there was a considerable falling off in the importation of American and Russian oils.

Numerous new wells were drilled during the year in search of new deposits of petroleum, but they were rewarded with small success, and the Dordtsche Petroleum Company continues the only one that is producing petroleum to any great extent. The Dordtsche company has erected a factory at Blora for the preparation of the various articles produced from the refuse, such as paraffin, ceresine, paraffin candles, etc., and a second factory has been erected at Samarang. Early in 1899 it was reported that the Java Petroleum Company had struck oil in the Kendal district, westward of Samarang, and were connecting the field with the works at the latter place by a pipe line.

The production of petroleum in Java for six years past is shown in the following table:

Production of crude petroleum in Java from 1893 to 1898.

Year.	Barrels (42 U. S. gallons).
1893	400,000
1894	168,000
1895	293,654
1896	505,029
1897	548,551
1898	557,511

The following statistics, given by the Dordtsche Petroleum Industry Maatschappij, Java, show their production of crude and refined petroleum during the years 1895, 1896, 1897, and 1898 in the districts of Soerabaya and Rembang:

Production of petroleum in Java in 1895, 1896, 1897, and 1898, by districts.

Districts.	1895.	1896.	1897.	1898.
Residency of Soerabaya:				
Crude.......gallons..	8,915,088	11,069,668	11,224,131	9,473,000
Refined.......cases..	525,004	604,418	627,966	546,163
Residency of Rembang:				
Crude.......gallons..	3,418,380	10,141,535	7,458,373	9,317,162
Refined.......cases..	222,904	638,916	791,431	930,311½

At the close of 1898 this company had 43 wells producing in the residency of Soerabaya and 10 wells producing in the residency of Rembang.

In the following table is given a statement of the production of crude petroleum in the residencies of Soerabaya and Rembang, by districts, in 1897:

Production of crude petroleum in the residencies of Soerabaya and Rembang in 1897, by districts.

Districts.	Liters.	Gallons.	United States barrels.
Residency of Soerabaya:			
Djabakotta	6,270,545	1,656,683	39,445
De Twaalf Dessa's	18,393,433	4,859,559	115,704
Lidah Koelon	14,705,675	3,885,251	92,506
Total	39,369,653	10,401,493	247,655
Residency of Rembang:			
Tinawoen	19,550,504	5,165,259	122,982
Panolan	27,595,979	7,290,879	173,592
Total	47,146,483	12,456,138	296,574
Total	86,516,136	22,857,631	544,229

1 liter=0.946 quart; 3.785 liters=1 gallon.

Production of refined petroleum in Java, 1889 to 1898.

Year.	Production.		
	Cases.	Liters.	Gallons.
1889	8,000	288,000	63,436
1890	27,760	999,360	220,123
1891	79,179	2,850,444	627,851
1892	247,839	8,922,204	1,965,243
1893	276,062	9,938,232	2,189,037
1894	452,728	16,298,208	3,589,914
1895	779,239	28,052,604	6,178,987
1896	1,250,000	45,000,000	9,911,894
1897	1,452,747	52,298,892	11,519,580
1898	1,476,474½	53,153,082	11,707,727

PETROLEUM TRADE OF JAVA.

The following table, which is from a British consular report, gives some interesting statistics in regard to the petroleum trade of Java. It shows that the import trade in American and Russian oils has gradually fallen off since 1896. At the same time there has been a considerable decline in the consumption.

Imports of illuminating oils into Java.

Illuminating oil.	1896.	1897.	1898.
	Barrels.	*Barrels.*	*Barrels.*
American Devoes	1,678,682	1,565,294	879,477
American Tiger	....	....	446,956
Russian	731,952	582,014	365,284
Langkat	330,652	494,228	625,559
Total	2,741,286	2,641,536	2,317,276

TAX ON PETROLEUM.

In spite of the vigorous protests of the commercial communities in Netherlands India, the internal-revenue tax on petroleum has been raised from 80 cents to $1 per hectoliter (26.417 gallons). This tax is for all oils, whether native or foreign. In addition the foreign oils pay a customs duty of 10 cents per hectoliter, which is the same as before. This new tax went into effect in 1899. None of the companies—American, Russian, or Sumatran—are prepared to predict the effect on their business by this extra tax; but they admit that they propose to add it to their price to the consumer. So it is safe to say that it may have the effect of diminishing trade somewhat, as the natives are poor and improvident and never have an extra cent to spare. The chances are that many who now use petroleum will revert to cocoanut oil, which they can make at home very cheaply.

BORNEO.

The first experimental borings for petroleum in 1897 were made in the Koetei district at the concession "Louise," which seems to be an extension of the mining district "Mathilde," of Balik Papan. A well at a depth of 192 feet found petroleum, which produced over 70,000 liters (440 barrels) every twenty-four hours. Of this product 15 cases were sent to Europe for analysis. In February, 1898, three more wells were sunk. A refinery is at the present time under erection, the necessary material having already been shipped from Europe. A giant gusher, located at Nati, in southeastern Borneo, was reported early in 1898. It was on the property of Messrs. G. Buy and A. Mohr, who own a large tract of land in that locality. The oil gushed forth with such force that it was impossible to collect it, and for three days the Negara and Martapoera rivers were covered with oil for hundreds of miles. A pipe line to connect the Nati field with Moear-Biberik, the nearest shipping point, was in course of construction in the spring of 1898. The Dutch Government is very slow about developing the oil deposits in the East Indies, and has shown itself decidedly hostile to foreign capital.

Mr. Sidney B. Everett, United States consul at Batavia, submitted the following report on petroleum in Borneo to the State Department under date of April 26, 1899:

Boring has taken place in various places in Borneo with such brilliant results that people are beginning to think that this is one of the richest petroleum fields in the world and has a great future. In the north, in the British North Borneo Company's territory, the Bombay-Burma Trading Company has had such a good yield that it has begun to build a refinery. On the island of Labuan, the same company is engaged in boring and has taken over the "Korszki" concession. Boring is also being successfully carried on in Brunei and Sarawak.

Of the prospects in the western part of Borneo no one seems to know much. The southern and eastern parts have excellent indications, especially Koetei, Passir, Balangan, Tandjong, and Kaluwar. In Koetei, three different companies are working—the London firm of Sam Samuel & Co., the Koetei Exploration Company, and the Dordtsche Maatschappij. The firm of Sam Samuel & Co. is starting with a capital of $4,800,000, and can increase it at any time, as the members of the syndicate comprise prominent bankers of Holland and England. It must be remembered that the firm of Sam Samuel & Co. and the well-known Shell Line Company, with which the Moeara Enim Company recently closed a contract, are the same. The Samuel firm has taken direction of the enterprise. Its headquarters are at Moeara Djawa, on one of the delta branches of the Mahakam River. Only Americans and Englishmen are employed. Up to the present time eight spouting wells have been bored. According to the latest news, the syndicate bored a fine new well last month; it took fire, but was extinguished. At Sanga-Sanga a petroleum tank has been constructed to store the surplus oil. At Balik Papan a refinery is being built, and the oil will be carried by pipe line from Sanga-Sanga to the harbor of Balik Papan. The deepest-draft ships can enter this harbor and lie right up against the wharf. In about six months it is hoped that the construction will be finished, so that the exportation of oil can be begun. There is a narrow-gauge railroad from Moeara Djawa to Sanga-Sanga. The syndicate also has three steam launches for use on the Mahakam River. For this railroad and the launches the only coal that is used is from the company's territory in Borneo.

In a recent interview Sir Marcus Samuel says:

"The refinery we are erecting in Koetei will be capable of dealing with 3,000 tons of oil per day, which would enable the Shell Company to supply the East through their own production with oil for illuminating purposes. We hope to have it completed within a few months. Geographically, their position is favorable, and the refinery and wells are situated only 100 yards from the seashore, where there is 30 feet of water. The wells are close to the refinery."

On March 15, 1899, in a lecture before the Society of Arts, after describing the work of the Shell Company in the East, especially in Borneo, the same authority said:

"It was intended, when the exploration of the fields was undertaken, to explore for oil, which, had it proved of a similar description to that found in Sumatra, would have been specially adapted for illuminating purposes, and I must therefore frankly state that the discovery of liquid fuel in the enormous quantities in which it has been found in these fields was the result rather of chance than of skill. The very first well bored yielded a supply of oil of a character which showed that with very little treating it was an ideal fuel. It is quite clear in countries where liquid fuel can be put down, as it can unquestionably now from Borneo to all ports east of the Suez Canal, at prices which will enable it to successfully compete with coal, its use is quite certain, and that in the immediate future. The company has undertaken the control of the vast fields of the Moeara Enim Company, who have, I believe, a property quite as rich as that being worked by the Shell Company, and that property, it is well known, was practically acquired by the Standard Oil Company; but the Dutch Government interfered, and it is now being controlled and will be managed by the Shell Company, to whom, I am happy to say, the Dutch Government's prejudices do not extend."

The second enterprise, that of the Koetei Exploration Company, is on the island of Miang, opposite the coast of Koetei. This territory is equally rich in oil. The company's own steamer will shortly come from Singapore, with the object of maintaining a regular service between the island and Samarinda. The capital of the Koetei Exploration Company is $120,000.

Near the firm of Sam Samuel & Co., which is working with so much success, a Mr. Stoop has been boring for the last two years, but so far without success.

In Passir nothing is being done, although the ground gives every indication of being rich oil territory.

In Balangan the Balangan Exploration Company is searching for petroleum. The signs are excellent, but at present no well has been bored, although gas and traces of oil have appeared. Near the oil fields big coal deposits have been discovered, the extent of which will shortly be investigated.

In the Tandjong district the Martapoera Company is at work. This concern has succeeded in striking oil twice, but has not yet bored a well that spouts. These wells will have to be pumped out to determine their richness. They have, for the present, been stopped up, in order to prevent loss of oil.

In Labuan Mas the firm Buijn is boring, but no spouting wells have so far been discovered. The ground shows every sign, however, of being as rich in petroleum as Koetei and Balangan.

The operations I have mentioned cover a very small part of the enormous island of Borneo, and a boundless field for American capital and energy is here offered. Petroleum, coal, marble, precious metals, and diamonds have been discovered. Wood and water are plentiful, and the only real difficulties are labor and climate. The former is being solved by importing coolies from China and Java, and as for the climate, one must be as careful as possible and trust to luck. In the interior it is said to be not so bad, and recent developments have shown that most of the tribes of this part of the country are now friendly enough. The native sultans do all they can to encourage enterprise. The Dutch Government is inclined to keep out foreigners, but indications are not lacking that it will abandon that policy.

JAPAN.

The discovery of petroleum in Japan is said to date back to the era of the Emperor Teudir, 674 A. C. Experiments for refining it were made in 1613, and for upward of three hundred years it is reported to have been used in a small way for illuminating as well as medicinal purposes. Nothing was done in the way of developing the lands where petroleum was known to exist until after the discovery of rich deposits in the United States. There were 15 oil districts known in 1866, and numerous small establishments for refining the oil were in existence. Very little was accomplished in these early efforts, and it was not until 1875 that the oil production of Japan assumed any commercial importance.

Mr. S. Takano, of Tokyo, who is connected with several of the leading oil companies of Japan, has made the following statement in regard to the petroleum developments in that country:

The general oil belt in Japan crosses the country from southeast to northwest and is several hundred miles in length and varies from 10 to 40 miles in width. Petroleum is found in all parts of the country, from Formosa in the south to Hokkaido in the north, but the main localities are scattered in the northern half of the Honshyu or main country, which begins from Totomi, Shinano, Echigo, Ugo, and ends with the Mutsu province. The leading oil districts at present are the four provinces Echigo, Totomi, Ugo, and Shinano, but more than 85 per cent is produced in Echigo. The geological formation is Upper Tertiary, and the oil-bearing rocks are mainly brownish sandstone, loose and coarse grained. The depth of the wells is from 300 to 2,000 feet. The production in a general way is stated to be 2,000 barrels a day in the whole oil district of Japan, of which Echigo province gives more than 1,600 barrels. The leading oil fields in Echigo province are Nagoaka, Amaze, Mitsu, Gendoji, Ushirodani, Miyogawa, and Hiyama. The crude oil from the different fields is variable in its physical and chemical qualities, the gravity being from 14° Baumé to 46° Baumé, and the color from dark green, with a pleasant odor, to pitch black, with an unpleasant odor. But the crude from Nagoaka and Amaze, the large oil fields in Japan, is 34° Baumé and 41° Baumé in gravity, respectively. The former is something like Canadian or Lima crude, containing some sulphur, though very little, while the latter is something like Pennsylvania middle division crude, free from all the impurities, gives a large percentage of burning oil, and much paraffin wax is obtained. The heavier kind of crude gives only 40 per cent of burning oil, while the lighter as much as 65 or 70 per cent. The fractional distillation made by Mr. Kondo, a chemist of the geological survey, Tokyo, Japan, will show the general character of the crude of Amaze, one of the leading oil districts:

Yield from crude petroleum from Amaze, Japan.

	Per cent.
Benzine (150° C.)	21.92
Burning oil (150° to 300° C.)	49.80
Heavy oil (300° C.)	20.52
Residuum and loss	7.76
Total	100.00

The residuum or tar from the heavy grades of oil is used extensively for fuel purposes, while some lubricating stock is made from the lighter crude.

The market price for crude is $2.30 for 50 gallons for the lighter kind, and $1 for 50 gallons for the heavy oil, while it sells for 9½ and 7 cents per gallon. The imported burning oils from Russia and the United States are sold in the Japanese market at from 10 to 11 cents. Heavy oil or tar costs $1.50 per barrel for boilers, and pitch or coke (soft) $1.20 per ton for carbon. There are more than 200 producing companies and 30 refineries in Japan. They have 3 pipe lines and another one is going to be laid soon, but the distant transportation is done by ships loaded with cases, and the old-fashioned method of carrying the oil barrels on the coolie's back is still to be seen in a few oil fields. The drilling is done largely and successfully by the American method, but there are many wells made by shafting and artesian methods. The deepest well made by shafting is 690 feet, while that of American drilling is 2,500 feet.

Mr. K. Nakashima, of the geological survey of Japan, states that the statistics of the production of crude petroleum in 1897 and 1898 have not as yet been ascertained by the mining bureau, but he has kindly given us a statement of the approximate production for each of these years and writes as follows:

The yield of crude oil in Echigo may be estimated with tolerable accuracy to have been a little over 200,000 koku in 1897, with an additional yield of about 40,000 koku in 1898.

By districts the production of Koshi ranks first, as usual, in Echigo, which, being little more than 140,000 koku in 1897, increased to nearly 180,000 koku in 1898. Next comes Naka-Kambara, whose production was 30,000 koku, remaining nearly stationary in both years. Third, the production of Santo, which in 1897 was 18,000 koku, decreased nearly 4,000 koku in 1898, mainly due to the decrease of production in Amaze. The production of Kariha was not more than 6,000 koku in 1897, but in 1898 shows an increase of 3,000 koku, and a still further increasing ratio can be seen in the present year.

In the latter part of 1898 a new oil region was discovered in the village of Nagamine (Kariha district), Echigo, not far from the town of Kashiwazaki by the seashore, and at present (1899) the wells are said to be yielding 400 koku (378 barrels) daily. By the increase of successful drilling the area of the productive oil zone is known to be gradually widening, and perhaps this field may prove to become comparatively prominent in the near future.

Besides Echigo, the production of Totoumi ranges annually from 2,000 to 3,000 koku. The production of other provinces, as those of Hokkaido, Ugo, Kozuke, etc., are not so noticeable. From past experience, and making allowance for all such minor yielding sources, the production of crude oil is estimated at not more than 210,000 koku in 1897 and 250,000 koku in 1898.

The production of crude petroleum in Japan from 1875 to 1898, inclusive, is shown in the following table. The production and value of refined petroleum for the same years are given, except for 1896, 1897, and 1898.

Production of petroleum in Japan, 1875 to 1898, inclusive.

Year.	Production.				Value received for crude and refined sold.	
	Crude.		Refined. (a)			
	Koku. (b)	Gallons.	Koku. (b)	Gallons.	Yen. (c)	Dollars.
1875	4,830	191,751	....	....	....	....
1876	8,155	323,753	....	....	....	....
1877	10,114	401,526	....	....	....	....
1878	18,920	751,124	....	....	....	....
1879	24,816	985,195	....	....	....	....
1880	26,974	1,070,868	....	....	....	....
1881	17,721	703,524	....	....	....	....
1882	16,450	653,065	....	....	....	....
1883	21,659	859,862	....	....	....	....
1884	29,541	1,172,778	6,215	246,735	107,964	92,633
1885	30,931	1,227,961	7,326	290,842	98,496	84,510
1886	40,113	1,592,486	13,487	535,434	136,911	110,898
1887	30,304	1,203,069	8,830	350,551	126,298	99,018
1888	39,605	1,572,318	4,511	179,087	138,602	104,367
1889	55,871	2,218,079	7,097	281,751	250,977	184,217
1890	54,399	2,159,640	11,180	443,846	221,478	166,551
1891	55,983	2,222,525	13,012	516,576	207,029	172,041
1892	72,893	2,893,852	13,431	533,211	207,245	154,398
1893	83,644	3,320,667	10,941	434,358	178,290	117,850
1894	138,077	5,481,657	13,980	555,006	245,697	136,608
1895	149,497	5,935,031	17,241	684,468	351,607	172,639
1896	208,500	8,277,450	(d)	(d)	(d)	(d)
1897	210,000	8,337,000	(d)	(d)	(d)	(d)
1898	250,000	9,925,000	(d)	(d)	(d)	(d)

a This production of refined oil is not the whole amount of refined oil made in Japan, but is only that portion which is refined by those who produce crude oil and refine it themselves. Most of the crude oil goes into the hands of others, by whom it is refined, and as yet there is no means of ascertaining this quantity.

b 1 koku = 39.7 gallons.

c Value of yen on January 1, 1885, in United States money, 85.8 cents; 1886, 81 cents; 1887, 78.4 cents; 1888, 75.3 cents; 1889, 73.4 cents; 1890, 75.2 cents; 1891, 83.1 cents; 1892, 74.5 cents; 1893, 66.1 cents; 1894, 55.6 cents; 1895, 49.1 cents; 1896, 52.9 cents; 1897, 51.1 cents; 1898, 49.8 cents.

d Not ascertained.

The production of crude petroleum in Japan, as ascertained by the mining bureau, for the years 1880, 1884, 1885, 1892, 1893, 1894, and 1896, is given, by provinces, in the following table:

Production of crude petroleum in Japan in 1880, 1884, 1885, 1892, 1893, 1894, and 1896, by provinces.

Province.	1880.		1884.		1885.	
	Koku.	Gallons.	Koku.	Gallons.	Koku.	Gallons.
Echigo	22,607	897,498	24,482	971,935	25,923	1,029,143
Totoumi	3,875	153,838	3,784	150,225	3,630	144,111
Ugo	229	9,091	771	30,609	805	31,959
Shinano	263	10,441	481	19,096	425	16,873
Ishikari	....	....	23	913	148	5,875
Iburi	....	....	....	....	....	....
Kotsuke	....	....	....	....	....	....
Total	26,974	1,070,868	29,541	1,172,778	30,931	1,227,961

Province.	1892.		1893.	
	Koku.	Gallons.	Koku.	Gallons.
Echigo	69,042	2,740,968	80,259	3,186,282
Totoumi	2,832	112,430	2,507	99,528
Ugo	340	13,498	118	4,685
Shinano	626	24,852	402	15,959
Ishikari	53	2,104	78	3,097
Iburi	....	....	280	11,116
Kotsuke	....	....	....	....
Total	72,893	2,893,852	83,644	3,320,667

Province.	1894.		1896.	
	Koku.	Gallons.	Koku.	Gallons.
Echigo	134,826	5,352,592	205,348	8,152,316
Totoumi	2,548	101,156	2,424	96,233
Ugo	345	13,697	145	5,756
Shinano	248	9,846	322	12,783
Ishikari	105	4,168	37	1,469
Iburi	....	....	220	8,734
Kotsuke	5	198	4	159
Total	138,077	5,481,657	208,500	8,277,450

Production of most important localities in Echigo in 1896, 1897, and 1898.

District.	Village.	1896.	
		Koku.	Gallons.
Koshi	Yamamoto and Nigoro	142, 719	5, 665, 953
Naka-Kambara	Tsushima	24, 024	953, 758
Santo	Amaze	17, 795	706, 471
Kariha	Miyagawa	4, 072	161, 645
Nishi-Kubiki	Kami-Nadachi	2, 446	97, 087
Naka-Kubiki	Sugawara	2, 370	94, 073
Total		193, 426	7, 678, 987

District.	Village.	1897.	
		Koku.	Gallons.
Koshi	Yamamoto and Nigoro	146, 000	5, 796, 200
Naka-Kambara	Tsushima	30, 000	1, 191, 000
Santo	Amaze	18, 000	714, 600
Kariha	Miyagawa	6, 000	238, 200
Nishi-Kubiki Naka-Kubiki	Kami-Nadachi Sugawara	5, 000	198, 500
Total		205, 000	8, 138, 500

District.	Village.	1898.	
		Koku.	Gallons.
Koshi	Yamamoto and Nigoro	180, 000	7, 146, 000
Naka-Kambara	Tsushima	30, 000	1, 191, 000
Santo	Amaze	14, 000	555, 800
Kariha	Miyagawa	9, 000	357, 300
Nishi-Kubiki Naka-Kubiki	Kami-Nadachi Sugawara	7, 000	277, 900
Total		240, 000	9, 528, 000

We are indebted to the Japan-American Commercial and Industrial Association, which has offices in New York City and Tokyo, Japan, for the following report of imports of petroleum:

Imports of petroleum to Japan in 1897 and 1898.

Month.	1897.		1898.	
	Quantity.	Value.	Quantity.	Value.
	Gallons.	*Yen.*	*Gallons.*	*Yen.*
January	1, 768, 914	250, 786	5, 444, 500	732, 090
February	3, 998, 940	369, 038	7, 757, 719	856, 529
March	6, 359, 929	880, 458	7, 818, 106	882, 004
April	5, 572, 358	926, 527	2, 223, 395	286, 712
May	4, 633, 665	692, 782	5, 312, 702	540, 915
June	4, 934, 754	592, 152	6, 314, 720	733, 543
July	6, 926, 968	926, 287	4, 986, 870	595, 523
August	6, 527, 671	783, 677	6, 895, 907	754, 269
September	3, 475, 012	441, 623	4, 726, 186	417, 130
October	5, 465, 996	648, 409	3, 387, 042	274, 277
November	3, 306, 211	468, 294	5, 327, 590	603, 909
December	7, 087, 797	687, 319	7, 717, 535	906, 717
Total	60, 058, 215	7, 667, 352	67, 912, 272	7, 583, 618

Importation of petroleum into Japan from 1868 to 1898, inclusive.

Year.	Quantity.	Value.		Value of yen on Jan. 1.
	Gallons.	*Yen.*	*Dollars.*	*Cents.*
1868	31, 954	7, 236	3, 698	....
1869	5, 867	1, 662	849	....
1870	52, 711	21, 516	10, 995	....
1871	152, 296	72, 170	36, 879	....
1872	446, 804	160, 608	82, 071	....
1873	1, 000, 959	330, 599	168, 936	....
1874	1, 291, 179	306, 723	156, 735	....
1875	2, 775, 354	573, 671	293, 146	....
1876	2, 888, 729	444, 134	226, 952	....
1877	2, 682, 252	605, 598	309, 461	....
1878	10, 687, 753	1, 803, 076	921, 372	....
1879	16, 799, 642	2, 185, 223	1, 116, 649	....
1880	14, 895, 892	1, 400, 471	715, 641	....
1881	8, 007, 200	979, 112	500, 326	....
1882	20, 682, 205	2, 320, 905	1, 185, 982	....
1883	23, 631, 055	2, 456, 261	1, 255, 149	....

Importation of petroleum into Japan from 1868 to 1898, inclusive—Continued.

Year.	Quantity.	Value.		Value of yen on Jan. 1.
	Gallons.	*Yen.*	*Dollars.*	*Cents.*
1884	17,534,885	1,773,361	906,187	....
1885	17,636,020	1,667,722	1,430,905	85.8
1886	25,100,220	2,358,498	1,710,383	81.0
1887	21,058,865	1,871,428	1,467,200	78.4
1888	28,507,767	3,519,255	2,649,999	75.3
1889	36,998,843	4,587,135	3,366,957	73.4
1890	42,663,580	4,950,256	3,722,593	75.2
1891	40,482,160	4,535,720	3,769,183	83.1
1892	32,689,275	3,328,398	2,479,657	74.5
1893	49,763,392	4,401,041	2,909,088	66.1
1894	55,643,719	5,135,332	2,855,245	55.6
1895	44,152,414	4,309,929	2,116,175	49.1
1896	54,692,886	6,331,036	3,349,118	52.9
1897	60,058,215	7,667,352	3,918,017	51.1
1898	67,912,272	7,583,618	3,776,642	49.8

In his report on the trade and navigation of Yokohama for the year 1897 Acting Consul-General Forster states that the import of kerosene shows a large increase over that of 1896. The total deliveries were: American, 1,679,791 cases; Russian, 1,135,157 cases; Langkat, 48,862 cases; total, 2,863,813; an increase of deliveries of American oil over 1896 of 413,518 cases and of Russian of 130,559 cases. The production of Japanese kerosene is estimated at 500,000 cases annually.

The following article[1] gives a most comprehensive statement of the Japanese petroleum industry:

The artesian method of drilling is the most simple and least expensive known in Japan. It is nothing but the American drilling on a very small scale. It is original with Japan, and there have been many improvements made since the introduction of the American method. The drilling machine is handled by two men, and even water power is used in some places. Still it can go down as far as 600 or even 900 feet. Most of such wells are put down in a new field for experiment, and they are almost all, when the oil is struck, flowing wells, producing from 2 to 20 barrels a day. This drilling will cost them from $70 to $100 to finish. It takes fifteen or twenty days.

Shooting the wells.—No nitroglycerin shooting was ever tried in the Japanese oil field. The main objection lies in the character of the rock, which is considered too soft and loose, unfit for successful shooting, and the result would be to destroy the whole well.

[1] Written for the Petroleum Gazette by Professor Shiu-ichi Takano, Tokyo.

According to statistics of the mining bureau of Japan the production has been:

Production of petroleum in Japan from 1891 to 1896.

	Koku.
1891	55,983
1892	72,893
1893	83,643
1894	138,077
1895	149,497
1896	208,500

The above figures, however officially made, are not large enough to indicate the true production, and, according to my careful observation, if about 20 per cent is added to each it will give the actual amount of the annual production during that period.

In 1897 they produced at least 450,000 barrels, and in 1898 it was nearly 720,000 barrels, or 2,000 barrels a day, or a little less than that of Canada. At present the daily production of crude oil in Japan is, according to the latest information the writer has received, nearly 2,300 barrels, which will be divided up among the different districts as in the following table:

Daily product of Japanese petroleum.

Province.	District.	Production.
		Barrels.
Echigo	Nagoaka	900
	Miyagawa	400
	Miitsu	350
	Amaze	150
	Hiyama	75
	Gendoji	95
Totomi	Sugegaya	150
Shinano	Kami-Minauchi	80
Ugo	Oguni	50
Other minor districts		50
Total		2,300

Compared with the American production, the above figures are, no doubt, very insignificant, but it shows the annual production has increased in the past eight years from 55,000 to 828,000 barrels—an increase of about fifteen times the amount produced eight years ago. The consumption of refined oil has become so great in Japan that not only has the domestic production been insufficient to supply the demand, but it has been one of the chief articles imported every year.

In 1868 the imported oil was only 639 barrels, $3,698 in value. Since that time the increase has never stopped, as may be seen by the following statistics compiled by the mining bureau.

Imports of petroleum oil in Japan.

	Gallons.		Gallons.
1868	31,954	1882	20,682,208
1869	5,867	1883	23,631,055
1870	52,711	1884	17,634,885
1871	152,296	1885	17,636,020
1872	446,804	1886	25,100,220
1873	1,000,959	1887	21,058,865
1874	1,291,179	1888	28,507,767
1875	2,775,354	1889	36,998,843
1876	2,888,729	1890	42,663,580
1877	2,682,252	1891	40,482,160
1878	10,687,753	1892	32,689,275
1879	16,799,642	1893	49,763,392
1880	14,895,892	1894	55,643,719
1881	8,007,200		

And by the latest statistics of the treasury department it is known that we imported oil to the value of $3,911,740 and $4,001,793 in American money during the years 1897 and 1898, respectively. In gallons it makes, in round numbers, nearly 78,000,000 and 85,000,000.

Again, the monthly statistics of this year are given by the same office as it is in the following table:

Comparative recent imports of petroleum.

Month and year.	Gallons.	Value.
January, 1898	5,444,500	$366,147
January, 1899	6,990,746	400,218
February, 1898	7,757,719	428,162
February, 1899	7,133,710	515,169
March, 1898	7,818,108	982,004
March, 1899	5,760,711	365,199

For convenience, to illustrate the idea, the average monthly importation in the first three months of this year will give 6,628,389 gallons, or, in 50-gallon barrels, 132,567 barrels in round numbers. In view of the statistics in the past we may make herewith a preliminary calculation, as follows: Thus, take the 132,567 barrels at the end of this year, that is the amount of refined oil that is going to be imported into Japan during this year. On the other hand, the annual domestic production in Japan is calculated as about 828,000 barrels. Only 40 per cent of the annual production, it can safely be said, is refined for burning oil, as the crude is used to a great extent for boilers and locomotives directly for fuel. In other words, they make but 331,200 barrels of refined oil in one year. Almost all the refined oil is consumed in the country. Comparing both imported and domestic refined oil, it is very clear that the latter furnishes only 17 per cent, while the former 83 per cent of the annual consumption in Japan. That is, the imported is nearly five times as much as the domestic. Of the imported refined oils there are only two kinds, namely, the American and Russian. The former will have 70 per cent as compared with the latter, which is 30 per cent, nearly.

Whether or not the Japanese oil field will bring as prosperous times as the American field attained once is the most important question for both scientific and business men.

I would like to take the liberty, as a professional geologist who has been engaged in this industry for several years, to say in conclusion that while the oil fields will not be as productive as those of Pennsylvania or Baku, foretelling from the geological nature and the history in the past, I believe, very faithfully, that they will come pretty near in time to surpassing the richest fields in the world, if the industry is continued and carried on by intelligent minds and active hands in the future.

INDIA.

From the Review of Mineral Production in India for 1897, issued by the department of revenue and agriculture, Calcutta, we extract the following information relative to the production of petroleum in India:

The provinces of India that produce petroleum are Burma, Assam, the Punjab, and Baluchistan. In the last-mentioned region production may, however, be said to have ceased, since operations have been entirely discontinued. In the Punjab the production last year was 2,041 gallons, or 13.66 per cent less than in 1896 and 8.10 per cent more than the average of the past three years. The major portion of the Punjab oil was raised at Rawalpindi; the balance of 730 gallons was obtained from Bannu and used in the railway engineering department.

Burma.—The petroleum refinery business was taken over by the Burma Oil Company as recently as 1888. Prior to that the business had been carried on by a private company for about twenty-three years. The Rangoon Oil Company was formed about 1865 to purchase and refine the oil produced from the native wells in Upper Burma, but owing to the high prices demanded for the crude oil by the monopolist who controlled the produce of these wells the refinery could not be worked at a profit, and as stated above it changed hands in 1888. In the same year it was turned into a limited company under its present name, and since that time the company has been drilling for oil on modern principles, but has so far obtained barely sufficient oil to keep the refineries going. With the exception of a few native refineries in Upper Burma worked upon primitive methods, the Burma Oil Company's refineries are the only ones in Burma. The amount of refined product may be taken at about 40,000 tons per annum. The export of solid paraffin to Europe depends upon the state of the market there, but may be stated at an average of about 15,000 tons per annum.

The production in 1897 was 18,904,710 gallons, or an increase of 27.59 per cent on the previous year and 46.49 per cent on that of the average of the past three years. This is certainly a very satisfactory result, and if a continuous supply and expansion, such as that secured last year, can be maintained, the industry may be regarded as exceedingly prosperous. The increased output is said to be due to some extent to new operations. It may be localized as 15,822,954 gallons from the Magwe district, 2,918,818 gallons from Pokokku district, 107,742 gallons from the Kyaukpyu district, and 55,196 gallons from Akyab.

Assam.—Petroleum is found in large quantities at Digboi, in Lakhimpur district. There are altogether 29 wells. The output of crude oil in 1897 was 222,077 gallons, or about 16,000 gallons less than 1896. The decrease is in no manner due to lack of oil, but to want of sufficient refining apparatus. There is some probability of this want being supplied before long, in which case the output will greatly increase. Petroleum is also found, but not worked, in other parts of the province. According to the returns of large industries, the output of the petroleum refinery at Margherita, in the Lakhimpur district, belonging to the Assam Railways and Trading Company, Limited, was in 1897, 57,500 gallons of oil and 340 maunds of wax, valued at 23,000 and 2,550 rupees, respectively, against 38,700 gallons of oil, valued at 18,000 rupees, in 1896. The average number of persons employed in the refinery was 143 in 1897, against 193 in 1896.

The following table shows the production of petroleum in India from 1889 to 1897:

Production of petroleum in India from 1889 to 1897.

Year.	Production.	
	Gallons.	Barrels (42 U. S. gallons).
1889	3, 298, 737	94, 250
1890	4, 931, 093	140, 888
1891	6, 136, 495	175, 328
1892	8, 725, 331	249, 295
1893	10, 359, 812	295, 994
1894	11, 139, 597	318, 274
1895	13, 013, 990	371, 828
1896	15, 057, 094	430, 203
1897	19, 128, 828	546, 538

In the following table is given the production of petroleum in India, by British provinces and native States, from 1894 to 1897.

Production of petroleum in India from 1894 to 1897.

Province or State.	1894.			1895.		
	Quantity.	Value.		Quantity.	Value.	
	Gallons.	*Rupees.*	*Dollars.*	*Gallons.*	*Rupees.*	*Dollars.*
Assam	166, 904	33, 380	8, 178	36, 435	7, 287	1, 574
Burma	10, 920, 951	1, 057, 545	259, 099	12, 975, 995	1, 534, 951	331, 549
Punjab	1, 742	409	100	1, 560	353	76
Native States	50, 000	9, 375	2, 297	....	....	....
Total	11, 139, 597	1, 100, 709	269, 674	13, 013, 990	1, 542, 591	333, 199

Province or State.	1896.			1897.		
	Quantity.	Value.		Quantity.	Value.	
	Gallons.	*Rupees.*	*Dollars.*	*Gallons.*	*Rupees.*	*Dollars.*
Assam	238, 730	23, 873	5, 562	*a* 222, 077	*b* 22, 208	4, 997
Burma	14, 816, 000	1, 769, 145	412, 211	18, 904, 710	2, 241, 289	504, 290
Punjab	2, 364	337	79	2, 041	275	62
Total	15, 057, 094	1, 793, 355	417, 852	19, 128, 828	2, 263, 772	509, 349

The value of the rupee on January 1, 1885, in United States money was 37.8 cents; 1886, 35.7 cents; 1887, 34.6 cents; 1888, 32.2 cents; 1889, 32.3 cents; 1890, 33.2 cents; 1891, 36.6 cents; 1892, 32.8 cents; 1893, 29.2 cents; 1894, 24.5 cents; 1895, 21.6 cents; 1896, 23.3 cents; 1897, 22.5 cents; 1898, 20.1 cents.

a The decrease in the quantity and value is partly due to the fact that the Assam Oil Syndicate, which extracted a small quantity of oil in 1896, did not work in 1897, and partly to ordinary fluctuation.

b Value of the crude or unrefined oil at the well.

From a commercial point of view the approximate average composition of Burma petroleum is as follows:

Usual composition of Burma petroleum.

	Per cent.
Illuminating oil	50
Lubricating oil	40
Paraffin wax	10

PROSPECTS OF INDIAN PETROLEUM.

If it be found possible to produce this oil at paying rates and in sufficient quantity, the home market would be almost limitless. The consumption of mineral oil in India is increasing with marvelous rapidity. The imports of foreign mineral oils rose from a valuation of 598,797 rupees in 1870–71 to 4,870,580 rupees in 1880–81, and to 8,518,279 rupees in 1885–86.

The foreign imports of oil are derived mostly from Russia. The supply commenced in 1886–87, and is drawn from the Caucasus via the Black Sea, the Straits of Constantinople, and the Suez Canal. The imports of American oil have declined since 1893–94, and now they are less than half those of Russia. The fluctuations are shown in the following table of thousands of gallons:

Fluctuations of imports into India from 1886 to 1897.

Years.	From Russia.	From United States.	From other countries.	Total.
1886–87	1, 577	29, 144	1, 229	31, 950
1891–92	28, 333	27, 293	2, 483	58, 109
1896–97	45, 483	19, 312	3, 626	68, 421

The value of kerosene imported during the past year reached 30,882,791 rupees, or over three crores of rupees. The increased demand for cheap oil was no doubt partly due to scarcity of local vegetable oils, owing to failure of crops. During the past year Madras imported considerable quantities of kerosene from Sumatra. It is said that the imports of kerosene oil from Sumatra into India in 1897 rose from 558,271 gallons to 5,332,703 gallons.

The following table shows quantity and value of oil carried by rail and river in British India between April 1, 1896, and March 31, 1897:

Quantity and value of petroleum (kerosene) carried by rail and river in British India between April 1, 1896, and March 31, 1897.

	Exports.		Imports.	
	Quantity.	Value.	Quantity.	Value.
British provinces (excluding chief seaports).	*Gallons.*	*Rupees.*	*Gallons.*	*Rupees.*
Madras	44, 320	35, 664	2, 011, 504	1, 462, 438
Bombay	468, 600	263, 588	3, 229, 104	1, 816, 423
Sind	10, 968	5, 998	183, 920	100, 599
Bengal	5, 835, 344	3, 100, 025	11, 583, 656	6, 156, 663
Northwest provinces and Oudh	114, 208	85, 656	3, 353, 880	1, 786, 564
Punjab	29, 824	19, 572	2, 122, 320	1, 155, 639
Central provinces	16, 856	13, 432	1, 673, 424	922, 068
Berar	7, 792	4, 870	995, 592	560, 031
Assam	3, 480	1, 849	2, 442, 296	1, 297, 470
Total	6, 531, 392	3, 530, 654	27, 595, 696	15, 257, 895
Native States.				
Rajputana and central India	5, 040	3, 973	1, 234, 424	708, 743
Nizams Territory	792	505	539, 944	359, 425
Mysore	25, 264	20, 320	882, 352	583, 727
Total	31, 096	24, 798	2, 656, 720	1, 651, 895
Chief seaports.				
Madras ports	1, 955, 232	1, 573, 350	62, 624	45, 134
Bombay	7, 123, 864	4, 007, 174	3, 080	1, 733
Karachi	1, 521, 472	832, 055	32	19
Calcutta	13, 155, 976	6, 989, 112	880	467
Total	23, 756, 544	13, 401, 691	66, 616	47, 353
Grand total	30, 319, 032	16, 957, 143	30, 319, 032	16, 957, 143

From the above statement it will be seen that 30,319,032 gallons of oil were carried on the railways and rivers of India during the year. Bengal was the largest importing province, having taken 11,583,656 gallons, of which practically the whole was received from Calcutta. After Bengal the northwest provinces and Oudh would appear to be the most important provinces, the imports of which were 3,353,880 gallons, of which the Bengal province, and not Calcutta, was the chief source of supply. In 1896–97 Bombay would appear to have been the third most important receiving province. Assam may be spoken of as fourth, with 2,442,296 gallons derived exclusively from Bengal and Calcutta. The Punjab, fifth in order of demands, 2,122,320 gallons, the supply being derived mainly from Bengal and Karachi. It is perhaps hardly necessary to mention other particulars, except that the exporting centers are as follows: Calcutta, 13,155,976 gallons; Bombay port town, 7,123,864 gallons; Madras ports, 1,955,232 gallons, and Karachi, 1,521,472 gallons.

The following table shows the coastwise traffic in kerosene oil and other mineral oils from 1892 to 1897.

Coastwise traffic in kerosene oil and other mineral oils.

IMPORTS.

[Gallons.]

Description.	Bengal.	Bombay.	Sind.	Madras.	Burma.	Total.
1892–93.						
Kerosene:						
Indian	....	....	....	53, 115	84, 072	137, 187
Foreign	652, 810	3, 144, 367	43, 886	1, 898, 697	509, 894	6, 249, 654
Other kinds:						
Indian	1, 197, 467	5, 328	....	23, 074	230, 197	1, 456, 066
Foreign	2, 229	780	503	16, 252	10, 190	29, 954
1893–94.						
Kerosene:						
Indian	....	....	....	4, 932	188, 408	193, 340
Foreign	619, 094	3, 421, 391	394, 672	2, 756, 085	442, 436	7, 633, 678
Other kinds:						
Indian	1, 376, 402	4, 971	....	16, 530	195, 456	1, 593, 359
Foreign	4, 579	408	4, 486	27, 300	8, 385	45, 158
1894–95.						
Kerosene:						
Indian	355	....	....	11, 838	240, 326	252, 519
Foreign	303, 123	3, 663, 583	420, 608	1, 657, 117	387, 621	6, 432, 052
Other kinds:						
Indian	1, 529, 093	20, 265	....	25, 518	247, 645	1, 822, 521
Foreign	11, 308	713	789	31, 591	9, 327	53, 728
1895–96.						
Kerosene:						
Indian	41, 360	....	....	20, 705	355, 250	417, 315
Foreign	639, 276	2, 962, 546	601, 252	1, 570, 378	390, 339	6, 163, 791
Other kinds:						
Indian	2, 049, 609	17, 299	....	11, 500	236, 101	2, 314, 509
Foreign	3, 994	2, 318	775	48, 744	10, 067	65, 898
1896–97.						
Kerosene:						
Indian	38, 000	....	....	4, 030	244, 731	286, 761
Foreign	1, 147, 823	2, 380, 644	84, 897	2, 540, 006	407, 330	6, 560, 700
Other kinds:						
Indian	2, 636, 965	7, 816	....	19, 585	235, 000	2, 899, 366
Foreign	8, 445	2, 510	1, 014	70, 100	22, 352	104, 421

Coastwise traffic in kerosene oil and other mineral oils—Continued.

EXPORTS.

[Gallons.]

Description.	Bengal.	Bombay.	Sind.	Madras.	Burma.	Total.
1892-93.						
Kerosene:						
Indian	364	....	....	224	171,679	172,267
Foreign	696,261	7,535,020	496,388	49,592	475,242	9,252,503
Other kinds:						
Indian	3,500	....	....	....	1,456,103	1,459,603
Foreign	18,229	32,391	....	558	275	51,453
1893-94.						
Kerosene:						
Indian	....	....	....	112	285,776	285,888
Foreign	760,202	10,525,863	31,489	74,594	405,395	11,797,543
Other kinds:						
Indian	6,294	....	....	....	1,582,724	1,589,018
Foreign	8,225	61,261	47	76	3,388	72,997
1894-95.						
Kerosene:						
Indian	....	....	....	462	359,288	359,750
Foreign	359,581	8,310,399	114,489	142,231	358,744	9,285,444
Other kinds:						
Indian	12,245	....	....	....	1,799,858	1,812,103
Foreign	26,842	68,895	750	97	2,093	98,677
1895-96.						
Kerosene:						
Indian	417	....	....	240	402,904	403,561
Foreign	1,126,777	7,853,567	39,476	137,287	352,329	9,509,436
Other kinds:						
Indian	11,487	120	....	....	2,267,406	2,279,013
Foreign	50,225	78,818	10	39	4,735	133,827
1896-97.						
Kerosene:						
Indian	....	....	....	3	999,212	999,215
Foreign	1,616,623	8,131,636	124,640	104,642	346,840	10,324,381
Other kinds:						
Indian	9,078	....	....	1	2,412,868	2,421,947
Foreign	73,565	99,877	45	44	4,433	177,964

In the above tables it will be observed that effort has been made to distinguish Indian from foreign petroleum. In calculating quantities the Bengal standard of 280 gallons to the ton is employed.

The following is a statement of quantity of kerosene oil imported into British India by sea from foreign countries, as reported in the British Colonial Statistical Abstract and given in Commerce and Navigation, published by Bureau of Statistics, United States Treasury Department:

Quantity of kerosene oil imported into British India by sea from foreign countries from 1886 to 1897.

Year.	Quantity.	Value.
	Gallons.	*Rupees.*
1886-87	30,963,763	....
1887-88	30,200,042	....
1888-89	38,285,559	....
1889-90	51,839,400	....
1890-91	52,561,297	....
1891-92	55,508,063	....
1892-93	64,409,305	....
1893-94	83,611,938	....
1894-95	50,364,624	....
1895-96	63,312,422	....
1896-97	64,471,307	2,859,356

NATURAL GAS.

By F. H. OLIPHANT.

INTRODUCTION.

In the United States the very wide distribution of natural gas has made it an object of almost universal interest. Its first use dates back to the evaporation of salt brine (in the most crude manner) on the Kanawha and Ohio rivers. It now supplies a large proportion of the domestic consumption of nearly all the cities and towns in western New York, western Pennsylvania, and Ohio, and nearly all of those in northern Indiana, northwestern West Virginia, northeastern and northwestern Kentucky, and southeastern Kansas. To a smaller extent it is used for domestic service in the States of Texas, Utah, California, Colorado, Illinois, and Missouri.

There were no new fields of large extent discovered in 1898, although a number of very large wells were found in southwestern Pennsylvania, West Virginia, and central Ohio, in territory previously determined. The State of Kansas during 1898 has developed considerable new gas territory in the folding strata above the Mississippian limestone. The great proportion of the business for 1898 was the gathering together, transportation, and consumption of the gas in areas previously determined.

There have been occasional surprises in all the fields where unexpected volume and pressure have been found, but the new production has been comparatively small, and they were but a small factor toward holding up the declining pressure over the great gas-bearing areas. The continual drain is being felt in all of the fields. The enlarging of the lines conveying the gas to market, the increase in the lines reaching small outlying pools, and the application of the gas pump have in many instances made the supply to the consumer more regular than it was in the period of the original high pressure.

It is remarkable how many of these companies have kept up the supply to their consumers. The exhaustion of one field or locality and the necessary shifting of pipes and appliances have frequently occurred. There have been periods in the history of many of the prominent companies which furnish natural gas when the supply known to be under their control would scarcely last a single year without great reduction in the consumption, yet by the judicious selection of new territory and extension of lines the condition has been entirely changed and a supply for several years to come secured. There must come a time, however, not so far distant, when the present known fields will become exhausted. The many miles of pipe of large size now in use and the assistance of the gas compressor may postpone it for a number of years.

In western Pennsylvania and West Virginia there are a number of possibilities along the numerous anticlines in the sands below the Fifth, in the Ohio black shale of Devonian age, or the still lower Corniferous and Clinton limestones or the Medina sandstone. In New York and Ohio there are possibilities in the lower portion of the Trenton limestone down to the Potsdam sandstone. Deeper drilling at the proper localities may possibly tap new reservoirs.

It is very satisfactory to know that the consumption of natural gas for the last five years has been much more economical than during the first five years of its introduction on a large scale. This is due in great measure to the introduction of the meter instead of the orifice, which forced the consumer to secure more perfect combustion and more economical heat-saving appliances. It is considered that a given amount of effective work can now be accomplished with less than one-half the gas that was required at the time of its introduction.

The appliances for holding back the gas in the wells when it is not required, the packing of the lines at night, when the consumption is lightest, so as to meet the pull in the daytime, the more judicious selection of the position of regulators feeding from the high to the low system, the proportioning of the sizes of the low-pressure lines to the demand, the proper selection of the location of drips, the installation of the gas compressor where the rock pressure in the wells is no longer able to force the gas through the original pipe line, the selection of improved joints for connecting the pipe lines, and a more thorough stopping of all leaks, no matter how small, are some of the more recent conditions brought about by the decreased volume of the fields.

The calorific value of natural gas is high, as 1,000 cubic feet will in practice, where the conditions are favorable, evaporate 1,000 pounds of water at 212° F. This amount multiplied by 966, the number of British thermal units required to evaporate 1 pound of water, equals 966,000 British thermal units, which is one-third greater than the same amount of manufactured gas and double the value of enriched water gas.

One thousand cubic feet of natural gas will weigh approximately 45 pounds at 60° F., the same amount of dry air being 76.5 pounds in weight. Its composition closely approximates marsh gas, CH_4, with from 2 to 15 per cent of nitrogen. The remaining 85 to 98 per cent is almost pure marsh gas, viz, 75 per cent of carbon and 25 per cent of hydrogen. The gas in northwestern Ohio and Indiana has 0.20 per cent of sulphuretted hydrogen in its composition. Slightly less than 11 cubic feet of air is necessary for the complete combustion of 1 cubic foot of natural gas.

The gas engine using natural gas is increasing in importance each year, and is particularly applicable to the pumping of oil wells and driving oil pumps used in the transportation of the oil.

Owing to the large number of widely separated points at which power is required in the operating of wells in the field, it has been the usual practice heretofore to divide the wells into clusters, placing a boiler as near the center as convenient and from it steam lines are carried to the several wells. It is the usual practice to cover these lines with wooden boxes, but with the best appliances the condensation in these long lines is great, often only one or two wells could be pumped at one time, the work accomplished at the wells was not half the amount furnished by the boiler. Where wells were pumped by rod connections the loss was not so great. The gas engine has in very many instances replaced the steam engine and boiler. In some instances this has been done by removing the steam engine entirely, in others by the substitution of a gas cylinder for a steam cylinder, on the same engine bed. The dispensing with the troublesome boiler and the substitution of a much more economical engine has placed in the hands of the oil operator a much more economical source of power not subject to the contingencies of the former method with a great saving of labor and material, and also a great saving in the quantity of gas consumed, as the following table from actual tests, will indicate, not that all the gas engines pumping wells are fully as economical as shown in the following table. To offset this, however, it must be remembered that the ordinary oil pumping plant is a very extravagant combination so far as economy in the use of steam, to work accomplished. Many plants will show greater economy in favor of the gas engine than is indicated in this table:

Fuel per indicated horsepower per hour.

Type of engine.	Equivalent of gas and coal.	
	Gas.	Coal.
	Cubic feet.	*Pounds.*
Natural gas engine	13	1.3
Triple expansion condensing	16	1.6
Double expansion condensing	20	2.0
Single cylinder and cut-off	40	4.0
Ordinary high pressure without cut-off	75	7.5
Ordinary oil well pumping engine	130	13.0

Natural gas in connection with a mantle of alkaline earth (thoria, etc.) has produced the cheapest and best illuminant. Where gas can be had at 25 cents per 1,000 cubic feet and 50-candle power can be obtained from the consumption of 2½ cubic feet per hour, the cost per candle power is but .00125 of one cent.

In an ordinary Argand burner, with chimney, it will give about

12-candle power in consuming 5 to 6 cubic feet per hour. If consumed in an ordinary tip, 7 to 8 cubic feet per hour will yield 6-candle power. All natural gas has not the same illuminating value. In some districts it carries a small percentage of the heavier hydrocarbons, which add much to its illuminating properties.

VALUE AND DISTRIBUTION OF NATURAL GAS PRODUCED IN THE UNITED STATES.[1]

The number of pipe lines reaching out of one State into others has made the complete separation of the value of the gas consumed in each State a rather difficult problem. New York receives gas from its own territory, from Pennsylvania, and from Canada. Pennsylvania receives gas from West Virginia. Ohio receives gas from Pennsylvania, West Virginia, and Indiana, besides its own gas. West Virginia receives some gas from Pennsylvania. Indiana furnishes Illinois a large amount of gas. The following table shows an increase of $1,470,391 in 1898 as compared with 1897. Although there has been an increase in the amount of gas consumed in 1898 over 1897, yet it has not been so large as these figures would seem to indicate, but is in part due to the more complete returns secured in 1898 and is very close to the exact amount of all the companies and many individuals using natural gas. It is impossible to give the number of million of cubic feet consumed, as a number of small companies have not yet installed the meter, and base the value of the gas consumed by the size of the orifice used.

If we place the average value of natural gas at 18 cents per thousand cubic feet, the total cubic feet would approximate 85,000,000,000. This enormous quantity would fill a vessel one square mile in area to a height of 3,050 feet, if it were possible to have the same density throughout, and would require 4,250,000 tons of coal to equal its heating value.

The figures in this table are obtained from the best information that it was possible to secure with a large amount of labor and skill. It shows that the largest amount and value of natural gas was produced in 1888. In this year Pennsylvania alone produced over $19,000,000 as compared with a total value of $15,296,813 for all States in 1898; of this amount Pennsylvania produced $6,806,742. These figures indicate the large falling off in the production of Pennsylvania.

The State of Ohio produced the largest amount in 1889, amounting to $5,215,669, and in 1898 produced $1,488,308. Indiana produced the largest amount in 1893, valued at $5,718,000, and has held up pretty close to this value up to and including 1898, in which year it was $5,060,969. There is a considerable percentage of gas unreported, as it comes from wells owned by numerous companies and individuals and is piped and consumed by them in the operation of pumping and drilling wells, supplying the homes of their workmen, and usually the family of the farmer from whose land the gas is obtained. This gas is not usually sold, and we have no means of arriving at its exact proportion

[1]Much credit should be given Miss Belle Hill for the careful compilation of the tables in this report.

and value. It is estimated that if this amount was reduced to the value of the fuel displaced it would add 25 per cent to the value of that transported and sold.

In the following table is given the approximate value of natural gas produced in the United States from 1888 to 1898, by States.

Approximate value of natural gas produced in the United States from 1888 to 1898.

State.	1888.	1889.	1890.	1891.	1892.
Pennsylvania	$19,282,375	$11,593,989	$9,551,025	$7,834,016	$7,376,281
New York	332,500	530,026	552,000	280,000	216,000
Ohio	1,500,000	5,215,669	4,684,300	3,076,325	2,136,000
West Virginia	120,000	12,000	5,400	35,000	500
Indiana	1,320,000	2,075,702	2,302,500	3,942,500	4,716,000
Illinois		10,615	6,000	6,000	12,988
Kentucky		2,580	30,000	38,993	43,175
Kansas		15,873	12,000	5,500	40,795
Missouri		35,687	10,500	1,500	3,775
Arkansas		375		250	100
Texas		1,728	6,000		100
Utah		150			
South Dakota		25			
California		12,680	33,000	30,000	55,000
Other States	75,000	1,600,000	1,600,000	250,000	200,000
Total	22,629,875	21,107,099	18,792,725	15,500,084	14,800,714

State.	1893.	1894.	1895.	1896.	1897.	1898.
Pennsylvania	$6,488,000	$6,279,000	$5,852,000	*a* $5,528,610	*b* $6,242,543	*c* $6,806,742
New York	210,000	249,000	241,530	256,000	200,076	229,078
Ohio	1,510,000	1,276,100	1,255,700	1,172,400	1,171,777	1,488,308
West Virginia	123,000	395,000	100,000	*d* 640,000	*e* 912,528	*f* 1,334,023
Indiana	5,718,000	5,437,000	5,203,200	*g* 5,043,635	*g* 5,009,208	*h* 5,060,969
Illinois	14,000	15,000	7,500	6,375	5,000	2,498
Kentucky	68,500	89,200	98,700	99,000	90,000	103,133
Kansas	50,000	86,600	112,400	124,750	105,700	174,640
Missouri	2,100	4,500	3,500	1,500	500	145
Arkansas	100	100	100	60	40	
Texas	50	50	20			765
Utah	500	500	20,000	20,000	15,050	7,875
Colorado		12,000	7,000	4,500	4,000	3,300
California	62,000	60,350	55,000	55,682	50,000	65,337
Other States	100,000	50,000	50,000	50,000	20,000	20,000
Total	14,346,250	13,954,400	13,006,650	13,002,512	13,826,422	*i* 15,296,813

a Includes $912,000 worth of gas produced in Pennsylvania but consumed in New York and Ohio.

b Includes $999,882 worth of gas produced in Pennsylvania but consumed in New York, Ohio, and West Virginia.

c Includes $1,242,265 worth of gas produced in Pennsylvania but consumed in New York, Ohio, and West Virginia.

d Includes $126,000 worth of gas produced in West Virginia but consumed in Pennsylvania and Ohio.

e Includes $269,336 worth of gas produced in West Virginia but consumed in Pennsylvania and Ohio.

f Includes $589,438 worth of gas produced in West Virginia but consumed in Ohio and Pennsylvania.

g Includes value of some gas produced in Indiana but consumed in Ohio and Illinois.

h Includes $1,098,568 worth of gas produced in Indiana but consumed in Ohio and Illinois.

i Does not include value of gas produced in Canada and consumed in Buffalo and Detroit.

DETAILED STATEMENT OF THE COMPANIES MAKING COMPLETE RETURNS.

This table is interesting because all of the companies making complete returns are incorporated in it, and the year 1898 is compared with 1897. Many companies do not keep their accounts in such shape that they can give all the data asked. Yet it will be seen on referring to the total value of natural gas by States that Pennsylvania and Ohio gave complete reports for a large proportion of the total value. It is interesting to note that the value of the gas sold in Pennsylvania and Ohio is close to the value of the fuel displaced. In Indiana, where the gas is sold at a lower figure, the value of the fuel displaced is 70 per cent greater than the value of the natural gas.

The table is very complete and is worthy of careful study and comparison.

Natural gas records in 1897 and 1898.

	Pennsylvania.		Indiana.		Ohio.	
	1897.	1898.	1897.	1898.	1897.	1898.
Amount received for sale of gas or value of gas consumed	$5,195,144	$5,458,051	$3,669,883	$3,575,682	$1,220,668	$1,083,293
Value of coal or wood displaced	$5,053,871	$5,393,011	$4,894,266	$6,093,317	$1,241,071	$1,037,996
Domestic fires supplied	189,681	202,533	180,807	153,683	57,128	51,291
Iron and steel works supplied	39	32	9	6	1	0
Glass works supplied	48	45	53	55	1	1
Other establishments supplied	979	839	780	1,686	165	212
Total establishments supplied	1,066	916	842	1,747	167	213
Total wells producing Jan. 1	1,864	2,010	2,183	2,334	379	411
Total producing wells drilled	267	277	348	512	97	34
Total wells abandoned	121	93	197	214	65	58
Total wells producing Dec. 31	2,010	2,194	2,334	2,632	411	387
Total dry holes drilled	80	67	57	79	28	9
Total feet of pipe laid	26,970,418	29,601,758	21,098,720	23,310,122	7,783,813	7,446,610
Total establishments reporting	108	108	349	349	56	56

Value of natural gas consumed in the United States in 1898, by States, and the value of coal or wood displaced by same, as reported by 1,169 persons, firms, and corporations.

State.	Companies or individuals reporting.	Amount received for sale of gas, or value of gas consumed.	Estimated value of coal or wood displaced by gas.
Pennsylvania	232	$6,064,477	$6,022,916
Indiana	533	*a* 4,682,401	7,722,551
Ohio	237	2,250,706	2,200,073
New York	62	1,006,567	970,234
West Virginia	19	914,969	1,043,403
Kansas	29	174,640	221,240
Kentucky	21	103,133	103,543
California	11	65,337	93,432
Utah and Colorado	3	11,175	15,000
Illinois	16	2,498	2,498
Missouri	3	145	145
Texas	3	765	765
Total	1,169	*b* 15,276,813	18,395,800

a Includes value of gas consumed in Chicago, Illinois.

b In addition to this, a large quantity of gas is piped from Canada and consumed in the cities of Buffalo and Detroit, the value of which is not included in this table.

USES TO WHICH NATURAL GAS IS APPLIED.

The following table shows the principal uses to which natural gas is applied. The amount consumed as an illuminant increases yearly, but in the table it is not separated from that supplying domestic fires. It will be noticed that 1,169 companies and individuals reported in 1898, as compared with 889 in 1897, which accounts for the general increase in this table. Much gas is also consumed near the wells in the manufacture of a superior article of lampblack, unreported; and a large amount of natural gas of which we have no record is consumed by individuals and companies inside of the gas belts. A number of iron mills and steel works in and about Pittsburg have their own lines extending to the gas fields.

Uses to which natural gas produced in the United States in 1898 was put, as reported by 1,169 persons, firms, and corporations.

State.	Companies or individuals reporting.	Domestic fires supplied.	Establishments supplied.				
			Iron mills.	Steel works.	Glass works.	Other establishments.	Total.
Pennsylvania	232	213,410	26	8	55	932	1,021
Indiana	533	173,454	8	2	83	1,774	1,867
Ohio	237	68,211			9	340	349
New York	62	68,662			2	101	103
West Virginia	19	28,652			5	120	125
Kansas	29	6,186				44	44
Kentucky	21	12,317					
California	11	552				3	3
Utah and Colorado	3	430					
Illinois	16	113					
Missouri	3	11					
Texas	3						
Total	1,169	571,998	34	10	154	3,314	3,512

RECORD OF WELLS AND MILES OF PIPE, BY STATES.

In the following table will be found the number of companies and individuals reporting, the producing wells at the close of 1897 and 1898, the producing wells drilled, and the nonproducing or dry holes drilled in 1898, together with the total feet of pipe in use at the close of 1898:

Record of wells and amount of pipe line, as reported by 1,169 persons, firms, and corporations in 1898.

State.	Companies or individuals reporting.	Wells.					Total pipe laid to Dec. 31, 1898.	
		Producing, Dec. 31, 1897.	Producing, drilled in 1898.	Abandoned in 1898.	Producing, Dec. 31, 1898.	Nonproducing holes drilled in 1898.	Feet.	Miles.
Pennsylvania	232	2,467	373	131	2,709	74	34,453,129	6,525.2
Indiana	533	2,881	706	262	3,325	111	29,655,721	5,616.6
Ohio	237	729	120	43	806	12	11,244,478	2,129.6
New York	62	359	63	11	411	9	4,150,044	786.0
West Virginia	19	196	32	1	227	4	7,319,410	1,386.2
Kansas	29	90	*a* 34	3	121	18	869,283	164.6
Kentucky	21	81	3	3	81	3	358,300	68.0
California	11	21	2		23		126,850	24.0
Utah and Colorado	3	18		6	12		221,200	41.9
Illinois	16	30	9	6	33	10	30,000	5.7
Missouri	3	4			4		750	.5 (Missouri and Texas)
Texas	3		4		4		2,000	
Total	1,169	6,876	1,346	466	7,756	241	88,431,165	16,748.3

a Thirteen wells not used in 1898.

RECORDS BY STATES.

PENNSYLVANIA.

No new gas field with original pressure was discovered in 1898, excepting a few wells located in Greene County. All of the wells have shown more or less decline, especially those of the older fields. The rock pressure varies from 10 pounds in some of the older fields in Westmoreland County to from 600 to 800 pounds per square inch in the deep Gordon and Fifth sands of Greene County.

The area of natural gas territory in southwestern and northwestern Pennsylvania is large, as all of the following counties have or have had gas fields of more or less importance: Allegheny, Armstrong, Beaver, Butler, Clarion, Elk, Erie, Forest, Fayette, Greene, Indiana, Jefferson, Lawrence, McKean, Mercer, Potter, Tioga, Venango, Warren, Washington, and Westmoreland counties.

Some gas produced in Allegheny, Beaver, and Washington counties is piped into Ohio and consumed there. A large quantity of natural gas produced in McKean, Warren, and Potter counties is piped into the State of New York and consumed there. Gas produced in Greene and Washington counties, Pennsylvania, is piped into West Virginia. A large quantity of gas produced in West Virginia is consumed in Pennsylvania.

The following table shows that the lowest value of natural gas was in 1896. Since then there has been an increase in value for the two years following:

Value of natural gas produced in Pennsylvania from 1885 to 1898.

Year.	Value.	Year.	Value.
1885	$4,500,000	1892	$7,376,281
1886	9,000,000	1893	6,488,000
1887	13,749,500	1894	6,279,000
1888	19,282,375	1895	5,852,000
1889	11,593,989	1896	5,528,610
1890	9,551,025	1897	6,242,543
1891	7,834,016	1898	6,806,742

The number of wells producing at the close of 1898 was 2,709, as reported by 232 companies and individuals. There were 373 producing wells and 74 dry holes found. There were 131 wells abandoned. There were 1,171 miles of pipe line completed of a size of two-inch and greater in 1898.

OHIO.

The decline in the value of natural gas produced in Ohio since 1892 has been arrested, and a gain of $316,531 reported in 1898 over that of 1897. This has been caused by the increased production in what is known as the Lancaster field, near the center of the State, where a great many vigorous wells, ranging from 2,000,000 to 8,000,000 cubic feet in twenty-fours, have been found. The gas in this field comes from the Clinton limestone, at a depth of from 2,100 to 2,350 feet, or from 1,300 to 1,400 feet below tide, the rock pressure being originally 700 pounds to the square inch is close to that now in the southern extension of the old field and about 130 pounds in the older or northern portion of the field. Some of the towns supplied from this field are: Columbus, Chillicothe, Circleville, Baltimore, Basil, Lancaster, Logan, Mount Sterling, Newark, Piqua, Pleasantville, Sidney, Springfield, Thurston, Urbana, Zanesville, and Athens.

The northwestern Ohio or Trenton gas field has decreased until there was but an average of 15 pounds to the square inch during 1898, as compared with 30 pounds in 1897 and 45 pounds in 1896. The gas pumps connecting clusters of gas wells have in many instances reduced the pressure to below that of the atmosphere. It is remarkable how long gas wells in certain localities will furnish gas at a very low pressure and not show a large volume of water.

A large amount of gas goes from West Virginia into Ohio and is there consumed. A large amount from Indiana is consumed in Ohio. Pennsylvania furnishes a considerable quantity that is consumed in Ohio. Canada also furnishes some gas that is consumed in Ohio.

Indications point to considerable increase in the consumption and production in this State in the near future of natural gas coming from the southern extension of the Lancaster field, as well as an increased amount coming from West Virginia.

The value of the natural gas produced (not consumed) is shown in the following table, from 1885 to 1898, by years:

Value of natural gas produced in Ohio from 1885 to 1898.

Year.	Value.	Year.	Value.
1885	$100,000	1892	$2,136,000
1886	400,000	1893	1,510,000
1887	1,000,000	1894	1,276,100
1888	1,500,000	1895	1,255,700
1889	5,215,669	1896	1,172,400
1890	4,684,300	1897	1,171,777
1891	3,076,325	1898	1,488,308

At the close of 1898 there were 806 producing gas wells in the State of Ohio reported, as compared with 729 at the close of 1897. There were 120 productive gas wells drilled—12 were dry, and 43 were abandoned.

INDIANA.

The production of natural gas in this State has remained almost the same since 1892. That of 1898 was about $50,000 greater in value than in 1897. A very large amount of gas continues to be piped out of the State into Ohio and Illinois. All the gas, except a small amount of shale gas near the southeastern portion of the State, continues to come from the Trenton limestone at an average depth of about 1,000 feet. A wide belt extending along the crest of this great Cincinnati arch in its general northwestern trend continues to furnish a large percentage of gas. The wells along this elevated portion are comparatively free from salt water. On the flanks of this ridge and toward the northwestern extremity there is increased trouble from salt water; many wells in this portion of the gas field have been abandoned. There are also a number of ridges of slight elevation in the surface of the Trenton limestone that have furnished good wells when the location has been on the higher portions. There has been such a large amount of gas consumed by manufacturers in an uneconomical manner that the failure of wells in the immediate vicinity has caused suspension of operations.

The practice of many of the companies, of receiving payment based upon the size of the orifice instead of a meter, has caused a large amount of gas to be consumed in an uneconomical manner.

The original rock pressure in this field over the entire area in 1886, when first tapped, was 325 pounds to the square inch; in 1896 it was down to an average of 220 pounds; in 1897 it was 195 pounds; and for 1898 it was 160 to 170 pounds, as estimated from numerous records of pressures. There are isolated localities where a pressure as high as 220 pounds is reported, and some wells only show 60 to 70 pounds. If the rock pressure was reduced to 100 pounds there would still remain 20 per cent of the original volume at the beginning of the present year. For local use in many fields 100 pounds would be considered too high. In this field, however, the nearness of salt water to the gas pay in the rock has made it necessary to maintain a considerable pressure; otherwise the well would be flooded and its gas flow shut off.

In the following table will be found a statement of the value of the natural gas produced in Indiana from 1886 to 1898:

Value of natural gas produced in Indiana from 1886 to 1898.

Year.	Value.	Year.	Value.
1886	$300,000	1893	$5,718,000
1887	600,000	1894	5,437,000
1888	1,320,000	1895	5,203,200
1889	2,075,702	1896	5,043,635
1890	2,302,500	1897	5,009,208
1891	3,942,500	1898	5,060,969
1892	4,716,000		

The number of wells producing at the close of 1898 was 3,325. There were 706 productive and 111 unproductive wells drilled in 1898. There were 262 wells abandoned.

WEST VIRGINIA.

There was a large amount of new work done in this State in 1898. Tyler and Wetzel counties furnished several large gas wells, with remarkable rock pressure. Several wells in these counties have volumes that approach 20,000,000 cubic feet in twenty-four hours, with a rock pressure of 1,200 pounds to the square inch. A large proportion of the gas produced in this State is piped into Ohio and Pennsylvania and there consumed. During 1898 a 10-inch line was completed from the southern part of Tyler County, connecting with Pittsburg, Oakdale, and McDonald, Pennsylvania, and Steubenville, Ohio, by the Tri-State Gas Company. At the close of the year another 10-inch pipe line was almost completed, connecting a part of the Tyler and Wetzel counties gas field with Akron, New Philadelphia, Canton, and several other smaller towns in Ohio. The Carnegie Gas Company during the year extended its line from Greene County, Pennsylvania, into Wetzel County for supplying their works near Pittsburg.

The other lines leading out of the State were the Philadelphia Gas Company of Pittsburg; the Wheeling Natural Gas Company, which supplies Wheeling, West Virginia, and Bridgeport, Ohio, and the Mountain State Gas Company, which supplies Marietta, Ohio, from wells in Pleasants County.

The sands that furnish gas in a small way are the Mahoning or Cow Run sands, and Salt Sand. The large volume comes from the Big Injun, Squaw, Gantz, Fifty Foot, Gordon, Fourth, Fifth, and Elizabeth sands, ranging in depth from 500 to 3,000 feet. The counties so far furnishing gas are named in the order of their importance—Wetzel, Tyler, Ritchie, Marion, Doddridge, Pleasants, Harrison, Marshall, Wirt, Roane, Mingo, Kanawha, Calhoun, Weston, and Gilmore.

Central Wetzel and eastern Tyler counties hold the deepest part of the great Appalachian basin, where the gas rocks are well developed and the gas sealed up in them. Several wells have found gas in three distinct strata, which indicates the large amount of storage. In the crumples and folds of this basin, as well as upon its first anticline to the east, most of these large wells before mentioned have been found. The indications are that a large supply, lasting many years, has been secured, which must be depended upon to replace many of the failing gas fields in Pennsylvania and Ohio in the future.

The towns of Fairview, Fairmount, Farmington, Grafton, Mannington, Morgantown, Parkersburg, Clarksburg, Weston, Sistersville, New Martinsville, Moundsville, Charleston, Cameron, Waverly, St. Marys, Belmont, Eureka, Salem, West Liberty, Sherrard, Wellsburg, and several smaller places in West Virginia are supplied with natural gas produced in this State. Wheeling is partially supplied from wells in West Virginia and in part from Pennsylvania.

Value of natural gas produced in West Virginia from 1889 to 1898.

Year.	Value.	Year.	Value.
1889	$12,000	1894	$395,000
1890	5,400	1895	100,000
1891	35,000	1896	640,000
1892	500	1897	912,528
1893	123,000	1898	1,334,023

The increase in the value of natural gas produced in 1898 as compared with 1897 was 46 per cent, as compared with 40 per cent the year before. There were 227 wells producing at the close of 1898 as compared with 196 wells producing at the close of 1897, as reported by nearly all of the companies producing natural gas, who also report 32 productive gas wells drilled, only 4 dry holes found, and but 1 well was abandoned.

In all the States producing gas a large amount is consumed and unreported. This has been in a general way estimated at 25 per cent additional to the figures given. In West Virginia, owing to the number of deep wells pumped, together with the number of drilling wells often requiring 100 days to complete them, about 33 per cent should be added to the value in the above table to cover the value of all the fuel displaced by natural gas in this State.

NEW YORK.

There is a large area of gas-producing territory in the western and central portions of this State in strata beginning with the black Devonian shale and extending down to the Potsdam. Although the wells are generally light in pressure, many have considerable volume. The counties producing natural gas are Allegany, Cattaraugus, Chautauqua, Erie, Livingston, Niagara, Onondaga, Ontario, Oswego, Seneca, and Steuben. By far the greater portion furnished by the State comes from the neighborhood of Wellsville and Ricebrook, in Allegany County. These wells are found skirting the oil-producing region and are gradually decreasing in volume and pressure.

A large number of these wells are connected, reenforced by a few scattering wells, supplying the towns of Friendship, Nile, Belmont, Andover, Cuba, Ceres, Wellsville, Scio, Stanards Corners, Allentown, Bolivar, Richburg, Olean (in part), Willing, and Independence, wholly or in part. Buffalo receives the greater portion of its gas from Pennsylvania, with some from Canada and Erie County, New York. Jamestown and Salamanca receive their gas from Pennsylvania; and Olean receives nearly all of its gas from that State also.

The town of Ripley is supplied with gas from wells in Chautauqua County. There are many small wells that produce gas at moderate depths in the black shale that supply many individual families with light and heat.

Clarence, Depew, Alden, East Aurora, Orchard Park, North Tonawanda, and a small part of Buffalo are supplied by wells in Erie County that are about 950 feet in depth. The gas is found in the red Medina sandstone, and the pressure is holding up well. The gas wells in Livingston County also get their supply from the same rock at about 1,100 feet in depth. The present pressure is 200 pounds to the square inch, as compared with 400 pounds when first tapped. These wells supply Caledonia. Baldwinsville is supplied from wells 2,200 to 2,400 feet in depth in Onondaga County, where the bottom of the Trenton limestone is reached. They have a pressure of 1,500 pounds to the square inch, and are quite large in volume when first struck, but soon decrease.

Honeoye Falls, North and West Bloomfield receive gas from Ontario County which formerly came from the black shale, but latterly a better supply is found in the Medina sandstone. Pulaski, Sandy Creek, and Lacona all get gas from Oswego County from the bottom of the Trenton limestone, where it is found in pockets with high rock pressure, but lacking in volume or storage capacity.

The value of natural gas produced in New York from 1885 to 1898 is given in the following table:

Value of natural gas produced in New York from 1885 to 1898.

Year.	Value.	Year.	Value.
1885	$196,000	1892	$216,000
1886	210,000	1893	210,000
1887	333,000	1894	249,000
1888	332,500	1895	241,530
1889	530,026	1896	*a* 256,000
1890	552,000	1897	200,076
1891	280,000	1898	229,078

a A portion of this amount should be credited to Pennsylvania, but it was impossible to make the separation.

The above table shows a considerable increase for 1898 over 1897. There were 411 producing wells at the close of 1898 as compared with 359 at the close of 1897. There were 63 wells drilled and 11 abandoned in 1898. It must be remembered that very many of the wells reported are shallow and only supply a single family. Thus, in Erie County, for example, 105 wells furnished light and heat for 67 consumers. There are many shallow wells sufficient to supply a single family found in along the south shore of Lake Ontario that are highly prized.

KANSAS.

The value of the output from this State is gradually increasing. Gas is produced in a commercial way in Allen, Labette, Montgomery, Miami, and Wilson counties. A few good wells were also found in Franklin County, but are not yet utilized. Some drilling has been done in Crawford County, but with poor success. Several other counties have small flows of gas from individual wells. There is much to indicate that many other pools will be found in the future.

The usual depth of the wells is from 900 to 1,150 feet. The rock pressure varies from 300 to 325 pounds to the square inch. The volume of some of the best wells was from 6,000,000 to 8,000,000 cubic feet in twenty-four hours. The largest and best wells get their gas in a porous brown sand 15 to 20 feet in thickness (not unlike the Bradford sand in color and texture), which is found near the bottom of the Cherokee shale and about 40 to 60 feet above the top of the Mississippian limestone. There seems to be a series of gentle elevations and depressions in the floor of this limestone and sandstone. Gas is found in the higher portions and oil is found in the troughs. This is notably the case at Neodesha.

It is used in nearly all of the towns in southeastern Kansas for domestic and manufacturing purposes. So far the wells have shown but slight reduction in the original pressure. The gas from the Iola field is used extensively in the reduction of the zinc ores raised at Joplin, Missouri, with great success. Six large reduction works are established at this place. The following is taken from the interesting report on the Iola gas field, Allen County, by Prof. Edward Orton, who visited it in 1898:

IOLA GAS FIELD, ALLEN COUNTY.

EXTENT AND CHARACTER OF FIELD.

This line of thought has been suggested to me by an examination that I have recently made of the gas field of Allen County, southeastern Kansas, which is known as the Iola gas field. It is small in area, but of great promise in production. Its length in an east-and-west line has been demonstrated by the drill to be at least 7 miles, while its breadth, proved in the same way, has been found to exceed 3 miles.

More than two dozen wells have already been drilled in the field, and the wells range in production from 2,000,000 to over 10,000,000 feet in twenty-four hours. There are a half dozen of the number, each of which produces about 7,000,000 feet a day.

The rock pressure of the field is 325 pounds, with an outside range of 5 pounds in a single well.

A little oil has been found, mainly on the western boundary of the field and at a lower depth than the gas. Salt water occurs below both gas and oil, but has not proved thus far aggressive. The height to which it rises has not been determined. It is not less than several hundred feet.

The gas rock is a sandstone of moderate grain, with an average thickness of about 20 or 25 feet. It is occasionally interrupted by wedges of shale, and disappears as a sandstone altogether beyond the boundaries I have named.

All these characteristics stand for a gas field in the second division above named. Every feature of the Iola field indicates a porous or reservoir rock as the source of its gas.

GEOLOGY OF THE REGION.

Sources of information.—The geology of southeastern Kansas is comparatively simple. In describing it I rely mainly on the published reports of the geological survey conducted by the State university under the direction of Prof. Erasmus Haworth.

The formations.—Coal Measures and Subcarboniferous limestone.—All strata reaching the surface in this section of the State belong to the so-called Coal Measures, with the single exception of the great Subcarboniferous limestone, which may be regarded as the floor of the eastern half of Kansas. This stratum rises to-day only in the southeastern angle of the State, and its outcrop does not exceed 45 square miles, but though small in area, it has extreme economic interest and importance, for it carries zinc and lead ores in large quantities. As a source of the former, this 45 square miles is beyond question the most valuable tract known in the United States. Perhaps no equal area in the world exceeds it in this respect. This Subcarboniferous stratum is coming to be known in Kansas and the adjoining States as the Mississippian limestone. In sinking deep wells it constitutes a particularly valuable landmark, because its flinty beds are certain to attract the driller's notice, and are universally regarded by him in his search for petroleum as the "farewell rock." When he strikes this floor he knows that his work is done.

There are large areas of Kansas and adjoining States in which the Coal Measures, so called, do not justify their name. In many long sections furnished by the drill they are found to consist altogether of limestone, shale, and sandstone, but in other districts the series contain important beds of coal, the aggregate of which, as computed, runs into large figures, and constitute an invaluable reliance of all these regions for time to come.

The Western Coal Measures have been variously divided by the geologists who have studied them in the several States. It is a pleasure to find that they are coming to a general agreement, which promises at no distant day a harmonious account of this great chapter of our geological history.

Cherokee shales.—In southeastern Kansas the lowermost division of the Coal Measures—namely, that immediately overlying the Mississippian limestone—is known as the "Cherokee shales." It is counted the equivalent of the "Des Moines shales," of Keyes, in Iowa. The Cherokee shales have a thickness of about 450 feet, and contain, in certain districts, by far the most valuable seams of coal found in Kansas. Though consisting largely of shale, as the name would lead us to expect, thin courses of limestone and considerable bodies of sandstone also occur in it. Some of the sandstones rise in important and valuable outcrops, but other beds begin and end in the shale series, and for our knowledge of them we are indebted wholly to the driller. They are capricious and unstable to a high degree.

Other divisions.—Above the Cherokee shales come several well-marked and easily identified divisions known in Kansas geology as the "Oswego and the Pawnee limestones," about 100 feet in combined thickness, the Pleasonton shales," about 250 feet thick, and carrying in certain localities valuable beds of coal, the "Erie limestone and shale," the "Thayer shale," and the "Iola limestone," together aggregating several hundred feet of strata.

The divisions here named comprise all the strata traversed in the wells of the Iola gas field.

Iola gas rock.—The gas rock already described is one of the unstable, lenticular sandstones of the Cherokee shale, and lies near the bottom of this division. Its upper surface is above 75 feet above the Mississippian limestone.

All these strata are described by Haworth as dipping to the west at an average rate of 17 feet to the mile.

The surface of this portion of the State also slopes to the west, but not as rapidly as the strata descend. The surface slope to the westward is given by Haworth as about 10 feet to the mile. These facts are indicated in the accompanying diagram (Pl. 11). The elevation of Iola is 956 feet above tide; of Laharpe, 5 miles to the eastward, 1,045 feet, and of Moran, 12 miles east of Iola, 1,098 (see Gannett's Gazetteer of Kansas). This gives an average descent from Moran to Iola of nearly 12 feet to the mile. Other elevations used in this paper were obtained from the aneroid, and can not vary far from the true figures.

Iola arch at Edwards well.—At the Edwards well, 2 miles beyond Laharpe, the Iola gas rock has completely disappeared as a sandstone, but the driller continued his work until he reached the Mississippian limestone, or the "flint," as it is commonly called. This was reached at 1,061 feet, or very nearly at tide level. The same stratum was also struck in one of the wells at Laharpe, but here at a depth of 982 feet, or 63 feet above tide, showing a rise to the westward of 31 feet to the mile in place of the normal descent in that direction of 17 feet to the mile.

A low arch, which may perhaps with greater propriety be styled a terrace, thus comes into view. So far as present knowledge goes, the arch begins at the location of the Edwards well, in which, as will be remembered, the surface of the Mississippian limestone lies at tide level. The stratum rises to the westward from this point and does not regain tide level until it is followed about 2 miles beyond Iola. At Iola its place is calculated to be 37 feet above tide.

We have thus a stretch of territory about 8 miles in length from east to west in which there is no fall to the Mississippian floor of the section. Its normal dip of 17 feet to the mile would carry it 126 feet below tide in that distance.

The gas rock is not coextensive with the arch, as, it will be remembered, it fails to appear in the Edwards well. If it had continued to that point in its normal volume, its upper surface would have been found 77 feet above tide.

At Laharpe, however, it is found in full force, and its surface here is 140 feet above tide, as determined by the average of two 905-foot wells. It rises 19 feet higher in the next 3 miles, being found at 159 feet above tide in the Remsberg well. This is the highest point of the Iola gas rock, so far as explorations have now gone, and it is interesting to note that this well is the largest producer of gas in the entire field. Its volume exceeds 10,000,000 cubic feet a day, which is about 3,000,000 in excess of any other well in the field. The surface of the gas rock descends 43 feet in the next 2 miles to the westward. The average depth to the gas rock of two wells at Iola is 840 feet, which shows its surface to be 116 feet above tide. Within the next 2 miles the Mississippian limestone gets down to tide level again, and this point marks the limit of the Iola arch.

STRUCTURE AS A FACTOR IN INTERPRETATION.

It is thus seen that the Iola gas field comes fully into line with a large number of other gas fields that belong to the same class with it. In all of these, structure is the dominant factor, a factor which helps us to a rational explanation of the characteristic phenomena of all.

The production of natural gas in Kansas from 1889 to 1898 has been as follows:

Value of natural gas produced in Kansas from 1889 to 1898.

Year.	Value.	Year.	Value.
1889	$15,873	1894	$86,600
1890	12,000	1895	112,400
1891	5,500	1896	124,750
1892	40,795	1897	105,700
1893	50,000	1898	174,640

During the past year 52 wells were drilled for gas, 34 of which were productive and 18 were either dry or produced such a small quantity of gas that they were abandoned. The number of wells producing at the close of 1898 was 111.

KENTUCKY.

Nearly all the natural gas consumed in this State is found in shallow wells in the Devonian black slate at a depth of 480 to 500 feet in Meade County. This gas is carried to Louisville, a distance of 35 miles, and there consumed in a domestic way. In summer, and usually in winter, it is ample for this demand, but in severe weather, lasting in that locality but a few days, it has been found insufficient. This deficiency is supplied by manufactured gas made as long as the occasion may demand, which is not usually over four or five days.

There were some good gas wells found in Martin and Floyd counties during 1898, where a number have been shut in for several years. The latter part of 1898 witnessed the completion of a 10-inch gas line from the mouth of the Big Sandy River to Warfield, distant 45 miles south.

Value of natural gas produced in Kentucky from 1889 to 1898.

Year.	Value.	Year.	Value.
1889	$2,580	1894	$89,200
1890	30,000	1895	98,700
1891	38,993	1896	99,000
1892	43,175	1897	90,000
1893	68,500	1898	103,133

During 1898 there were 81 producing wells in the State; 3 producing wells were drilled and 3 abandoned, and 3 dry holes drilled.

CALIFORNIA.

There are many wells producing a small amount of gas scattered in the Sacramento and San Joaquin valleys of California. There are also numerous springs through this region, in which gas is found bubbling up with the water. The range of these springs in some localities is northwesterly to southeasterly, and may mark the line of an old earthquake fracture. The more or less violent folding of the strata in most of this region, together with earthquakes of varying severity, has prevented the accumulation of large reservoirs of high-pressure natural gas throughout these valleys. There may be large reservoirs in the probable anticlinals that are buried under the mass of alluvium that is found.

At Stockton, in the San Joaquin Valley, some 25 wells have been sunk. The wells usually range from 1,000 to 1,400 feet in depth. One of them (an exception to the rule) is 2,500 feet in depth, furnishing gas sufficient to supply a number of families with heat and light. Most of these wells flow gas and water together, and furnish from 20,000 to 50,000 cubic feet per day. The pressure varies from 3.3 inches to 6.8 inches of water.

There are numerous wells which furnish from 1,000 to 20,000 cubic feet, usually associated with flowing water, in Merced, Tulare, and Fresno counties. At Los Angeles there are some wells that flow moderate quantities of gas in the locality of the oil wells, the gas from which is used for generating steam and for domestic purposes.

The production of natural gas in California from 1889 to 1898 has been as follows:

Value of natural gas produced in California from 1889 to 1898.

Year.	Value.	Year.	Value.
1889	$12,680	1894	$60,350
1890	33,000	1895	55,000
1891	30,000	1896	55,682
1892	55,000	1897	50,000
1893	62,000	1898	65,337

UTAH.

There is considerable difficulty in keeping the wells on the border of Salt Lake, 12 miles north of the city, clear of decomposed shale, which is so dry that it falls off and obstructs the flow of gas. It is hard to clean out, and has almost shut off the flow of gas.

Value of natural gas produced in Utah from 1893 to 1898.

Year.	Value.
1893	$500
1894	500
1895	20,000
1896	20,000
1897	15,050
1898	7,875

COLORADO.

The value of natural gas used in 1898 is placed at $3,000. There are no wells that furnish gas alone in this field. A number of the oil wells furnish gas, and several use gas pumps to assist the oil production.

There is an irregular supply furnished to a small part of the town of Florence, and in several instances it is used in connection with other fuel under the boilers of pumping wells.

ILLINOIS.

Natural gas is found in Bureau and Randolph counties. In Bureau County the pressure remains steady from 3 to 30 pounds, and the average depth is about 140 to 160 feet. The gas is found in a greensand capped by a hard blue clay. It is used for domestic purposes, and a large number of families have their own gas wells. The supply has been steadily maintained for ten years. In Randolph County there are a number of gas wells (in the town of Sparta) that have furnished a constant supply of gas for eight years, but which at this writing are nearly exhausted.

The production of natural gas in Illinois from 1889 to 1898 was as follows:

Value of natural gas produced in Illinois from 1889 to 1898.

Year.	Value.	Year.	Value.
1889	$10,615	1894	$15,000
1890	6,000	1895	7,500
1891	6,000	1896	6,375
1892	12,988	1897	5,000
1893	14,000	1898	2,498

MISSOURI.

Very little can be said relative to the production of natural gas in Missouri. A small quantity of gas is produced in Kansas City and used for domestic purposes. In Bates County a small amount of gas is produced and consumed by the owners of the wells.

TEXAS.

During the year 1898 four gas wells were completed in the Corsicana oil field of Navarro County, Texas, the product of two being utilized. This gas was used for fuel in drilling other wells. Many, if not all, of the oil wells in this field produce a small amount of gas.

Near San Antonio, Bexar County, is a gas well which has been producing for several years, but no use is made of the product.

CANADA.

The following is taken from the report of the Bureau of Mines, Volume VII, Part First, 1899, for the Province of Ontario:

> The natural-gas statistics differ but slightly from those of 1897. The number of producing wells bored during the year was 14 and of nonproducing wells 5, but the total number of producing wells only shows an increase of 2. An extension of 18¼ miles was made to the length of pipe lines for distribution of gas, yet the value of gas supplied for consumption was less than in the previous year by nearly $7,000. The amount of wages paid for labor was also less by nearly $11,000, owing, it is probable, to the smaller number of men employed in drilling wells.

The number of companies which own natural gas wells is now 15, and nearly all the wells are in the counties of Welland, Haldimand, and Essex. There are a number of small wells in Elgin, where the source of supply is in the drift, but their returns are not included in the statistics of the table.

The following table shows the number of producing wells, miles of pipe, workmen employed, value of the gas product at the point of production, and the wages for labor:

Statistics of natural gas in Province of Ontario, Canada.

Year.	Producing wells.	Miles of gas pipe.	Workmen employed.	Value of gas product.	Wages for labor.
1893	107	117	59	$238,200	$24,592
1894	110	183½	99	204,179	53,130
1895	123	248	92	282,986	73,328
1896	141	287¼	87	276,710	47,527
1897	140	297	84	308,448	42,338
1898	142	315¼	85	301,599	31,457

It will be noticed in the above table that the value of the gas is estimated at the point of production, and not the value at the points of consumption, as is usual in fixing value in the United States.

The following table shows the value of natural gas produced in Canada, including that delivered in the United States at the cities of Buffalo and Detroit by pipe lines, from 1892 to 1898:

Value of natural gas produced in Canada from 1892 to 1898.

Year.	Value.
1892	$150,000
1893	366,233
1894	313,754
1895	423,032
1896	364,156
1897	325,873
1898	364,699

IMPORTS.

In the following table will be found a statement of the value of the natural gas imported into the United States from 1891, when it was first enumerated:

Value of natural gas imported into the United States from 1891 to 1898.

Calendar year.	Value.
1891 (latter half)	$25,540
1892	74,737
1893	90,653
1894	62,523
1895	89,419
1896	87,446
1897	80,607
1898	95,527

ILLUMINATING AND FUEL GAS AND BY-PRODUCTS.

By William B. Phillips, Ph. D.

INTRODUCTION.

For the following statistics bearing on the manufacture of illuminating and fuel gas and the immediate by-products obtained from it, something over one thousand returns have been received from gas works throughout the country. While they are not as complete as could be wished, it is believed that they are as accurate as circumstances would allow.

No attempt was made to ascertain the capital invested, the number of persons employed, the wages paid, or other information of a more strictly industrial nature. The tables submitted and the remarks offered are based on such returns as were received. It is hoped that a foundation has been laid for future work in this direction, and that succeeding years will add to the variety and the extent of the inquiries.

PRODUCTION.

The main purpose of the inquiries was to ascertain the present status of fuel gas, tar, and ammonia liquor, and especial attention was paid to these products. At the close of 1898 there were 280 Semet-Solvay ovens in operation, 180 Otto-Hoffmann, and 90 Newton-Chambers, 550 in all, with 500 more Otto-Hoffmann under construction. The amount of coal used in by-product coke ovens last year was 402,297 tons, and, allowing a yield of 10 gallons of tar and 20 pounds of sulphate of ammonia per ton of coal, the possible production of tar was 4,022,970 gallons and of sulphate 8,045,940 pounds. Applying the same figures to the by-product business as it existed at the close of 1897, we find a possible production of tar of 3,576,290 gallons and of sulphate of ammonia of 7,152,580 pounds. The increase in the tar-making capacity of the country, due to the development of the by-product system of coking, was 446,680 gallons in one year, while the possible increase in sulphate of ammonia was 893,360 pounds. From the recovery ovens now in operation and under construction it is not improbable that by the middle of 1900 the annual production of tar can be increased by 7,000,000 gallons, and of sulphate of ammonia by 16,000,000 pounds, or 8,000 tons.

How much tar and sulphate of ammonia are made from coal carbonized at gas works? According to the returns the amount of coal carbonized at gas works in 1898 with respect to tar was 1,942,963 tons and the yield of tar was 24,384,798 gallons, or 12.55 gallons per ton, the yield varying from 7.85 gallons in Louisiana and Mississippi to 14.30 gallons in Massachusetts. The returns as to sulphate are by no means so complete, but from all the data at hand it is thought that the amount did not exceed 3,000 tons, and possibly was not above 2,500 tons. About 3,600 tons of sulphate were made at by-product coke plants in 1898, so that the total production was about 6,600 tons.

While the possible increase in the production of tar is less than one-third the possible increase in the production of sulphate of ammonia, above the 3,000 tons made from gas liquor proper, is more than one and one-half times. That is to say, taking the gas-liquor ammonia at 3,000 tons, the amount of ammonia (reckoned as sulphate) that could have been produced at by-product coke plants in 1898 was 4,000 tons, and this amount can be doubled by the middle of 1900.

There has been considerable difficulty in securing information as to the production of sulphate of ammonia. A few gas companies work up their own liquor, but the general custom is to sell the liquor to distilling companies at so much per unit of anhydrous ammonia, or at so much per gallon, the strength being given in degrees Twaddell. These distilling companies are located in various parts of the country, and purchase crude liquor from the gas companies, conveying it to their works in tank cars. Shipments over a distance of 800 miles have been made. In this way the refining of the liquor—i. e., its conversion into more valuable forms—is kept distinct from its mere production.

As this matter will be discussed further along, no other reference is needed here, and we pass to a review of the returns made by the gas companies.

The following table gives the production and value of the materials obtained from the dry distillation of coal in 1898, by States:

Production and value of materials obtained from distillation of coal, 1898, by States.

State.	Number companies reporting.	Tar produced.				Value of ammonia liquor produced.	Value of sulphate ammonia produced.	Coke produced.				Total value by-products.	Total value gas sold.	Total value all products.
		Quantity.	Value.	Price per gallon.	Yield per ton of coal.			Quantity.	Value.	Price per ton.	Yield per ton of coal.			
		Gallons.		*Cents.*	*Gallons.*			*Net tons.*			*Per ct.*			
Alabama	9	166,810	$8,117	4.87	9.86	0	0	10,140	$33,415	$3.295	59.9	$41,532	$163,507	$205,039
Arkansas	3	39,500	2,695	6.82	11.97	0	0	2,160	7,135	3.303	65.5	9,830	50,310	60,140
California	26	*a* 272,448	16,681	6.12	10.12	0	0	16,471	150,997	9.167	59.6	167,678	543,046	710,724
Colorado	4	192,900	10,797	5.60	10	$1,367	0	9,948	37,448	3.764	65.1	49,612	213,806	263,418
Connecticut	7	438,476	25,791	5.88	9.39	2,989	0	28,298	102,970	3.639	63.8	131,750	505,524	637,274
Delaware	3	133,000	5,757	4.33	12.16	1,000	$630	4,134	10,849	2.624	64	18,236	60,657	78,893
Georgia	8	262,911	11,007	4.19	11.25	36,176	0	15,532	62,179	4.003	64.7	109,362	248,357	357,719
Illinois	26	674,758	20,751	3.08	11.51	3,163	0	34,280	112,812	3.291	61.4	136,726	587,772	724,498
Indiana	20	624,482	13,948	2.23	10.36	4,577	9,800	*b* 31,175	84,932	2.766	56.3	113,257	588,377	701,634
Iowa	13	224,010	8,934	3.99	10.04	0	0	12,157	54,269	4.464	58.3	63,203	259,179	322,382
Kansas	9	*c* 176,830	7,671	4.34	10.66	0	0	*c* 10,294	37,365	3.630	62.1	45,036	194,128	239,164
Kentucky	9	592,400	15,629	2.64	12	836	0	29,567	75,776	2.563	59.9	92,241	502,801	595,042
Louisiana and Mississippi	3	23,619	1,537	6.51	7.85	0	0	1,835	6,530	3.559	61	8,067	32,995	41,062
Maine	5	134,615	7,093	5.27	12.66	1,081	0	6,634	26,688	4.023	66.9	34,862	156,990	191,852
Maryland and District of Columbia	5	106,100	4,007	3.78	13.89	25,715	0	4,721	10,975	2.325	61.8	40,697	96,856	137,553
Massachusetts	45	2,518,219	134,901	5.36	14.30	18,788	0	115,980	419,623	3.618	64.5	573,312	2,100,720	2,674,032
Michigan	21	685,589	24,993	3.65	11.51	10,264	0	36,480	127,341	3.491	63.6	162,598	571,950	734,548
Minnesota and Nebraska	4	181,564	5,121	2.82	11.32	0	0	9,809	40,871	4.167	58.5	45,992	236,703	282,695
Missouri	20	*d* 267,905	13,765	5.14	10.41	0	0	*d* 14,663	46,023	3.139	57	59,788	1,120,311	1,180,099
Montana and New Mexico	3	40,548	4,124	10.17	8.06	0	0	3,027	13,941	4.606	60.2	18,065	76,794	94,859
Nevada	3	8,750	795	9.09	10.74	0	0	363	5,143	14.168	44.5	5,938	30,887	36,825
New Hampshire	4	159,383	9,139	5.73	12.11	578	0	8,731	26,193	3.000	66.3	35,910	176,148	212,058

a Product of 21 companies. *b* Includes 465 tons coke which had no market. *c* Product of 8 companies. *d* Product of 18 companies.

Production and value of materials obtained from distillation of coal, 1898, by States—Continued.

State.	Number companies reporting.	Tar produced.				Value of ammonia liquor produced.	Value of sulphate ammonia produced.	Coke produced.				Total value by-products.	Total value gas sold.	Total value all products.
		Quantity.	Value.	Price per gallon.	Yield per ton of coal.			Quantity.	Value.	Price per ton.	Yield per ton of coal.			
		Gallons.		*Cents.*	*Gallons.*			*Net tons.*			*Per ct.*			
New Jersey	13	325,921	$12,303	3.77	12.88	$1,682	0	15,689	$44,992	$2.868	58.6	$58,977	$331,082	$390,059
New York	41	*a* 4,799,740	184,012	3.83	11.03	22,041	0	*a* 248,271	860,900	3.468	59.5	1,066,953	4,543,185	5,610,138
North and South Carolina	3	118,916	5,619	4.73	10.68	0	0	6,896	36,616	5.310	61.9	42,235	165,327	207,562
North Dakota, Utah, and Wyoming	3	33,129	2,322	7.01	12.73	0	0	1,352	7,929	5.865	52	10,251	38,696	48,947
Ohio	41	*b* 3,901,258	120,603	3.11	13.59	90,037	0	205,947	381,427	1.852	68.8	592,067	2,567,309	3,159,376
Oregon	4	*c* 69,819	5,944	8.51	9.08	450	0	*c* 2,399	11,292	4.707	52.6	17,686	76,455	94,141
Pennsylvania	22	4,163,103	109,317	2.63	13.58	13,720	0	190,591	355,989	1.868	61.5	479,026	2,902,123	3,381,149
Rhode Island	4	646,130	31,741	4.91	12.75	13,483	0	33,608	89,074	2.650	66.3	134,298	568,295	702,593
Tennessee	8	393,445	13,143	3.34	11.40	9,380	0	22,636	65,324	2.886	65.6	87,847	365,058	452,905
Texas	11	173,304	11,807	6.81	11.26	140	0	9,461	47,430	5.013	61.5	59,377	243,324	302,701
Virginia	9	218,546	6.877	3.15	9.76	132	0	11,025	27,465	2.491	49.3	34,474	216,861	251,335
Washington	6	117,606	10,157	8.64	8.44	0	0	8,295	34,321	4.138	59.6	44,478	232,960	277,438
West Virginia	5	231,806	6,078	2.62	13.22	2,717	0	11,186	15,112	1.351	63.8	23,907	101,604	125,511
Wisconsin	13	1,267,258	29,224	2.31	12.70	23,832	0	42,524	129,775	3.052	59.7	182,831	632,198	815,029
Total	433	24,384,798	902,400	3.70	12.55	284,148	$10,430	1,216,279	3,601,121	2.961	62.6	4,798,099	21,502,295	26,300,394

a Product of 40 companies. *b* Product of 40 companies; includes 27,500 gallons which was not sold, and no value is given for same. *c* Product of 3 companies.

The number of companies reporting was 433, Massachusetts heading the list with 45; Ohio and New York being next, with 41 each; California and Illinois third, with 26 each; Pennsylvania fourth, with 22; Michigan fifth, with 21; Indiana and Missouri sixth, with 20 each; Iowa, New Jersey, and Wisconsin seventh, with 13 each, and so on. Some of the States are grouped together, as, for instance, Louisiana and Mississippi, Maryland and the District of Columbia, Montana and New Mexico, etc. This was done in order that no less than 3 returns should be considered. When only 1 return was received it was included with the returns from some other State.

The value of the products obtained from coal at the gas works in 1898 was $26,300,394, of which $21,502,295 was contributed by the gas, $3,601,121 by the coke, $902,400 by the tar, $284,148 by the ammoniacal liquor, and $10,430 by the sulphate of ammonia made at the gas works. Of coal gas the production was 19,469,464,957 cubic feet; of water gas, 30,418,987,448 cubic feet; of oil gas, 497,016,263 cubic feet; making a total of 50,385,468,668 cubic feet, exclusive of gas made in recovery coke ovens. If we assume a yield of 9,000 cubic feet per ton of coal used in the recovery ovens, the amount of gas to be credited to such establishments is 3,620,673,000 cubic feet, making the grand total of all gas made in the United States in 1898 54,006,141,668 cubic feet.

TAR.

The total production of tar from gas works was, as already stated, 24,384,798 gallons, valued at $902,400, or 3.70 cents per gallon. In addition 3,000,000 gallons were made at by-product coke ovens. The price per gallon at the gas works varied from 2.23 cents in Indiana to 10.17 in Montana and New Mexico. The largest production in any one State was in New York, where, with 40 companies reporting, the yield was 4,799,740 gallons.

The arrangement of the States in order of production is as follows:

Rank of States in tar production.

Rank.	State.	Production.	Yield per ton of coal.	Value per gallon.	Total value.
		Gallons.	*Gallons.*	*Cents.*	
1	New York	4, 799, 740	11. 03	3. 83	$184, 012
2	Pennsylvania	4, 163, 103	13. 58	2. 63	109, 317
3	Ohio	3, 901, 258	13. 59	3. 09	120, 603
4	Massachusetts	2, 518, 219	14. 30	5. 36	134, 901
5	Wisconsin	1, 267, 258	12. 70	2. 31	29, 224
6	Michigan	685, 589	11. 51	3. 65	24, 993
7	Illinois	674, 758	11. 51	3. 08	20, 751
8	Rhode Island	646, 130	12. 75	4. 91	31, 741
9	Indiana	624, 482	10. 36	2. 23	13, 948

Rank of States in tar production—Continued.

Rank.	State.	Production.	Yield per ton of coal.	Value per gallon.	Total value.
		Gallons.	*Gallons.*	*Cents.*	
10	Kentucky	592,400	12.00	2.64	$15,629
11	Connecticut	438,476	9.39	5.88	25,791
12	Tennessee	393,445	11.40	3.34	13,143
13	New Jersey	325,921	12.88	3.77	12,303
14	California	272,448	10.12	6.12	16,681
15	Missouri	267,905	10.41	5.14	13,765
16	Georgia	262,911	11.25	4.19	11,007
17	West Virginia	231,806	13.22	2.62	6,078
18	Iowa	224,010	10.04	3.99	8,934

In explanation of this table it must be said that in determining the total production of tar all the returns were added together, but in determining the yield of tar per ton of coal due regard was had to the fact that some companies reported coal carbonized but did not report the amount of tar made from this coal. This amount of coal was, therefore, deducted from the total amount carbonized before an estimate was made of the yield of tar per ton of coal. The actual amount of coal carbonized in making the 24,384,798 gallons of tar was 1,942,963 tons, inasmuch as there was no tar returned from 99,735 tons of coal carbonized. The actual yield of tar per ton of coal, based on the returns made, was 12.55 gallons, obtained by dividing the number of tons of coal used in making tar into the total number of gallons of tar reported.

It is not necessary to continue this table, as the rank of the other States can be obtained from the table on pp. 227–228. No information has been gathered as to the quality of the tar, as to how much of it is used directly and how much is distilled for "dead oil" and pitch.

The center of the tar industry is in New York, Pennsylvania, and Ohio, these three States producing more than one-half of the entire amount. The yield per ton of coal in these States is high, averaging 12.15 gallons, while the price per gallon at the works varies from 2.63 cents in Pennsylvania to 3.83 cents in New York. The State of Massachusetts, credited with a production of 2,518,219 gallons, is distinguished by the high yield per ton of coal, 14.30 gallons, while in Connecticut the yield fell to 9.39 gallons. The 18 States classified in the preceding table represent more than 91 per cent of the entire production, and the range of yield and of prices may be taken as fairly indicating the condition of the business during the period under consideration.

COKE.

The total production of gas coke in 1898 was 1,216,279 tons, from 1,942,963 tons of coal, or 62.6 per cent. The total value of the coke was $3,601,121, an average of $2.96 a ton. The value per ton varied from $1.35 in West Virginia to $14.16 in Nevada. The largest production was in New York—248,271 tons. The arrangement of the States in order of production is as follows:

Rank of States in production of gas coke.

Rank.	State.	Production.	Proportion of coke from coal.	Value per ton.	Total value.
		Tons.	*Per cent.*		
1	New York	248,271	59.5	$3.46	$860,900
2	Ohio	205,947	68.8	1.85	381,427
3	Pennsylvania	190,591	61.5	1.86	355,989
4	Massachusetts	115,980	64.5	3.61	419,623
5	Wisconsin	42,524	59.7	3.05	129,775
6	Michigan	36,480	63.6	3.49	127,341
7	Illinois	34,280	61.4	3.29	112,812
8	Rhode Island	33,608	66.3	2.65	89,074
9	Indiana	31,175	56.3	2.76	84,932
10	Kentucky	29,567	59.9	2.56	75,776
11	Connecticut	28,298	63.8	3.63	102,970
12	Tennessee	22,636	65.6	2.88	65,324
13	California	16,471	59.6	9.16	150,997
14	New Jersey	15,689	58.6	2.86	44,992
15	Missouri	14,663	57.0	3.13	46,023
16	Iowa	12,157	58.3	4.46	54,269
17	West Virginia	11,186	63.8	1.35	15,112
18	Virginia	11,025	49.3	2.49	27,465

These 18 States represent over 90 per cent of the total production. The highest percentage yield of coke was in Ohio, 68.8 per cent, and the lowest in Virginia, 49.3 per cent. The States of New York, Ohio, and Pennsylvania contribute over 53 per cent of the production. According to the returns the percentage yield of coke from coal in gas works is somewhat less than from coke ovens, taking the country as a whole, the figures being 62.6 per cent and 63.3 per cent, respectively, for 1898. In the Connellsville region, Pennsylvania, the yield of coke in 1897 from bee-hive ovens was 67 per cent; in West Virginia, Flat-Top district, 61.5 per cent; in Alabama, 58.8 per cent. In 1898, in Pennsylvania, the yield of gas coke was 61.5 per cent; in West Virginia, 63.8 per cent; and in Alabama, 59.9 per cent.

Gas coke does not come much into use as a blast-furnace fuel, the greater part going for domestic purposes, to bakeries, for electrical uses, etc. As a rule it is harder and denser than ordinary bee-hive coke. Experiments made by the writer on gas coke from run-of-mine Pratt coal, Alabama, showed an apparent specific gravity of 1.25; true specific gravity, 2.10; percentage of cells by volume, 40.50; volume of cells in 100 parts by weight, 43; compressive strain in pounds per square inch, 600.

AMMONIA LIQUOR AND SULPHATE OF AMMONIA.

Sixty returns were made as to the amount of ammonia liquor produced at gas works in 1898, and in addition there were six reports from establishments not giving a separate account of the liquor but stating the amount of aqua ammonia produced. The total amount of ammonia liquor reported by the 70 establishments was 25,749,792 gallons, produced from 1,358,094 tons of coal and valued at $284,148. The strength of the liquor was stated in various ways, some giving it in ounces, some in degrees Twaddell, and a very few in percentage of anhydrous ammonia. One-ounce liquor is liquor which on distillation of 1 gallon with caustic lime will yield sufficient ammonia to neutralize 1 ounce of sulphuric acid of specific gravity 1.84. One gallon of 1-ounce liquor contains 0.3479 ounce of ammonia, which is equivalent to 1.3498 ounces of sulphate of ammonia. Sulphate of ammonia, used largely as a fertilizing material and as a source of other ammonia compounds, contains, when pure, 25.81 per cent of anhydrous ammonia and 74.19 per cent of sulphuric acid. So that to find the amount of sulphate of ammonia equivalent to one part of anhydrous ammonia (NH_3) multiply by 3.88, and to find the amount of anhydrous ammonia equivalent to one part of sulphate of ammonia multiply by 0.2581. One degree Twaddell corresponds to 2-ounce liquor, and 1 per cent liquor corresponds to 4 ounce liquor. If the strength of ammonia liquor is given in ounces, as 10-ounce liquor, 16-ounce liquor, etc., and it be desired to express the strength in terms of ounces of anhydrous ammonia per gallon, multiply the number of ounces given by 0.3479. If the strength is expressed in degrees Twaddell, multiplying by 2 gives the strength in ounces, and multiplying this by 0.3479 gives the number of ounces of anhydrous ammonia per gallon. If the strength is expressed as percentage, multiplying by 4 gives the strength in ounces, and multiplying this by 0.3479 gives the number of ounces of anhydrous ammonia per gallon.

It would appear advisable to adopt a uniform system for expressing the strength of ammonia liquor based on a more accurate principle than the old ounce system or the Twaddell system, and certainly the percentage system is much to be preferred. What percentage of ammonia does the gas liquor contain? This question once answered, there is nothing more to be desired except the guaranty that the method adopted for the estimation of the ammonia shall be such as to commend itself both to buyer and seller. Throughout the trade generally gas liquor containing 1 per cent of ammonia is considered as 4-ounce liquor, and this is well understood. It would be advisable, therefore, to discard all other ways of grading gas liquor in favor of the percentage system, for this is the basis on which the liquor is bought.

It has been a great labor to reduce the returns made to a common basis, so that comparisons might be drawn, and after all the calculations had been finished it was found to be impracticable to present a table of results other than the one given on pages 233–235. In the first place many establishments did not report the gas liquor at all, and it happened, also, that from many States there was but one report, and from many others but two reports. It would be unfair to tabulate the returns by States, so that while indeed such a table was prepared it will not be presented. It is hoped that the returns for 1899 will be so much more complete that the next report can include a tabular view of the returns of gas liquor, its strength and value by States. In the meantime such general observations will be made as seem to be warranted by the data to hand.

In the following table are given by numbers, such returns as have been received, and from these the calculations have been made. It has been thought best to tabulate the returns by numbers and not by States, as in this way the really essential facts are brought out without prejudice to the establishments reporting.

Production and value of ammoniacal liquor.

Number.	Coal used.	Ammonia liquor made. Per ton of coal.	Ammonia liquor made. Total.	Strength of liquor. As reported.	Strength of liquor. Equivalent to ounces anhydrous ammonia per gallon.	Strength of liquor. Equivalent to ounces sulphate of ammonia per gallon.	Value of liquor as reported. Per gallon.	Value of liquor as reported. Total.	Possible production of sulphate of ammonia.
	Tons.	*Galls.*	*Gallons.*				*Cents.*		*Pounds.*
1	12,430	22.0	273,460	8 oz.	2.78	10.78	0.50	$1,367	184,244
2	16,741	26.9	450,000	1-1.25 %	1.55	6.01	.60	2,989	169,031
3	5,800	2.2	12,500	28.5 T.	19.83	76.94	8.0	1,000	60,109
4	4,480	44.9	200,900	4.30 %	6.18	23.97	12.8	25,715	301,598
5	13,819	126.0	1,741,321	7 oz.	2.43	9.42	2.0	34,826	1,025,202
6	2,700	3.3	9,000	14 %	19.48	75.58	15.0	1,350	42,514
7	4,500	3.0	13,500	60 oz.	20.87	81.27	6.0	810	68,509
8	2,900	2.0	6,000	65 oz.	22.61	87.72	9.0	540	32,895
9	5,952	1.5	9,187	80 oz.	27.83	107.98	10.0	919	62,000
10	4,153	2.1	8,944	45 oz.	15.65	60.72	10.0	894	33,942
11	11,066	1.6	17,250	73 oz.	25.40	98.55	13.7	2,363	106,236

Production and value of ammoniacal liquor—Continued.

Number.	Coal used.	Ammonia liquor made.		Strength of liquor.			Value of liquor as reported.		Possible production of sulphate of ammonia.
		Per ton of coal.	Total.	As reported.	Equivalent to ounces anhydrous ammonia per gallon.	Equivalent to ounces sulphate of ammonia per gallon.	Per gallon.	Total.	
	Tons.	*Galls.*	*Gallons.*				*Cents.*		*Pounds.*
12	9,553	2.9	27,686	14 %	19.48	75.58	8.0	$2,214	130,782
13	585	89.3	52,250	5.5 oz.	1.91	7.41	1.6	836	24,198
14	5,132	11.7	60,100	7.2 %	10.09	39.14	1.70	1,081	147,019
15	8,601	10.4	89,200	16 oz.	5.56	21.57	1.5	1,338	120,253
16	5,887	11.8	69,511	16 oz.	5.56	21.57	1.5	1,042	93,709
17	8,909	14.7	130,706	16 oz.	5.56	21.57	1.5	1,960	176,208
18	22,873	28.8	658,549	9.5 oz.	3.30	12.80	.72	4,741	526,837
19	3,680	28.9	106,228	9.5 oz.	3.30	12.80	.84	893	84,976
20	16,561	8.2	136,295	16 oz.	5.56	21.57	2.0	2,726	183,742
21	10,158	6.5	65,600	16 oz.	5.56	21.57	1.37	898	88,431
22	5,203	11.7	60,661	16 oz.	5.56	21.57	1.5	910	81,778
23	4,630	8.1	37,618	16 oz.	5.56	21.57	1.3	489	50,714
24	9,647	16.4	158,686	16 oz.	5.56	21.57	1.25	1,983	213,927
25	5,273	6.8	35,884	9.15 oz.	3.18	12.33	.86	308	27,653
26	10,080	14.9	150,000	8.0 oz.	2.78	10.78	1.0	1,500	101,906
27	1,800	13.8	2,480	80 oz.	27.83	107.98	12.0	298	16,737
28	12,201	3.9	47,000	60 oz.	20.87	81.27	9.6	4,512	232,481
29	5,230	2.0	10,760	70 oz.	24.35	94.47	8.75	942	63,531
30	10,927	137.8	1,505,275	7 oz.	2.43	9.42	......	....	888,770
31	3,631	10.4	37,925	16 oz.	5.56	21.57	1.52	578	51,127
32	7,315	1.9	13,546	60 oz.	20.87	81.27	7.99	1,083	68,805
33	2,393	3.8	9,000	44 oz.	15.30	59.36	6.66	599	33,390
34	676	10.0	6,750	8 oz.	2.78	10.78	......	....	4,548
35*a*	32,616	......	....	....	......	......	......	10,162	621,219
36*b*	14,507	......	....	....	......	......	......	4,347	843,353
37*c*	15,459	......	....	....	......	......	......	6,057	303,253
38*d*	2,021	......	....	....	......	......	......	504	34,028
39	1,300	3.8	5,000	47 oz.	16.35	63.43	5.7	285	19,822
40	5,631	.2	1,283	60 oz.	20.87	81.27	7.95	102	6,517
41	296,698	......	....	....	......	......	......	....	4,503,453
42	2,000	3.0	6,000	56 oz.	19.49	75.62	9.73	584	28,357
43*e*	1,860	......	....	....	......	......	......	....	95,983

a Reports 160,108 pounds of ammonia. No strength.
b Reports 217,359 pounds of ammonia. No strength.
c Reports 78,158 pounds of ammonia. No strength.
d Reports 8,770 pounds of ammonia. No strength.
e Reports 1.33 pounds of ammonia per ton of coal.

Production and value of ammoniacal liquor—Continued.

Number.	Coal used.	Ammonia liquor made. Per ton of coal.	Ammonia liquor made. Total.	Strength of liquor. As reported.	Strength of liquor. Equivalent to ounces anhydrous ammonia per gallon.	Strength of liquor. Equivalent to ounces sulphate of ammonia per gallon.	Value of liquor as reported. Per gallon.	Value of liquor as reported. Total.	Possible production of sulphate of ammonia.
	Tons.	*Galls.*	*Gallons.*				*Cents.*		*Pounds.*
44	4,422	2.0	8,923	64 oz.	22.26	86.36	14.2	$1,269	48,156
45	112,300	37.2	4,180,000	3.44 oz.	1.19	4.61	.5	20,900	1,204,362
46*a*	100,000	......	....	....	......	....	......	25,000	1,940,000
47	20,000	16.0	320,000	60 oz.	20.87	81.27	12.0	38,400	1,625,400
48*b*	1,428	(*b*)	(*b*)	4° T.	......	....	......	....	....
49	4,839	1.7	8,000	56 oz.	19.49	75.62	14.0	1,120	37,810
50	10,470	1.2	12,564	80 oz.	27.83	107.98	15.0	1,885	84,791
51	3,330	1.8	6,000	44 oz.	15.30	59.36	11.3	678	22,260
52	5,325	2.1	11,220	54.2 oz.	18.85	73.13	7.0	785	51,282
53	3,340	2.7	9,000	53 oz.	18.43	71.50	5.0	450	40,219
54	9,600	.2	2,083	80 oz.	27.83	107.98	12.3	256	14,058
55	7,747	2.3	17,500	56 oz.	19.49	75.62	12.0	2,100	82,700
56	229,690	51.1	11,735,000	4.5 oz.	1.56	6.05	......	....	3,812,297
57	44,811	30.0	1,344,330	10 oz.	3.47	13.46	.75	10,082	1,130,918
58	3,502	2.7	9,500	64 oz.	22.26	86.36	13.5	1,282	51,214
59	4,198	9.5	40,000	16 oz.	5.56	21.57	12.5	5,000	53,925
60	8,727	15.2	132,464	4.25 oz.	1.47	6.70	.3	397	55,469
61	36,814	31.4	1,155,170	4 oz.	1.39	5.39	.7	8,086	326,648
62*c*	6,600	......	....	....	......	....	......	875	45,279
63	6,000	14.2	85,000	56 oz.	19.49	75.62	6.6	5,610	401,731
64	7,000	1.6	11,000	60 oz.	20.87	81.27	6.6	726	55,873
65	12,461	19.3	240,997	8 oz.	2.78	10.78	.9	2,169	162,372
66	2,036	2.1	4,188	80 oz.	27.83	107.98	3.34	140	21,014
67	1,646	1.2	1,997	64 oz.	22.26	86.36	6.66	132	10,779
68	15,099	......	....	....	......	....	......	2,717	2,718
69	54,716	2.4	132,401	64 oz.	22.26	86.36	18.0	23,832	714,634
70	14,415	3.9	56,400	....	......	....	8.00	4,512	....
	1,358,094	......	25,749,792	....	......	....	......	284,148	23,949,696

a Reports 500,000 pounds of ammonia. No strength.
b Not saved.
c Reports 11,670 pounds of ammonia. No strength.

The total amount of gas liquor produced in 1898, as reported by 70 establishments, was 25,749,792 gallons, valued at $284,148. For this output there were required 1,358,094 tons of coal. The output of liquor per ton of coal, as well as the price per gallon, depends upon the strength, so it is obvious that no general average can be obtained. The production, per ton of coal carbonized, varies within very wide limits, i. e., from 0.2 gallon to 137.8 gallons, while the price per gallon varies from 0.3 cent to 18 cents.

Of liquor giving from 1 to 5 ounces of ammonia per gallon there were made 23,767,678 gallons, or 92.4 per cent of the total; from 5 to 10 ounces, 1,027,102 gallons, or 4 per cent; from 10 to 15 ounces, 60,100 gallons, or 0.3 per cent; from 15 to 20 ounces, 214,850 gallons, or 0.8 per cent; from 20 to 25 ounces, 575,910 gallons, or 2.2 per cent; from 25 to 30 ounces, 47,752 gallons, or 0.3 per cent. The amount of liquor containing less than 10 ounces of ammonia, or 38.8 ounces of sulphate of ammonia, per gallon is 96.4 per cent of the entire output. It is not customary in this country to concentrate the ammonia liquor sold to the distilling companies above what is known as "30-ounce liquor," or 7.5 per cent of ammonia. The amount of liquor concentrated above this strength is comparatively insignificant, although a little is carried to "80-ounce," corresponding to 20 per cent of ammonia, or 27.83 ounces of ammonia (= 107.98 ounces of sulphate of ammonia) per gallon.

As already stated, it is thought that the total production of sulphate of ammonia from gas liquor did not exceed 3,000 tons in 1898. If all the gas liquor reported had been worked up into sulphate the production would have been 11,974 tons. The difference between these figures, 8,974 tons, represents the sulphate that could have been made, but was not made because the ammonia distilled from the liquor was used in some other form. In other words, the 8,974 tons represent 2,316 tons of anhydrous ammonia obtained from gas liquor but not made into sulphate. Besides sulphate there are other valuable uses to which ammonia is put, e. g., in ice factories, chemical works, etc., and there is a large and increasing demand for it.

Six establishments report the actual amount of ammonia made instead of the amount of ammonia (gas) liquor, the total production being 976,065 pounds, strength not specified. One establishment reports the yield of ammonia per ton of coal. These returns of ammonia are calculated out for sulphate, and are included in the possible total production of sulphate.

VALUATION OF AMMONIA LIQUOR.

The old-fashioned ways of valuing ammonia liquor by expressing its strength in degrees Baumé (the spindle test), or in degrees Twaddell, or as liquor of so many "ounces," are giving place to chemical methods. The actual amount of ammonia is determined by analysis, and the payment for a shipment is based on returns from the laboratory.

Gas liquor contains ammonia in many different forms, as, for instance, free ammonia (generally very little), and the following ammonia compounds: Acetate, carbonate, chloride, cyanide, ferrocyanide, hydrosulphide, sulphate, sulphide, sulphocyanide, thiosulphate, thiocarbonate.

There is no other reliable method for ascertaining the amount of ammonia in gas liquor except by chemical analysis. The method is very simple and but little apparatus is required. Two methods which are in daily use in large establishments are given here.

Method A.—The liquid containing ammonia is measured into a distilling flask of about 300 cubic centimeters capacity, provided with a tight-fitting stopper, through which passes the tube for conveying the gaseous ammonia into the receiving flask. This tube has a bulb on it so as to prevent the boiling liquid from passing over, and its upper end is curved and fitted tightly into a wider tube, which dips into the receiving flask (an Erlenmeyer flask of about 200 cubic centimeters capacity). The receiving flask contains standard sulphuric acid. A small amount of caustic soda is added to the liquor in the distilling flask, the connections are made, and the liquor is boiled. The caustic soda decomposes the ammonia compounds present in the liquor and free ammonia passes over and is absorbed in the standard acid. After boiling for a few minutes, the length of time depending on the richness of the liquor, the apparatus is disconnected, the tubes are washed out into the receiving flask, and the excess of acid is determined by standard alkali.

If it is desired to determine the percentage of ammonia in sulphate of ammonia, 10 grams of a good average sample are dissolved in water and the solution is diluted to 500 cubic centimeters. Of this, 50 cubic centimeters are then distilled with caustic soda, and the vapors are passed into 20 cubic centimeters standard acid. After distillation the excess of acid is titrated with standard soda lye. If we assume, for instance, that of the 20 cubic centimeters standard acid 5 cubic centimeters have been titrated back with soda lye, then 15 cubic centimeters have been saturated by ammonia. One gram of sulphate of ammonia will give $0.017 \times 15 = 0.255$ grams of ammonia. One cubic centimeter standard acid is equivalent to 0.017 grams of ammonia. The sulphate, consequently, contains 25.5 per cent of ammonia.

If it is desired to determine the ammonia in gas liquor, then 10 cubic centimeters of the gas liquor is retained in 20 cubic centimeters standard acid. If, for instance, 20 cubic centimeters have been used and 6 cubic centimeters have been titrated back by soda lye, then the percentage of ammonia in the gas liquor is $14 \times 0.017 \times 10 = 2.38$ per cent.

One determination requires about one-half to three-quarters of an hour.

Method B.—The weak ammonia liquor obtained from by-product coke ovens contains about 1 per cent of ammonia. The daily reports of the recovery of ammonia are made up from the volume of weak liquor obtained, and its strength in ammonia figured in grams per liter. A sample of the weak liquor is taken, the degree Baumé is determined, and a certain volume is withdrawn for analysis. This analysis includes the determination of the free and fixed ammonia. The results are expressed in percentage and in grams per liter.

The method may be described as follows:

Fifty cubic centimeters of the liquor with 50 cubic centimeters distilled water are placed in a quart distilling flask, which is then heated over a Bunsen flame. The products of distillation pass out through a Kjeldahl connecting bulb tube. The distillate is received in an Erlenmeyer flask containing an excess of normal sulphuric acid, distilled water, and a few drops of cochineal solution. When all the free ammonia has been expelled the boiling is discontinued, 50 cubic centimeters of cold distilled water and 2 grams soda ash are added to the contents of the distilling flask and the boiling is continued until all the fixed ammonia is driven off, the distillate being received in an Erlenmeyer flask prepared as in the test for the free ammonia. The excess of normal acid is determined in each flask by titrating with normal caustic soda.

Samples of the waste liquor from the distillers are frequently taken and the total and fixed ammonia is obtained by the following method:

Five hundred cubic centimeters are placed in a quart distilling flask arranged as for weak liquor. The distillate, however, is received in an open 6-inch porcelain dish two-thirds filled with distilled water, to which are added a few drops of cochineal. The free ammonia present in the liquor is estimated by drops of normal sulphuric acid from a burette, and is usually very small. After the free ammonia has all come off the solution in the flask is allowed to cool and 2 grams of soda ash added and the fixed ammonia is expelled, being received in a 6-inch porcelain dish and estimated as for the free ammonia.

The concentrated liquors range from 11° to 13° Baumé and from 15 to 22 per cent of ammonia. For checking the amount of the ammonia recovered by distillation with that sent to the distiller the tests are reported in grams per liter. The gravity is also obtained at 15.5° C., and the percentage of ammonia by weight is determined. The method of analyzing the strong liquors may be described as follows:

After cooling to 15.5° C. the specific gravity by the hydrometer is obtained and 50 cubic centimeters of the liquor are placed in a 500-cubic centimeter flask, which is filled to the mark with distilled water. The contents of the flask are thoroughly mixed and 50 cubic centimeters are placed in a quart distilling flask, arranged as for weak liquors, with 100 cubic centimeters of distilled water and 2 grams soda ash. The distillate is received in an Erlenmeyer flask containing an excess of normal sulphuric acid, distilled water, and a few drops of cochineal solution.

The excess of normal acid is determined by titrating with normal caustic soda.

At the eighteenth annual meeting of the Western Gas Association, held in Pittsburg, May, 1895, Dr. Frank L. Slocum, for the local committee, presented some facts in regard to gas liquor. Among other valuable data he gave a table of the analysis of gas liquor taken from different parts of the works. It is of great interest and is here reproduced, with the exception of some portions which do not apply to the subject in hand.

Analysis of gas liquor taken from different parts of a gas plant by F. L. Slocum.

	From one part of the hydraulic main.	From another part of the hydraulic main.	From first air cooler.	From second air cooler.	From third air cooler.	From fourth air cooler.	From first washer.	From second washer.
Color	Muddy orange.	Muddy orange.	Clear.	Nearly clear.	Brown-red.	Dark brown.	Clear.	Clear.
Specific gravity at 15.5° C	1.011	1.012	1.035	1.075	1.115	1.120	1.022	1.010
Ounces by distillation test	6.1	6.0	16.2	36.1	53.0	58.0	16.5	8.3
Ounces by saturation test	2.7	2.8	15.9	35.7	52.5	57.4	16.1	8.1
Ammonium sulphide, grams per liter	5.20	6.29	34.71	71.43		120.6	22.74	17.43
Ammonia	2.60	3.14	17.36	35.71		60.30	11.37	8.71
Ammonium carbonate, grams per liter	8.05	7.29	48.34	116.00	112.93	173.23	64.46	24.14
Ammonia	2.75	1.16	17.14	41.14		61.43	22.86	8.57
Ammonium thiosulphate, grams per liter	1.74	1.17	Trace.	1.79	5.03	10.93	3.29	1.93
Ammonia	0.40	0.27	Trace.	0.59	1.16	2.52	0.73	0.44
Ammonium sulphate, grams per liter	0.11	0.49						
Ammonia	0.03	0.13	....	....	....	....	....	....
Ammonium sulphocyanide, grams per liter	1.60	1.86	0.13	Trace.	....	....	1.60	0.39
Ammonia	0.36	0.41	0.03	Trace.	....	....	0.36	0.09
Ammonium chloride, grams per liter	22.17	20.79	1.70	2.21	2.87	1.53	1.26	0.54
Ammonia	7.04	6.60	0.54	0.71	0.91	0.48	0.40	0.17
Ammonium ferrocyanide, grams per liter	....	Trace.	0.31	0.59	1.79	5.36	....	....
Ammonia	....	....	0.07	0.14	0.43	1.29	....	....
Total ammonia, grams per liter	13.29	13.14	35.13	78.29	115.43	126.00	35.71	18.00
Value for sulphate production	Very poor.	Very poor.	Very good.	Very good.	Excellent.	Excellent.	Very good.	Poor.

To convert grams per liter to ounces per gallon multiply by 0.128.

ILLUMINATING AND FUEL GAS.

Returns from 433 companies show a total production of 19,469,464,957 cubic feet of gas from 2,042,698 tons of coal, or 9,465 cubic feet per ton. The total quantity of gas sold was 18,431,201,414 cubic feet, valued at $21,502,295, or $1.166 per 1,000 cubic feet. The quantity of gas unaccounted for was 1,038,263,543 cubic feet. The gas sold for illuminating purposes was 15,955,149,507 cubic feet, valued at $18,953,114, or $1.188 per 1,000 cubic feet. The quantity of gas sold for fuel purposes was 2,476,051,907 cubic feet, valued at $2,549,181, or $1.029 per 1,000 cubic feet.

The following table gives the quantity and value of the gas produced in 1898, by States:

Quantity and value of gas produced in 1898, by States.

State.	Number companies reporting.	Quantity of coal carbonized.	Total quantity gas produced.	Quantity gas produced per ton of coal.	Gas sold for illuminating purposes.			Gas sold for fuel purposes.			Total gas sold.			Quantity gas unaccounted for.
					Quantity.	Value.	Price per M.	Quantity.	Value.	Price per M.	Quantity.	Value.	Average price.	
		Short tons.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*			*Cubic feet.*			*Cubic feet.*			*Cubic feet.*
Alabama	9	16,929	105,941,100	6,258	82,397,600	$143,137	$1.737	15,289,100	$20,370	$1.332	97,686,700	$163,507	$1.674	8,254,400
Arkansas	3	3,300	26,673,200	8,083	21,358,500	42,717	2.00	5,314,700	7,593	1.429	26,673,200	50,310	1.886	0
California	26	27,740	266,904,824	9,622	209,154,960	454,619	2.173	47,349,837	88,427	1.868	256,504,797	543,046	2.117	10,400,027
Colorado	4	16,931	154,990,300	9,154	114,085,300	174,956	1.534	37,850,000	38,850	1.026	151,935,300	213,806	1.407	3,055,000
Connecticut	7	*a* 42,751	429,509,570	*b* 9,908	306,770,300	410,573	1.338	92,294,600	94,951	1.029	399,064,900	505,524	1.267	30,444,670
Delaware	3	6,458	58,736,800	9,095	43,977,600	45,523	1.035	14,759,200	15,134	1.025	58,736,800	60,657	1.033	0
Georgia	8	23,870	202,635,900	8,489	141,539,300	185,177	1.308	58,715,400	63,180	1.076	200,254,700	248,357	1.240	2,381,200
Illinois	26	55,850	508,561,350	9,106	308,880,500	410,525	1.329	152,571,200	177,247	1.162	461,451,700	587,772	1.274	47,109,650
Indiana	20	55,344	512,375,912	9,258	366,379,350	495,317	1.352	92,354,980	93,060	1.008	458,734,330	588,377	1.283	53,641,582
Iowa	13	19,657	*c* 184,677,047	*d* 9,106	*c* 121,686,119	188,022	1.545	*c* 51,266,388	71,157	1.388	*c* 172,952,507	259,179	1.499	*c* 11,724,540
Kansas	9	17,529	149,879,866	8,550	106,373,190	157,714	1.483	27,098,700	36,414	1.344	133,471,890	194,128	1.454	16,407,976
Kentucky	9	49,386	466,912,000	9,454	320,595,800	439,195	1.370	77,776,200	63,606	.818	398,372,000	502,801	1.262	68,540,000
Louisiana and Mississippi	3	3,009	23,342,601	7,758	15,263,094	27,985	1.834	3,333,458	5,010	1.503	18,596,552	32,995	1.774	4,746,049
Maine	5	9,934	*e* 129,674,270	*f* 9,828	103,475,440	140,529	1.358	12,533,800	16,461	1.313	116,009,240	156,990	1.353	13,665,030
Maryland and District of Columbia	5	7,639	70,090,400	9,175	65,882,770	92,154	1.399	4,207,630	4,702	1.117	70,090,400	96,856	1.382	0
Massachusetts	45	179,706	1,788,133,565	9,950	1,536,282,632	1,969,930	1.282	108,606,390	130,790	1.204	1,644,889,022	2,100,720	1.277	143,244,543
Michigan	21	56,882	536,570,736	9,433	327,911,922	390,472	1.191	185,302,944	181,478	.979	513,214,866	571,950	1.114	23,355,870
Minnesota and Nebraska	4	16,038	*c* 178,599,000	*d* 9,547	*c* 146,415,200	204,903	1.399	*c* 24,000,000	31,800	1.325	*c* 170,415,200	236,703	1.389	*c* 8,183,800

a Includes some coal made in manufacture of water gas.
b Excluding one company, which made water gas.
c Includes some oil gas.
d Excluding one company, which made some oil gas.
e One company used naphtha and oil to enrich.
f Excluding one company, which used naphtha and oil to enrich.

Quantity and value of gas produced in 1898, by States—Continued.

State.	Number companies reporting.	Quantity of coal carbonized.	Total quantity gas produced.	Quantity gas produced per ton of coal.	Gas sold for illuminating purposes.			Gas sold for fuel purposes.			Total gas sold.			Quantity gas unaccounted for.
					Quantity.	Value.	Price per M.	Quantity.	Value.	Price per M.	Quantity.	Value.	Average price.	
		Short tons.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*			*Cubic feet.*			*Cubic feet.*			*Cubic feet.*
Missouri	20	124,518	1,131,978,890	9,091	765,621,200	$813,959	$1.063	355,706,800	$306,352	$0.861	1,121,528,000	$1,120,311	$0.999	10,650,890
Montana and New Mexico	3	5,031	42,584,900	8,465	25,189,640	55,054	2.186	11,032,760	21,740	1.970	36,222,400	76,794	2.120	6,362,500
Nevada	3	815	6,939,900	8,515	6,810,900	30,504	4.479	129,000	383	2.969	6,939,900	30,887	4.451	0
New Hampshire	4	13,160	125,419,893	9,530	113,535,373	165,916	1.461	7,308,520	10,232	1.400	120,843,893	176,148	1.458	4,576,000
New Jersey	13	25,173	*a* 239,909,555	*b* 9,421	*a* 189,412,045	301,653	1.593	*a* 20,768,112	29,429	1.417	*a* 210,180,157	331,082	1.575	*a* 29,729,398
New York	41	411,188	*c* 4,035,178,038	*d* 9,723	*c* 3,836,678,939	4,443,375	1.158	*c* 87,098,699	99,810	1.146	*c* 3,923,777,638	4,543,185	1.158	*c* 111,400,400
North and South Carolina	3	11,138	109,113,500	9,797	84,591,500	138,301	1.635	22,522,000	27,026	1.200	107,113,500	165,327	1.543	2,000,000
North Dakota, Utah, and Wyoming	3	2,602	26,520,000	10,192	15,769,000	28,643	1.816	9,081,000	10,053	1.107	24,850,000	38,696	1,557	1,670,000
Ohio	41	299,353	2,935,993,358	9,808	2,326,232,712	2,234,475	.961	402,620,439	332,834	.827	2,728,853,151	2,567,309	.941	207,140,207
Oregon	4	5,112	38,780,000	7,586	28,910,000	65,909	2.280	6,497,850	10,546	1.623	35,407,850	76,455	2.159	3,372,150
Pennsylvania	22	310,043	2,867,466,490	9,249	2,774,161,972	2,856,400	1.0296	44,790,178	45,723	1.021	2,818,952,150	2,902,123	1.0295	48,514,340
Rhode Island	4	50,669	499,814,400	9,864	357,717,844	422,818	1.182	131,587,137	145,477	1.106	489,304,981	568,295	1.161	10,509,419
Tennessee	8	34,511	304,944,820	8,836	214,114,600	319,085	1.490	40,465,900	45,973	1.136	254,580,500	365,058	1.434	50,364,320
Texas	11	15,393	144,970,500	9,418	78,883,100	168,896	2.141	49,297,900	74,428	1.510	128,181,000	243,324	1.898	16,789,500
Virginia	9	22,384	203,564,372	9,094	181,822,558	212,652	1.170	3,362,800	4,209	1.252	185,185,358	216,861	1.171	18,379,014
Washington	6	13,928	129,688,100	9,311	92,967,250	182,852	1.967	33,153,850	50,108	1.511	126,121,100	232,960	1.847	3,567,000
West Virginia	5	17,530	151,416,900	8,637	120,350,844	99,005	.823	2,032,656	2,599	1.279	122,383,500	101,604	.830	29,033,400
Wisconsin	13	71,197	680,972,900	9,565	403,950,453	440,169	1.090	237,971,779	192,029	.807	641,922,232	632,198	.985	39,050,668
Total	433	2,042,698	19,469,464,957	*d* 9,465	15,955,149,507	18,953,114	1.188	2,476,051,907	2,549,181	1.0295	18,431,201,414	21,502,295	1.1666	1,038,263,543

a Includes some oil gas.
b Excluding one company, which made some oil gas.
c Includes some gas made from oil used as an enricher.
d Excludes companies which used oil to enrich.

The largest production in any one State was in New York, 4,035,178,038 cubic feet, while the smallest production was in Nevada, 6,939,900 cubic feet. The yield of gas per ton of coal varied from 6,258 cubic feet in Alabama to 9,950 in Massachusetts, excluding the yield of 10,192 cubic feet in North Dakota, Utah, and Wyoming, which are considered together.

The price of illuminating gas per 1,000 cubic feet varied from 82.3 cents in West Virginia to $4.479 in Nevada, while the price of fuel gas varied from 80.7 cents in Wisconsin to $2.969 in Nevada. Taking the country as a whole, the difference in the price of illuminating and fuel gas is about 16 cents, but individual States show a much wider variation than this. For instance, in Texas the difference is 63 cents; in Oregon, 66 cents; while in Nevada it rises to $1.51. In some of the States—e. g., Delaware, New York, and Pennsylvania—the difference is very small. Fuel gas, however, is for the most part sold at a less price per 1,000 cubic feet than illuminating gas. This is done to encourage a larger use of fuel gas. It is the same as illuminating gas, being made in the same way and conveyed in the same pipes. The largest producer of gas sold for illuminating purposes is the State of New York, with 3,836,678,939 cubic feet; but the largest producer of gas sold for fuel is Ohio, with 402,620,439 cubic feet. By reference to the table given on page 244, however, it will be seen that, stated as percentage of product sold, Pennsylvania uses 99.07 per cent of its product for illuminating purposes and only 0.93 per cent for fuel purposes; New York uses 97.86 per cent for illuminating, while Ohio uses 86.15 per cent. Considered in this way, Pennsylvania uses less fuel gas than any other State, while Texas uses more.

There may be constructed from the table last presented another table giving the rank of the principal States in the production of coal gas, whether for illuminating or for fuel purposes. Such a table is given below:

Rank of the principal States in illuminating and fuel gas, 1898.

Rank.	Illuminating gas.		Rank.	Fuel gas.	
	State.	Production in hundred millions of cubic feet.		State.	Production in millions of cubic feet.
1	New York	3,836.7	1	Ohio	402.6
2	Pennsylvania	2,774.2	2	Missouri	355.7
3	Ohio	2,326.2	3	Wisconsin	238.0
4	Massachusetts	1,536.3	4	Michigan	185.3
5	Missouri	765.6	5	Illinois	152.6
6	Wisconsin	403.9	6	Rhode Island	131.6
7	Indiana	366.4	7	Massachusetts	108.6
8	Rhode Island	357.7	8	Connecticut	92.3

Rank of the principal States in illuminating and fuel gas, 1898—Continued.

Rank.	Illuminating gas. State.	Illuminating gas. Production in hundred millions of cubic feet.	Rank.	Fuel gas. State.	Fuel gas. Production in millions of cubic feet.
9	Michigan	327.9	9	Indiana	92.3
10	Kentucky	320.6	10	New York	87.1
11	Illinois	308.9	11	Kentucky	77.8
12	Connecticut	306.8	12	Georgia	58.7
13	Tennessee	214.1	13	Iowa	51.3
14	California	209.1	14	Texas	49.3
15	New Jersey	189.4	15	California	47.3
16	Virginia	181.8	16	Pennsylvania	44.8
17	Georgia	141.5	17	Tennessee	40.5
18	Iowa	121.7	18	Colorado	37.8

The following table, giving the quantity of illuminating and fuel gas sold, by States, in 1898 is of considerable interest, as it is the first attempt made to illustrate this feature of the gas business. The information it contains is as accurate as could be secured, and while some of the States made no returns, yet on the whole the matter is fairly well covered.

Quantity of illuminating and fuel gas sold in 1898, by States.

State.	Illuminating. Quantity.	Illuminating. Per centage.	Fuel. Quantity.	Fuel. Per centage.	Total.
	Cubic feet.		*Cubic feet.*		*Cubic feet.*
Alabama	82,397,600	84.35	15,289,100	15.65	97,686,700
Arkansas	21,358,500	80.07	5,314,700	19.93	26,673,200
California	209,154,960	81.54	47,349,837	18.46	256,504,797
Colorado	114,085,300	75.02	37,850,000	24.98	151,935,300
Connecticut	306,770,300	76.87	92,294,600	23.13	399,064,900
Delaware	43,977,600	74.87	14,759,200	25.13	58,736,800
Georgia	141,539,300	70.67	58,715,400	29.33	200,254,700
Illinois	308,880,500	66.96	152,571,200	33.04	461,451,700
Indiana	366,379,350	79.86	92,354,980	20.14	458,734,330
Iowa	121,686,119	70.36	51,266,388	29.64	172,952,507
Kansas	106,373,190	79.62	27,098,700	20.38	133,471,890
Kentucky	320,595,800	80.47	77,776,200	19.53	398,372,000
Louisiana and Mississippi	15,263,094	82.07	3,333,458	17.93	18,596,552
Maine	103,475,440	89.19	12,533,800	10.81	116,009,240
Maryland and District of Columbia	65,882,770	94.11	4,207,630	5.89	70,090,400

Quantity of illuminating and fuel gas sold in 1898, by States—Continued.

State.	Illuminating.		Fuel.		Total.
	Quantity.	Per centage.	Quantity.	Per centage.	
	Cubic feet.		*Cubic feet.*		*Cubic feet.*
Massachusetts	1, 536, 282, 632	93. 44	108, 606, 390	6. 56	1, 644, 889, 022
Michigan	327, 911, 922	63. 88	185, 302, 944	36. 12	513, 214, 866
Minnesota and Nebraska	146, 415, 200	86. 12	24, 000, 000	13. 88	170, 415, 200
Missouri	765, 621, 200	68. 35	355, 706, 800	31. 65	1, 121, 328, 000
Montana and New Mexico	25, 189, 640	69. 97	11, 032, 760	30. 03	36, 222, 400
Nevada	6, 810, 900	98. 27	129, 000	1. 73	6, 939, 900
New Hampshire	113, 535, 373	94. 58	7, 308, 520	5. 42	120, 843, 893
New Jersey	189, 412, 045	90. 19	20, 768, 112	9. 81	210, 180, 157
New York	3, 836, 678, 939	97. 86	87, 098, 699	2. 14	3, 923, 777, 638
North and South Carolina	84, 591, 500	79. 06	22, 522, 000	20. 94	107, 113, 500
North Dakota, Utah, and Wyoming	15, 769, 000	63. 59	9, 081, 000	36. 41	24, 850, 000
Ohio	2, 326, 232, 712	86. 15	402, 620, 439	13. 85	2, 728, 853, 151
Oregon	28, 910, 000	82. 57	6, 497, 850	17. 43	35, 407, 850
Pennsylvania	2, 774, 161, 972	99. 07	44, 790, 178	. 93	2, 818, 952, 150
Rhode Island	357, 717, 844	73. 15	131, 587, 137	26. 85	489, 304, 981
Tennessee	214, 114, 600	84. 29	40, 465, 900	15. 71	254, 580, 500
Texas	78, 883, 100	61. 63	49, 297, 900	38. 37	128, 181, 000
Virginia	181, 822, 558	98. 38	3, 362, 800	1. 62	185, 185, 358
Washington	92, 967, 250	73. 77	33, 153, 850	26. 23	126, 121, 100
West Virginia	120, 350, 844	98. 61	2, 032, 656	1. 39	122, 383, 500
Wisconsin	403, 950, 453	62. 93	237, 971, 779	37. 07	641, 922, 232
Total	15,955,149,507	86. 57	2,476,051,907	13. 43	18,431,201,414

The special feature of this table is the comparison between the amounts of gas sold for illuminating and for fuel purposes. In Pennsylvania, practically all of the gas sold is for illuminating, less than 1 per cent of the quantity sold going for fuel. This is, perhaps, not a matter of surprise with respect to the western part of the State, where natural gas is so largely used as a domestic fuel, but that it should be true of the State generally was not to be anticipated. In Maryland and the District of Columbia more than 94 per cent of the gas sold goes for illuminating, and the same is true of New Hampshire. In Massachusetts, more than 93 per cent goes in the same way, while in Nevada and Virginia more than 98 per cent takes the same course. As percentage of the total amount of gas sold, Texas shows the largest consumption of fuel gas, and Pennsylvania the smallest. The States of

New York and Pennsylvania, which produced more than one-sixth of the total amount of coal gas sold, show a very small consumption of fuel gas. The only large producer showing a considerable consumption of fuel gas is Missouri, with a total output of 1,121,328,000 cubic feet, of which 355,706,800 cubic feet, or 31.65 per cent, went for fuel. Ohio, producing more than twice as much as Missouri, uses but 13.85 per cent for fuel, and Massachusetts, with one and a half times as much, uses only 6.56 per cent for fuel.

There are no previous statistics with which these may be compared, so it is impossible to discuss the growth of the fuel-gas business. The quantity of gas used for fuel in 1898 reached the considerable figures of 2,476,051,907 cubic feet, an average of 13.43 per cent of the total amount of gas sold during the year over the country at large. This includes domestic fires, factory fires, gas engines, etc. There is no doubt of the increasing use of coal gas as fuel, not only for domestic purposes but for gas engines, and it is highly probable that the adoption of prepayment meters for small consumers would be as profitable in many of our larger cities as it has been in England. By this system the quantity of gas furnished for 2 cents varies from 15 to 36 cubic feet, one company alone having 90,000 meters in use, supplying 72,000 stoves, and deriving a revenue of $450,000 a year from them. In Germany, Holland, France, Italy, and Sweden the penny-in-the-slot meter has met with large success. In Copenhagen the day consumption of gas is 80 per cent of the night consumption; the price of gas has been reduced from $1.80 to 78 cents per 1,000 cubic feet, while at the same time a dividend of 9 per cent has been earned on a capital of $2,500,000. In 36 German cities there are in use 2,323 gas engines, used in 150 different industries.

The following table gives the total production of gas, the quantity sold, and the quantity unaccounted for, by States, in 1898:

Total production of gas, amount sold, and unaccounted for in 1898, by States.

State.	Total production of gas.	Total gas sold.		Total gas unaccounted for.	
		Quantity.	Per cent.	Quantity.	Per cent.
	Cubic feet.	*Cubic feet.*		*Cubic feet.*	
Alabama	105,941,100	97,686,700	92.21	8,254,400	7.79
Arkansas	26,673,200	26,673,200	100.00	0	....
California	266,904,824	256,504,797	96.10	10,400,027	3.90
Colorado	154,990,300	151,935,300	98.03	3,055,000	1.97
Connecticut	429,509,570	399,064,900	92.91	30,444,670	7.09
Delaware	58,736,800	58,736,800	100.00	0	....
Georgia	202,635,900	200,254,700	98.82	2,381,200	1.18
Illinois	508,561,350	461,451,700	90.74	47,109,650	9.26
Indiana	512,375,912	458,734,330	89.53	53,641,582	10.47
Iowa	184,677,047	172,952,507	93.65	11,724,540	6.35

Total production of gas, amount sold, and unaccounted for, 1898, by States—Continued.

State.	Total production of gas.	Total gas sold.		Total gas unaccounted for.	
		Quantity.	Per cent.	Quantity.	Per cent.
	Cubic feet.	*Cubic feet.*		*Cubic feet.*	
Kansas	149, 879, 866	133, 471, 890	89. 05	16, 407, 976	10. 95
Kentucky	466, 912, 000	398, 372, 000	85. 32	68, 540, 000	14. 68
Louisiana and Mississippi	23, 342, 601	18, 596, 552	79. 67	4, 746, 049	20. 33
Maine	129, 674, 270	116, 009, 240	89. 46	13, 665, 030	10. 54
Maryland and District of Columbia	70, 090, 400	70, 090, 400	100. 00	0	....
Massachusetts	1, 788, 133, 565	1, 644, 889, 022	91. 99	143, 244, 543	8. 01
Michigan	536, 570, 736	513, 214, 866	95. 65	23, 355, 870	4. 35
Minnesota and Nebraska	178, 599, 000	170, 415, 200	95. 42	8, 183, 800	4. 58
Missouri	1, 131, 978, 890	1, 121, 328, 000	99. 06	10, 650, 890	. 94
Montana and New Mexico	42, 584, 900	36, 222, 400	85. 06	6, 362, 500	14. 94
Nevada	6, 939, 900	6, 939, 900	100. 00	0	....
New Hampshire	125, 419, 893	120, 843, 893	96. 35	4, 576, 000	3. 65
New Jersey	239, 909, 555	210, 180, 157	87. 61	29, 729, 398	12. 39
New York	4, 035, 178, 038	3, 923, 777, 638	97. 24	111, 400, 400	2. 76
North and South Carolina	109, 113, 500	107, 113, 500	98. 17	2, 000, 000	1. 83
North Dakota, Utah, and Wyoming	26, 520, 000	24, 850, 000	93. 70	1, 670, 000	6. 30
Ohio	2, 935, 993, 358	2, 728, 853, 151	92. 94	207, 140, 207	7. 06
Oregon	38, 780, 000	35, 407, 850	91. 30	3, 372, 150	8. 70
Pennsylvania	2, 867, 466, 490	2, 818, 952, 150	98. 31	48, 514, 340	1. 69
Rhode Island	499, 814, 400	489, 304, 981	97. 90	10, 509, 419	2. 10
Tennessee	304, 944, 820	254, 580, 500	83. 48	50, 364, 320	16. 52
Texas	144, 970, 500	128, 181, 000	88. 42	16, 789, 500	11. 58
Virginia	203, 564, 372	185, 185, 358	90. 97	18, 379, 014	9. 03
Washington	129, 688, 100	126, 121, 100	97. 25	3, 567, 000	2. 75
West Virginia	151, 416, 900	122, 383, 500	80. 83	29, 033, 400	19. 17
Wisconsin	680, 972, 900	641, 922, 232	94. 27	39, 050, 668	5. 73
Total	19,469,464,957	18,431,201,414	94. 67	1,038,263,543	5. 33

There is considerable leakage in the manufacture of gas, the total quantity unaccounted for being 1,038,263,543 cubic feet, or 5.33 per cent of the total production. In some of the States the gas unaccounted for rises to a remarkable figure, West Virginia, for instance, showing 19.17 per cent; Louisiana and Mississippi, 20.33 per cent; Tennessee, 16.52 per cent; Montana and New Mexico, 14.94 per cent, and Kentucky, 14.68 per cent. Missouri shows the smallest percentage, 0.94; Pennsylvania, 1.69 per cent; New York, 2.76 per cent; Ohio, 7.06 per cent, and Massachusetts, 8.01 per cent.

In the following table an effort has been made to show the production of coal gas, water gas, and gas made from oil, rosin, wood, etc.:

Production of coal, water, and oil gas in 1898, by States.

State.	Coal gas.		Water gas.		Oil, rosin, wood gas, etc.		Total.
	Cubic feet.	Per ct.	Cubic feet.	Per ct.	Cubic feet.	Per ct.	
Alabama	105,941,100	100.00					105,941,100
Arizona					1,980,000	100.00	1,980,000
Arkansas	26,673,200	43.25	35,000,000	56.75			61,673,200
California	266,904,824	15.99	1,380,057,600	82.66	22,577,200	1.35	1,669,539,624
Colorado	154,990,300	51.57	145,525,800	48.43			300,516,100
Connecticut	429,509,570	45.28	473,156,230	49.88	45,866,850	4.84	948,532,650
Delaware	58,736,800	30.25	6,600,000	3.40	128,823,100	66.35	194,159,900
Florida	(a)		69,584,300				69,584,300
Georgia	202,635,900	46.01	233,637,000	53.05	4,150,000	.94	440,422,900
Illinois	508,561,350	6.98	6,771,061,400	92.90	8,800,000	.12	7,288,422,750
Indiana	512,375,912	68.62	226,710,088	30.36	7,600,000	1.02	746,686,000
Iowa	184,677,047	36.72	272,239,653	54.13	46,000,000	9.15	502,916,700
Kansas	149,879,866	66.98	73,901,200	33.02			223,781,066
Kentucky	466,912,000	90.20	47,711,000	9.22	3,000,000	.58	517,623,000
Louisiana and Mississippi	23,342,601	9.75	216,000,000	90.25			239,342,601
Maine	129,674,270	76.79	39,200,100	23.21			168,874,370
Maryland and District of Columbia	70,090,400	2.98	2,280,000,000	96.90	3,000,000	.12	2,353,090,400
Massachusetts	1,788,133,565	35.92	3,176,264,381	63.82	12,857,000	.26	4,977,254,946
Michigan	536,570,736	61.56	321,285,967	36.87	13,660,830	1.57	871,517,533
Minnesota and Nebraska	178,599,000	29.87	406,593,324	68.00	12,730,000	2.13	597,922,324
Missouri	1,131,978,890	48.59	1,187,524,000	50.98	10,000,000	.43	2,329,502,890
Montana and New Mexico	42,584,900	100.00					42,584,900
Nevada	6,939,900	100.00					6,939,900
New Hampshire	125,419,893	60.80	75,250,607	36.48	5,616,783	2.72	206,287,283
New Jersey	239,909,555	9.52	2,250,817,200	89.28	30,266,700	1.20	2,520,993,455
New York	4,035,178,038	40.12	6,001,855,280	59.67	21,330,000	.21	10,058,363,318
North and South Carolina	109,113,500	71.45	35,807,000	23.44	7,798,000	5.11	152,718,500
North Dakota, Utah, and Wyoming	26,520,000	49.55	27,000,000	50.45			53,520,000
Ohio	2,935,993,358	84.07	545,847,216	15.63	10,491,000	.30	3,492,331,574
Oregon	38,780,000	51.11	37,092,200	48.89			75,872,200
Pennsylvania	2,867,466,490	48.63	2,935,729,502	49.79	92,968,800	1.58	5,896,164,792
Rhode Island	499,814,400	58.58	353,409,700	41.42			853,224,100
South Dakota			23,564,000	100.00			23,564,000
Tennessee	304,944,820	100.00					304,944,820
Texas	144,970,500	81.73	32,400,000	18.27			177,370,500
Vermont	(a)		38,417,900	93.89	2,500,000	6.11	40,917,900
Virginia	203,564,372	50.11	202,706,800	49.89			406,271,172
Washington	129,688,100	100.00					129,688,100
West Virginia	151,416,900	98.89	1,700,000	1.11			153,116,900
Wisconsin	680,972,900	57.65	495,338,000	41.93	5,000,000	.42	1,181,310,900
Total	19,469,464,957	38.64	30,418,987,448	60.37	497,016,263	.99	50,385,468,668

a Some coal gas produced, but no reports received.

Of the total quantity of gas made, coal gas is 38.64 per cent, water gas 60.37 per cent, and gas from oil, rosin, wood, etc., 0.99 per cent. The table was made from returns received, and from such other data as seemed to be reliable. Some of the States made no returns of any kind of gas except coal gas—e. g., Alabama, Montana and New Mexico, Nevada, Tennessee, and Washington. Arizona returns no coal gas or water gas, and there are no returns of coal gas from Florida and Vermont. South Dakota returns only water gas. In comparison with its total production, excluding the States that returned only coal gas, West Virginia has the highest rank as a producer of coal gas, with 98.89 per cent; then follow Kentucky, Ohio, Texas, Maine, North and South Carolina, Indiana, Kansas, Michigan, New Hampshire, Rhode Island, Wisconsin, Colorado, Oregon, Virginia, etc. Similarly, Maryland and the District of Columbia rank first as producers of water gas, with 96.90 per cent of its total production; then follow Vermont, Illinois, Louisiana, and Mississippi, New Jersey, California, Minnesota and Nebraska, Massachusetts, New York, Arkansas, Iowa, Georgia, Missouri, etc. The rank of the principal States in the production of coal gas, water gas, and gas from oil, rosin, wood, etc., is given in the following table:

Rank of the principal States in the production of the various kinds of manufactured gas, 1898.

Rank.	Coal gas.	Water gas.	Gas from oil, rosin, etc.
1	New York	Illinois	Delaware.
2	Ohio	New York	Pennsylvania.
3	Pennsylvania	Massachusetts	Iowa.
4	Massachusetts	Pennsylvania	Connecticut.
5	Missouri	Maryland and District of Columbia.	New Jersey.
6	Wisconsin	California	California.
7	Michigan	Missouri	New York.
8	Indiana	Ohio	Michigan.
9	Illinois	Wisconsin	Massachusetts.
10	Rhode Island	Connecticut	Minnesota and Nebraska.
11	Kentucky	Minnesota and Nebraska	Ohio.
12	Connecticut	Rhode Island	Missouri.
13	Tennessee	Michigan	Illinois.
14	California	Iowa	Indiana.

The following table gives the highest and lowest net price per 1,000 cubic feet of the illuminating and fuel gas sold in 1898, by States:

Highest and lowest price of illuminating and fuel gas in 1898, by States.

State.	Illuminating (net price per 1,000 cubic feet).			Fuel (net price per 1,000 cubic feet).			Total average.
	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	
Alabama	$2.25	$1.48	$1.737	$1.75	$1.00	$1.332	$1.674
Arkansas	2.00	2.00	2.00	1.50	1.25	1.429	1.886
California	4.00	1.50	2.173	3.00	1.25	1.868	2.117
Colorado	2.75	1.30	1.534	2.00	1.00	1.026	1.407
Connecticut	1.90	1.20	1.338	*a* 1.50	1.00	1.029	1.267
Delaware	1.50	1.00	1.035	1.50	1.00	1.025	1.033
Georgia	2.00	1.00	1.308	1.50	1.00	1.076	1.240
Illinois	2.00	1.00	1.329	2.00	.95	1.162	1.274
Indiana	1.80	1.00	1.352	1.50	.90	1.008	1.283
Iowa	2.50	1.25	1.545	2.00	1.25	1.388	1.499
Kansas	2.00	1.25	1.483	1.75	1.00	1.344	1.454
Kentucky	2.25	1.00	1.370	1.50	.75	.818	1.262
Louisiana and Mississippi	2.35	1.53	1.834	1.80	1.25	1.503	1.774
Maine	2.50	1.125	1.358	1.80	1.125	1.313	1.353
Maryland and District of Columbia	2.00	1.35	1.399	1.50	1.00	1.117	1.382
Massachusetts	2.50	1.00	1.282	2.00	1.00	1.204	1.277
Michigan	1.90	1.00	1.191	1.35	.80	.979	1.114
Minnesota and Nebraska	1.80	1.30	1.399	1.35	1.25	1.325	1.389
Missouri	2.50	1.00	1.063	2.00	.80	.861	.999
Montana and New Mexico	2.50	2.00	2.186	2.00	1.75	1.970	2.120
Nevada	5.00	4.00	4.479	4.00	2.50	2.969	4.451
New Hampshire	1.90	1.40	1.461	*a* 1.90	1.40	1.400	1.458
New Jersey	2.25	1.10	1.593	2.00	1.00	1.417	1.575
New York	2.70	.85	1.158+	2.00	.85	1.146	1.158—
North and South Carolina	1.80	1.60	1.635	*a* 1.50	*a*1.00	1.200	1.543
North Dakota, Utah, and Wyoming	2.50	1.00	1.816	1.40	1.00	1.107	1.557
Ohio	1.75	.80	.961	1.50	.50	.827	.941
Oregon	3.00	1.275	2.280	*a*2.50	1.60	1.623	2.159
Pennsylvania	2.25	1.00	1.0296	1.60	.60	1.021	1.0295
Rhode Island	1.90	1.10	1.182	1.50	1.10	1.106	1.161

a A small amount of gas sold for fuel at this price, quantity not determined, was included with illuminating gas.

Highest and lowest price of illuminating and fuel gas in 1898, by States—Continued.

State.	Illuminating (net price per 1,000 cubic feet).			Fuel (net price per 1,000 cubic feet).			Total average.
	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	
Tennessee	$3.00	$1.15	$1.490	$1.50	$1.00	$1.136	$1.434
Texas	2.50	1.70	2.141	2.00	1.25	1.510	1.898
Virginia	1.75	1.00	1.170	1.50	1.00	1.252	1.171
Washington	3.50	1.75	1.967	2.00	1.00	1.511	1.847
West Virginia	1.60	.75	.823	1.50	1.25	1.279	.830
Wisconsin	2.00	.90	1.090	1.75	.70	.807	.985
Average			1.188			1.0295	1.1666

The highest price obtained for illuminating gas was in Nevada, $5, and the lowest price was in West Virginia, 75 cents. The highest average price was also in Nevada, $4.47, while the lowest average was also in West Virginia, 82.3 cents. The highest price obtained for fuel gas was in Nevada, $4, and the lowest price was in Ohio, 50 cents. The highest average price for fuel gas was also in Nevada, $2.96, and the lowest average was in Wisconsin, 80.7 cents. The average price of illuminating gas was $1.188; of fuel gas, $1.029, making the general average price of all gas sold $1.166.

ASPHALTUM AND BITUMINOUS ROCK.

By EDWARD W. PARKER.

PRODUCTION.

In the preparation of these reports the numerous varieties of bitumens or hydrocarbons occurring in the United States and not discussed in the chapter on petroleum are included under the general head of asphaltum. It has been found advisable, however, to make a distinction, for trade purposes, between the purer forms of hard and soft asphaltum, such as elaterite, gilsonite, albertite, maltha, brea, etc., and the sandstones and limestones impregnated with bitumen and known as bituminous or asphaltic limestone, bituminous sandstone, etc. The latter are usually shipped without being previously treated or refined, are used principally for street paving, and are manipulated and mixed with the other ingredients at the place where they are to be used. This class of bitumens is known to the trade, particularly in California, which yields about 90 per cent of the product, as bituminous rock, and it is so considered in this report. In some cases the asphaltum or bitumen is extracted from the bituminous rock and sold as refined or gum.

The following table shows the annual production of asphaltum and bituminous rock in the United States since 1882:

Production of asphaltum and bituminous rock from 1882 to 1898.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1882	3,000	$10,500	1891	45,054	$242,264
1883	3,000	10,500	1892	87,680	445,375
1884	3,000	10,500	1893	47,779	372,232
1885	3,000	10,500	1894	60,570	353,400
1886	3,500	14,000	1895	68,163	348,281
1887	4,000	16,000	1896	80,503	577,563
1888	50,450	187,500	1897	75,945	664,632
1889	51,735	171,537	1898	76,337	675,649
1890	40,841	190,416			

It will be seen from the foregoing statement that the amount and value of the combined product of asphaltum and bituminous rock in 1898 was not materially different from that of 1897. There were, however, some differences in the quantities, values, and average prices of the several varieties produced in 1898 as compared with 1897. Bituminous rock makes up about 65 per cent of the tonnage, but contributes less than 25 per cent of the value. Most of the bituminous rock comes from California in the shape of bituminous sandstone. Nearly 95 per cent of the bituminous rock product is mined in California, and nearly 90 per cent of this is of the sandstone variety. The total production of bituminous rock in 1898 was 49,126 short tons, of which 43,624 tons were bituminous sandstone. In 1897 the output of bituminous sandstone amounted to 48,801 tons, indicating a decrease in 1898 of about 10 per cent. Compared with the production of 1896 the output in 1898 shows a decrease of 13,347 short tons, or about 23 per cent. In addition to this there was a decided falling off in values, the average price per ton declining from $3.25 in 1897 to $2.91 in 1898, with a total decrease in value of $32,083. The production of bituminous limestone increased from 2,100 short tons in 1897 to 5,502 tons in 1898, and while the total value showed an increase of nearly $16,000 the average price declined from $5 to $4.80. Liquid asphaltum or maltha made up 17 per cent of the total product in 1898 and contributed 40 per cent of the value. Compared with 1897 there was a decrease in output of 1,775 short tons, or 12 per cent, a loss of $40,350 in value, and a decline of 20 cents in the average price per ton. The production of crude asphaltum, exclusive of gilsonite from Colorado and Utah, and "Ventura," hard asphaltum from California, amounted to 11,300 tons, nearly double the output of 1897, while the value increased from $71,404 to $179,900, or more than 150 per cent. The output of hard and refined asphaltum decreased from 3,940 short tons in 1897 to 1,878 short tons in 1898, the decrease being due to partial suspension of operations on gilsonite properties in Utah. The value decreased less in proportion from $102,500 to $53,666, the average price per ton showing an advance of 10 per cent from $26 in 1897 to $28.58 in 1898. The amount of asphaltum sold in the form of mastic in 1898 was 1,158 short tons, valued at $17,840, or $15.40 per ton, against 483 short tons, worth $9,864, or a little over $20 per ton in 1897, and 100 tons at $9 per ton in 1896. From the foregoing it is seen that there was an advance in price for refined and crude hard asphaltum, and a decline in the price of all other varieties. In spite of this, the total increase in value in 1898 was a little larger in proportion than the increase in product, and the general average price per ton increased 1 per cent.

The following table exhibits the production and value of the several kinds of asphaltum and asphaltum products in 1896, 1897, and 1898. Both the amounts and value are for the product in the condition in which it was first sold.

Varieties of asphaltum, etc., produced in 1896, 1897, and 1898.

Variety.	1896.		1897.		1898.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Crude asphaltum	6,500	$78,000	5,971	$71,404	11,300	$179,900
Bituminous sandstone	56,971	170,913	48,801	158,914	43,624	126,831
Bituminous limestone (*a*)	4,300	21,500	2,100	10,600	5,502	26,412
Mastic	100	900	483	9,864	1,158	17,840
Hard and refined or gum (*b*)	3,122	92,240	3,940	102,500	1,878	53,666
Liquid or maltha	9,510	214,010	14,650	311,350	12,875	271,000
Total	80,503	577,563	75,945	664,632	76,337	675,649

a Not including mastic or refined asphaltum made from bituminous limestone.
b Including gilsonite and Ventura.

PRODUCTION BY STATES.

Five States and one Territory contributed to the asphaltum production in 1898. These were California, Colorado, Kentucky, Texas, Utah, and the Indian Territory. California is by far the most important producer, 93 per cent of the total product in 1898 being from that State. About 65 per cent of the amount, but only 23 per cent of the value, is represented by the production of bituminous rock. Hard asphaltum constitutes 17 per cent of the quantity and 30 per cent of the value. Eighteen per cent of the product and 45 per cent of the value was made up by liquid asphaltum or maltha, and the other 1 per cent of product and 2 per cent of the value was of mastic. The output from Colorado and Utah was chiefly gilsonite, about 80 per cent of the product of those two States being of this variety. The remaining 20 per cent was asphaltic limestone. The product of the Indian Territory is bituminous limestone. Kentucky's product is entirely of bituminous sandstone, and this variety constituted the small output obtained from Texas in 1898. The "litho-carbon" properties, upon which operations were suspended in 1896, remained inactive during 1898. It is reported that operations are to be resumed during the current year.

In the following table will be found the amount and value of the asphaltum production during the past five years, by States:

Production of asphaltum since 1894, by States.

State.	1894.		1895.		1896.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
California	51, 187	$251, 991	64, 046	$284, 086	74, 471	$492, 663
Kentucky	5, 383	21, 409	2, 359	11, 795	....	....
Indian Territory, Oklahoma, and Texas	*a* 3, 000	45, 000	*a* 1, 058	29, 900	*b* 2, 862	35, 220
Colorado and Utah	1, 000	35, 000	700	22, 500	3, 170	49, 680
Total	60, 570	353, 400	68, 163	348, 281	80, 503	577, 563

State.	1897.		1898.	
	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*	
California	68, 650	$598, 502	71, 086	$605, 451
Kentucky	3, 250	15, 150	1, 450	7, 800
Indian Territory, Oklahoma, and Texas	345	3, 480	*b* 1, 635	7, 952
Colorado and Utah	3, 700	47, 500	2, 166	54, 446
Total	75, 945	664, 632	76, 337	675, 649

a Texas only. *b* Indian Territory and Texas.

CALIFORNIA.

For several years the production of asphaltum and bituminous rock in California has represented practically 90 per cent of the entire output of the United States. Owing to the large amount of the bituminous rock produced in the State, and the comparatively higher value of gilsonite produced in Colorado and Utah, the percentage of the value of California's product is slightly smaller, averaging about 85 per cent of the total.

There are six counties in the State in which asphaltum or bituminous rock is mined—Kern, Monterey, San Luis Obispo, Santa Barbara, Santa Cruz, and Ventura. They are all in the southern half of the State, and all except Kern County border on the ocean, and in some cases the asphaltum deposits are close to the shore, so that the product can be loaded into vessels directly from the mine. Hard asphaltum is produced in Santa Barbara and Ventura counties. Liquid asphaltum, or maltha, is produced in Santa Barbara and Kern counties; and the product from the other three counties is bituminous rock. The liquid asphaltum is used as a flux in reducing the harder varieties to the proper consistency for cementing purposes. For this purpose it is claimed to be superior to coal tar and petroleum residuum.

The production of asphaltum, or more correctly speaking bituminous rock, on a commercial scale in California began in 1888. It was exclusively bituminous sandstone and was used entirely for street paving. As is often the case with new enterprises, the bituminous rock business in California in the first two or three years was overdone. The production jumped from practically nothing in 1887 to 49,300 short tons in 1888, and was nearly as large (47,968 tons) in 1889. There was no market ready to absorb so large an output. The product was intended to be used as a paving material, and conditions were not ripe for so radical a change from old methods and materials. The change had to come as a process of evolution, not revolution. Moreover, inexperience in the preparation of the material and in laying it upon the streets led to unsatisfactory results and the collapse of several companies engaged in the business. Consequently production fell off until in 1892 the output of bituminous rock was about one-half of that of 1889. In this year (1892) the production of hard asphaltum and maltha was reported for the first time, the former with an output of 6,250 short tons and the latter with 1,300 short tons, making the total product for the year 31,550 short tons, which was, notwithstanding the additional products, less than that of any year from 1888 to 1898.

More intelligent study as to the methods of treating the crude materials and mixing them with proper proportions and qualities of fluxes, sand, etc., preparing the foundation and base, and spreading the pavements have reestablished the industry on a firmer basis. Since 1894 the production of bituminous rock has averaged nearly 50,000 short tons a year, while the increasing production of the more valuable hard and liquid asphaltums have steadily increased the total value until in 1898 it was 2.4 times the value in 1894 and about four times that of 1888, although the total output in 1898 exceeded that of the other two years by only 40 per cent.

In the statistics of production since 1888, presented in the following table, it will be observed, the largest total output was in 1896, due to unusual activity in the mining of bituminous rock, while in 1898 the combined production of maltha and hard asphaltum, being the largest on record, made the total value for that year the largest also.

Annual production of asphaltum, etc., in California since 1888.

Year.	Bituminous rock.	Hard asphaltum.	Maltha.	Total.	Total value.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	
1888	49,300			49,300	$152,500
1889	47,968			47,968	126,885
1890				(*a*)	(*a*)
1891	39,962			39,962	154,164
1892	24,000	6,250	1,300	31,550	188,350
1893	33,000	*b*9,650		42,650	275,662
1894	45,397	*b*5,790		51,187	251,991
1895	51,921	8,375	3,750	64,046	284,086
1896	56,971	*c*8,000	9,500	74,471	492,663
1897	45,426	*d*8,454	14,650	68,650	598,502
1898	46,094	*d*12,142	12,850	71,086	605,451

a Not reported by States.
b Includes maltha or liquid asphaltum.
c Includes hard crude asphaltum and refined gum.
d Includes hard asphaltum, mastic, and gum.

KENTUCKY.

Two counties in Kentucky are credited with asphaltum production in 1898 as in 1897—Breckinridge and Logan. Grayson County has produced some in former years, but the deposits have not been worked for the last three years. The entire output is of bituminous sandstone, and its production has been comparatively small and irregular. Bituminous sandstone is reported as occurring in Butler, Carter, Warren, and Edmonson counties, but the deposits have not been developed.

No production was reported from any of the Kentucky deposits in 1896. The first product from the State was reported in 1891, since which time the output has been as follows:

Annual production of bituminous sandstone in Kentucky from 1891 to 1898.

Year.	Quantity.	Value.
	Short tons.	
1891	3,000	$6,000
1892	2,680	10,525
1893	1,929	6,570
1894	5,383	21,409
1895	2,359	11,795
1896	None.	None.
1897	3,250	15,150
1898	1,450	7,800

COLORADO AND UTAH.

The production of asphaltum in these two States is combined in these reports for two reasons: First, in order to maintain the confidential nature of individual statements; second, because the gilsonite product of Colorado is from an extension eastward, into Rio Blanco County of that State, of the gilsonite deposits in the Uncompahgre Indian Reservation, Uinta County, Utah. Gilsonite is also mined in Wasatch County, Utah, and asphaltic limestone is produced in Utah County. The gilsonite deposits have been fully described in previous volumes of Mineral Resources and in a report by Mr. George H. Eldridge in Part I of the Seventeenth Annual Report of the Survey. Production in 1898 shows a decrease of 42 per cent in amount, due to the partial suspension of mining operations pending the determination by the Indian Office and the parties at interest as to the boundary of the Uintah Indian Reservation.

Annual production of asphaltum, etc., in Utah since 1891.

Year.	Quantity.	Value.
	Short tons.	
1891	1,732	$82,100
1892	2,700	93,500
1893	*a* 3,200	90,000
1894	1,000	35,000
1895	700	22,500
1896	*b* 3,170	49,680
1897	*b* 3,700	47,500
1898	*b* 2,166	54,446

a Including 100 tons of ozocerite. *b* Including Colorado gilsonite.

RESULTS OF AN INVESTIGATION OF NIGRITE FROM UTAH.

During the last year Dr. William C. Day, of Swarthmore College, Pennsylvania, has continued his investigations of natural asphalts, with interesting results pertaining to a solid asphalt from Utah known as nigrite on account of its intensely black color. The following is a brief summary of the facts ascertained in this work.

OCCURRENCE.

The specimen investigated was furnished by Mr. C. A. Peterson, of St. Louis, who suggested the name "nigrite." He says:

The deposit lies in a fissure vein about 5 miles north of east from Soldier Summit, and bears no relation, geologically or otherwise, to the small deposits of ozocerite at and near Soldier Summit.

This mineral which I have chosen to call nigrite is deposited similarly to gilsonite and wurtzilite, but has none of the vulcanite qualities of the latter nor the pitchy, easy-fluxing character of the former.

The sample investigated was in the form of a black brittle mass showing both conchoidal and angular fracture. It pulverized easily to a black, highly glistening powder, thus differing from gilsonite and some other varieties of asphalt which give brown powders.

SPECIFIC GRAVITY.

The results of two determinations made by the Jolly balance at 17° C. gave 1.095 and 1.099.

CHEMICAL ANALYSIS AND SOLUBILITY.

Percentage of volatile matter, fixed carbon, and ash.

	Volatile matter.	Fixed Carbon.	Ash.
No. 1			0.12
No. 2	63.12	36.73	
No. 3	63.94	35.83	

Determinations of carbon, hydrogen, nitrogen, and sulphur.

	Carbon.	Hydrogen.	Nitrogen.	Sulphur.
No. 1	83.43	8.78	1.73	0.434
No. 2	83.23	8.61	1.73	.412

Summary of analytical results.

	Per cent.
Carbon	83.33
Hydrogen	8.69
Nitrogen	1.73
Sulphur	.42
Ash	.12
Oxygen (by difference)	5.71
Total	100.00

Solubilities in various solvents.

	Per cent.
Carbon bisulphide	21.28
Turpentine	5.82
Ether	6.15
Alcohol	.40
Gasoline	.48

DISTILLATION OF NIGRITE.

A quantity of nigrite was heated in a retort over free flame. The first effect was to soften the material, but not at any one time to melt it entirely. Water was soon given off, followed by a thick white smoke, while a thick brownish-yellow oil condensed in the receiver. A little later the oily distillate ceased to be liquid, but condensed in the condenser tube as a vaseline-like semisolid that would just barely flow. During the distillation the contents of the retort swelled up, nearly overflowing. The semisolid mass remaining in the condenser tube dissolved easily in ether, giving a red solution with strong green fluorescence. The oil which condensed in the receiver also showed green fluorescence.

DISCUSSION OF RESULTS.

Nigrite is peculiar in a number of respects. It possesses in greater or less degree the properties of the asphalts, but it is unique in giving a perfectly black streak, while other asphalts black in lump form give brown streaks. Its solubility in the solvents customarily employed with asphalts is low. It can not be entirely melted. While the distillation products are not easily volatile, the amount of volatile matter as compared with fixed carbon is high; nearly two-thirds of the material is volatilized by heating. This proportion of volatile matter is higher than that of some other asphalts whose volatile matter is of lower boiling point, or which are, in other words, more volatile.

The solubility of nigrite is low throughout. The residue left by the evaporation of the carbon bisulphide solution has an intensely black, lustrous surface, and melts at a comparatively high point.

The general character of nigrite suggests the idea that it was formed by distillation; that is, by the passage of steam through an oil, thus depriving it of the most volatile constituents, while subsequent direct heating of the residue converted it into the nigrite as found.

To test this idea the following experiment was carried out: A quantity of oil that had been obtained by the distillation of wood and fish, as in the process of making artificial asphalt,[1] was placed in a flask with water and distilled by passing steam through it. A quantity of oil was thus distilled off. This oil at first showed a lemon color, which afterward changed to a dark wine color. When all oil volatile with steam had been thus distilled off, the oil remaining undistilled had become heavier than water, though at the beginning it had floated upon the surface. This oil was dried as well as possible over chloride of calcium, and then subjected by itself to direct distillation. In this but little oil came over below 180° C. The largest yield of oil was obtained in the fourth fraction between the limits 245° and 315° C. The sixth fraction (distilling above 340° C.) was very thick.

[1] See American Chemical Journal, Vol. XXI, No. 6, p. 478.

The liquid residue was allowed to cool, when it solidified, giving a black material which, like nigrite, gave a perfectly black streak and showed the same kind of fracture and the same brittleness. Like the nigrite, it would not melt entirely on being heated again, but softened and conducted itself in much the same way as nigrite, yielding the same kind of thick, sirupy distillate.

It is believed that the differences between nigrite and gilsonite are due to the differences in their mode of formation rather than to differences in the organic material from which they may have been distilled.

INDIAN TERRITORY.

Considerable attention is being paid to the asphaltum deposits near Dougherty, in the Indian Territory. The first mines were opened in 1897, producing 540 short tons of bituminous limestone and sandstone. Of this product, 100 short tons were sold crude, 80 tons were sold as mastic, and 340 tons were used in the production of 40 tons of gum. In 1898 the marketed product consisted of 1,087 short tons of crude rock, 443 tons of mastic, and 25 tons maltha or brea.

TEXAS.

The "litho-carbon" property at Cline, Uvalde County, which has been in the hands of a receiver since 1896, was not operated in either 1897 or 1898. The only product from the State in the last two years, 65 tons in 1897 and 80 tons in 1898, was mined by the St. Jo Asphaltum Company in Montague County.

MISSOURI.

Liquid asphaltum is reported to have been discovered in the vicinity of Higginsville, Missouri, but no product had been obtained up to the close of 1898.

MONTANA.

Asphaltum has been found in Montana in the Flathead Valley, near Columbia Falls, and in the valley of the North Fork of the Flathead River, near the international boundary line, where it is associated with petroleum. At the first locality the material is not in place, but occurs as large rounded bowlders or blocks embedded in gravel and drift of glacial origin. Though not of commercial importance, this occurrence shows that large bodies of the material exist in the unexplored mountain region to the north, from which the glacial drift has been derived. The material is an impure wurtzilite or allied mineral, cuts like horn or rubber, can be lighted with a match, burns with a smoky flame, and is of sufficient purity for commercial use.

Little is known of the North Fork deposits. The petroleum comes from the coal-bearing series of Cretaceous rocks occurring in trough folds in the older rocks, the springs being mostly seepages through alluvial gravels. The asphalt samples from here are of excellent quality, and if found in quantity would prove of great value.

IMPORTS.

The United States draws its chief supply of foreign asphaltum from the island of Trinidad, off the coast of Venezuela, the exports from Trinidad to the United States during the last five years averaging about the same as the domestic production. In addition to the Trinidad asphaltum, we import some from Bermudez in Venezuela, Neufchatel and Val de Travers in Switzerland, Seysel in France, Germany, Cuba, and Mexico, and small amounts from other countries.

The following table shows the imports of crude asphaltum since 1867:

Crude asphaltum imported into the United States from 1867 to 1898.

Year ending—	Quantity.	Value.	Year ending—	Quantity.	Value.
	Long tons.			*Long tons.*	
June 30, 1867..	....	$6,268	June 30, 1883..	33,116	$149,999
1868..	185	5,632	1884..	36,078	145,571
1869..	203	10,559	1885..	18,407	88,087
1870..	488	13,072	Dec. 31, 1886..	32,565	108,528
1871..	1,301	14,760	1887..	30,808	95,735
1872..	1,474	35,533	1888..	36,494	84,045
1873..	2,314	38,298	1889..	61,952	138,163
1874..	1,183	17,710	1890..	73,861	223,368
1875..	1,171	26,006	1891..	102,433	299,350
1876..	807	23,818	1892..	120,255	336,868
1877..	4,532	36,550	1893..	74,774	196,314
1878..	5,476	35,932	1894..	102,505	313,680
1879..	8,084	39,635	*a* 1895..	79,557	210,556
1880..	11,830	87,889	*a* 1896..	96,192	304,596
1881..	12,883	95,410	*a* 1897..	115,528	392,770
1882..	15,015	102,698	*b* 1898..	69,857	203,385

a In addition to the crude asphaltum imported in 1895 there was some manufactured or refined gum asphaltum, valued at $36,664. In 1896 the value of the manufactured asphaltum imported was $77,449 and in 1897, $25,095. The quantity was not reported.

b Includes 3,069 long tons, "dried or advanced," valued at $17,005.

The following statement shows the amount and value of the asphaltum imported during the fiscal years ending June 30, 1897 and 1898, with the countries from which it was exported. The amount credited to Italy in 1897 is probably wholly or in part from Switzerland and shipped from an Italian seaport.

Imports of asphaltum during the fiscal years 1897 and 1898, with the countries from which exported.

Country.	1897.		1898.	
	Quantity.	Value.	Quantity.	Value.
West Indies:	*Long tons.*		*Long tons.*	
British (Trinidad)	85,034	$198,786	71,992	$217,660
Danish	400	2,000	....	....
Spanish (Cuba)	223	4,180	137	2,172
Switzerland	....	....	98	530
Italy	(*a*)14,581	(*a*) 77,456	1,260	7,531
Venezuela (Bermudez)	13,807	75,943	2,000	10,006
Germany	6,896	25,986	2,302	9,066
France	861	3,327	779	3,377
Mexico	273	3,992	438	5,773
Turkey in Asia	31	3,439	41	3,744
Great Britain	11	309	13	597
United States of Colombia	3	130	....	9
Canada	2	6	....	....
Total	122,122	395,554	79,060	260,765

a Probably including Switzerland.

PRODUCTION IN OTHER COUNTRIES.

TRINIDAD.

The island of Trinidad, off the coast of Venezuela, South America, one of the British West Indian possessions, is, next to France, the largest producer of asphaltum in the world.[1] The deposits are operated by an American corporation under a concession from the British Government and, independently, from land not belonging to the Crown and which was acquired by purchase. The chief source of the supply is a lake of pitch filling the crater of an extinct volcano. This lake lies 138

[1] The French asphaltum is in reality a bituminous limestone of which the bitumen contents average only about 14 per cent. Trinidad lake asphaltum, on the other hand, averages approximately 55 per cent bitumen. The product of France in 1897 was 257,127 short tons, of which the bitumen contents were about 38,000 short tons. The shipments of lake asphaltum in crude and crude equivalent from Trinidad in the same year amounted to 109,243 long tons, or 122,350 short tons, of which the bitumen contents, reckoned at 55 per cent, would be about 67,400 short tons. It will be seen from this that while France produced the largest amount in crude, Trinidad is the leader of the world in the bitumen contents of its product.

feet above sea level and has an area of 114 acres. The supply is being constantly renewed by a flow of soft pitch into the center of the lake from a subterranean source, but not in proportion to the amount drawn from it. The shipments of lake pitch for the last ten years have averaged over 80,000 tons per year. The flow into the lake is at the rate of about 20,000 tons per year, so that the renewal of supply is less than one-fourth the amount taken out. The depth of the lake, however, is about 135 feet at the center, and considering the extent of the deposit, there need be little apprehension of the early exhaustion of asphaltum. The material from this lake is known as "lake pitch." Distinctive from this is what is known as "land pitch," the overflow in past times of pitch from the lake, and deposits of similar nature but different origin. The overflow pitch mingled with the soil, and while it, with the other land deposits, forms another source of supply, the amount of mineral matter it contains is greater than the lake pitch, and the latter is in consequence preferred.

Mr. O. E. Thurber, treasurer of the Trinidad Asphalt Company, of New York City, has kindly furnished the following statements showing the exports of Pitch Lake asphaltum from 1881 to 1898; also the exports of land asphaltum from 1886 to 1898, and the total exports of all asphaltum (stated in tons of crude or equivalent) from 1886 to 1898. It will be noticed in the following tables that the total exports of asphaltum from Trinidad in 1898 were about 23,000 tons less than in 1897. There are two reasons assigned for this diminution: (1), the large shipments of asphaltum from Trinidad to the United States in the early part of 1897, made in anticipation of the Dingley tariff law, by reason of which larger stocks of material on hand were carried forward to and used in 1898; (2), owing to the readjustment of the finances in the new city of New York little asphalt paving was done in the boroughs of Manhattan and Brooklyn. The decreased amount of asphalt paving in New York City in 1898 as compared with 1897 would more than account for the decreased exports of Trinidad asphaltum.

Notwithstanding the decreases in 1898 as compared with 1897, the figures show that the shipments in 1898 were well up to the average for the last five years.

The shipments of Trinidad asphaltum to countries other than the United States and Europe have been so comparatively insignificant that they have been included under one caption.

Exports of Pitch Lake asphaltum from Trinidad, 1881 to 1898, inclusive.

Year.	To United States.			To Europe.			To other countries.			Grand total of exports in crude equivalent.
	Crude.	Dried.	Total equivalent in crude.	Crude.	Épuré and dried.	Total equivalent in crude.	Crude.	Épuré and dried.	Total equivalent in crude.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1881........	5,600	....	5,600	10,656	6,174	19,917	....	....	....	25,517
1882........	12,710	....	12,710	24.712	12,007	42,722	....	....	....	55,432
1883........	22,885	....	22,885	11,744	4,668	18,746	....	....	....	41,631
1884........	17,885	....	17,885	15,910	6,561	25,751	....	....	....	43,636
1885........	15,505	....	15,505	12,135	7,636	23,589	....	....	....	39,094
1886........	22,225	....	22,225	5,130	5,394	13,221	....	....	....	35,446
1887........	21,915	....	21,915	10,205	5,771	18,861	....	....	....	40,776
1888........	24,321	....	24,321	8,445	8,248	20,817	....	....	....	45,138
1889........	45,410	....	45,410	9,378	9,581	23,750	....	....	....	69,160
1890........	39,907	....	39,907	11,755	9,951	26,681	668	....	*a* 668	67,256
1891........	52,510	....	52,510	9,984	9,969	24,937	901	....	*a* 901	78,348
1892........	70,806	....	70,806	11,596	9,458	25,783	1,076	....	*a* 1,076	97,665
1893........	65,436	....	65,436	10,640	6,650	20,615	....	....	....	86,051
1894........	71,860	....	71,860	8,967	9,413	23,086	....	....	....	94,946
1895........	61,702	2,256	64,976	5,058	7,365	16,104	....	....	....	81,080
1896........	60,637	....	60,637	8,320	8,052	20,391	....	1,300	*b* 1,918	82,946
1897........	71,969	1,769	74,407	14,629	13,510	34,856	....	500	680	109,243
1898........	46,089	1,692	48,423	15,703	13,228	35,537	*a* 693	*b* 1,646	2,999	86,959

a Australia. *b* Argentina and Mexico.

Exports of land asphaltum from Trinidad, 1886 to 1898, inclusive.

Year.	To United States.			To Europe.			To other countries.			Grand total of exports in crude equivalent.
	Crude.	Épuré.	Total equivalent in crude.	Crude.	Épuré.	Total equivalent in crude.	Crude.	Épuré.	Total equivalent in crude.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1886........	2,297	....	2,297	....	....	....	....	....	....	2,297
1887........	1,195	2,100	4,345	220	....	220	....	....	....	4,565
1888........	5,316	1,536	7,620	619	....	619	....	....	....	8,239
1889........	10,490	2,052	13,568	....	....	....	833	....	*a* 833	14,401
1890........	15,406	1,341	17,417	....	....	....	....	....	....	17,417
1891........	20,507	7	20,517	139	....	139	40	....	*b* 40	20,696
1892........	17,406	....	17,406	699	....	699	....	....	....	18,105
1893........	3,450	....	3,450	2,432	1,862	5,225	110	178	*b* 377	9,052
1894........	3,365	325	3,853	2,200	4,699	9,249	13	94	*b* 154	13,256
1895........	4,445	199	4,744	1,770	2,368	5,322	....	169	*b* 254	10,320
1896........	11,943	71	12,049	842	1,988	3,824	....	....	....	15,873
1897........	19,243	....	19,243	293	700	1,343	415	178	682	21,268
1898........	18,160	....	18,160	700	258	1,087	404	312	872	20,119

a Australia. *b* Canada, Venezuela, and West Indies.

Total exports of all asphaltum from Trinidad, 1886 to 1898, inclusive.

Year.	To United States.			To Europe.			To other countries.			Grand total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1886	22,225	2,297	24,522	13,221		13,221				37,743
1887	21,915	4,345	26,260	18,861	220	19,081				45,341
1888	24,321	7,620	31,941	20,817	619	21,436				53,377
1889	45,410	13,568	58,978	23,750		23,750		833	833	83,561
1890	39,907	17,417	57,324	26,681		26,681	668		668	84,673
1891	52,510	20,517	73,027	24,937	139	25,076	901	40	941	99,044
1892	70,806	17,406	88,212	25,783	699	26,482	1,076		1,076	115,770
1893	65,436	3,450	68,886	20,615	5,225	25,840		377	377	95,103
1894	71,860	3,853	75,713	23,086	9,249	32,335		154	154	108,202
1895	64,976	4,744	69,720	16,104	5,322	21,426		254	254	91,400
1896	60,637	12,049	72,686	20,391	3,824	24,215	1,918		1,918	98,819
1897	74,407	19,243	93,650	34,856	1,343	36,199	680	682	1,362	130,511
1898	48,423	18,160	66,583	35,537	1,087	36,624	2,999	872	3,871	107,078

FRANCE.

The Statistique de l'Industrie Minérale gives the following as the output of asphaltum in France for six years, with the value of the product. For convenience and for comparison the quantities are expressed in metric tons and short tons, and the value both in francs and dollars:

Production of asphaltum in France from 1892 to 1897, inclusive.

Year.	Production.		Value.	
	Metric tons.	Short tons.	Francs.	Dollars.
1892	224,000	246,848	1,678,000	323,854
1893	222,000	244,644	1,612,000	311,116
1894	231,000	254,562	1,758,000	339,294
1895	267,000	294,234	1,843,000	355,700
1896	226,000	249,052	1,741,000	336,013
1897	233,328	257,127	1,699,492	328,002

It would appear from the foregoing statement that France is the leading country of the world in the production of asphaltum. It must be remembered, however, that the French product is entirely bituminous limestone, of which the bitumen contents are only 14 per cent. As explained in the footnote to the discussion of Trinidad production, the amount of bitumen in the Trinidad lake-pitch product in 1897 was about 50 per cent more than that of the bitumen contents of the French output, although the French product of crude was more than double that of the lake and land pitch product of Trinidad combined.

GERMANY.

The production of asphaltum in the German Empire for the years 1886 to 1897, according to the official report Die Bergwerke, Salinen und Hütten im Deutschen Reich und Luxemburg, is shown in the following table. Metric tons are converted into short tons, and marks into dollars.

Production of asphaltum in Germany from 1886 to 1897, inclusive.

Year.	Production.		Value.	
	Metric tons.	Short tons.	Marks.	Dollars.
1886	42,894	47,270	216,075	51,426
1887	34,483	38,000	186,125	44,298
1888	41,534	45,770	255,250	60,749
1889	43,496	47,933	325,246	77,408
1890	51,144	56,361	377,987	89,961
1891	49,150	54,163	375,712	89,419
1892	53,279	58,713	418,850	99,686
1893	47,238	52,056	356,982	84,962
1894	55,981	61,691	451,049	107,350
1895	59,563	65,638	454,424	108,153
1896	61,552	67,830	453,394	107,908
1897	61,645	67,933	378,534	91,984

ITALY.

Following Germany in amount of asphaltum produced is Italy, the product for the five years 1893 to 1897, inclusive, being shown in the following table. It will be observed, however, that while the product of Italy in 1897 was about 10 per cent less than that of Germany, the value was about double.

Production of asphaltum in Italy from 1893 to 1897.

Year.	Production.		Value.	
	Metric tons.	Short tons.	Lire.	Dollars.
1893	25,980	28,630	565,800	109,200
1894	60,493	66,663	1,403,390	270,854
1895	46,713	51,478	1,023,751	197,584
1896	45,456	50,092	888,638	171,507
1897	55,339	60,984	948,273	183,017

PRODUCTION OF OZOCERITE IN GALICIA.

The production of ozocerite, or mineral wax, in Galicia, Austria, for six years, as near as can be ascertained, has been as follows:

Production of ozocerite in Galicia from 1891 to 1896.

Year.	Metric tons.	Short tons.
1891	6,158.6	6,787.0
1892	5,637.6	6,213.0
1893	5,624.8	6,198.5
1894	6,743.1	7,431.0
1895	6,644.5	7,322.0
1896	7,210.0	7,945.0

SUMMARY OF WORLD'S PRODUCTION SINCE 1890.

The following table exhibits, in convenient form for comparison, the production of asphaltum in the principal producing countries, for such years as it can be obtained since 1890. In addition to the production given in this table, Russia is credited with an output of 16,640 metric tons in 1893 and 16,067 metric tons in 1894. Mexico is said to have produced some asphaltum in 1894–95, having a value of $3,751, but the quantity was not stated. The United States imported 438 long tons from Mexico in the fiscal year 1898. We also imported 13,807 long tons from Venezuela in 1897 and 2,000 tons in 1898. We imported 400 long tons from Danish West Indies in 1897, but none in 1898. Small amounts are imported from Cuba, Turkey in Asia, Great Britain, Canada, and Colombia, but no statistics of the total production in these countries are available. The quantities in the following table have been reduced to short tons of 2,000 pounds:

Production of asphaltum in principal producing countries since 1890.

Year.	United States.		Trinidad.		Germany.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
1890	40,841	$190,416	94,834	$254,019	59,361	$89,961
1891	45,054	242,264	110,929	297,132	54,163	89,419
1892	87,680	445,375	129,438	347,310	58,713	99,686
1893	47,779	372,232	106,515	285,309	52,056	84,962
1894	60,570	353,400	121,186	324,606	61,691	107,350
1895	68,163	348,281	102,368	274,200	65,638	108,153
1896	80,503	577,563	110,667	296,457	67,830	107,908
1897	75,945	664,632	146,172	292,344	67,933	91,984

Production of asphaltum in principal producing countries since 1890—Continued.

Year.	France.		Italy.		Spain.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
1890........	198, 934	$335, 092	49, 728	$232, 351	47	$94
1891........	278, 316	402, 631	31, 054	131, 028	274	505
1892........	246, 848	323, 854	38, 107	162, 308	554	1, 014
1893........	244, 644	311, 116	28, 630	109, 200	904	1, 235
1894........	254, 562	339, 294	66, 663	270, 854	1, 085	1, 939
1895........	294, 234	355, 700	51, 478	197, 584	870	1, 525
1896........	249, 052	336, 013	50, 092	171, 507	1, 231	2, 156
1897........	257, 127	328, 002	60, 984	183, 017	1, 825	3, 196

STONE.

By WILLIAM C. DAY.

INTRODUCTION.

The data included in this report are obtained almost without exception from the individual quarrymen of the United States. Their replies are so complete and comprehensive that it is almost entirely unnecessary to make any estimates or approximations whatever. The totals given are the results of simply adding the figures returned in reply to direct inquiries. The report, therefore, could not be written until all of these replies were received and tabulated. It is hence evident that the more promptly these replies are made the sooner the results can be tabulated and the complete report written. Most of the replies are returned with very gratifying promptness, but in the case of a few what seems to be unnecessary delay retards the completion of the report. It is therefore hoped that in the future those who have needed second and sometimes even third reminders will in the interest of prompt publication make an effort to avoid unnecessary delay in making their returns.

For several years past efforts have been made to collect results of scientific, physical, and chemical tests of stone. A considerable mass of material has accumulated, and instead of scattering these results through various parts of the report, as heretofore, it has been thought wise to condense them, in so far as possible, in tabular form, thus bringing the figures relating to different products so closely together that they may be readily compared. While it may seem that a rather large mass of material has been thus acquired, it will be found on inspection that in reality comparatively little has been done. These results will be found at the end of the present report, and it is hoped that the number may be increased materially in the course of a year or two.

ACKNOWLEDGMENTS.

While the individual returns from quarrymen constitute the most important source of information used in this report, the following technical journals have been consulted, and the value of information obtained

from them is hereby acknowledged: Stone, of New York; The Monumental News, of Chicago; The Granite Cutters' Journal, of Baltimore; The Stone Trade News, of Concord, New Hampshire; The Mining Industry and Review, of Denver, Colorado, and The Journal of the Franklin Institute, of Philadelphia.

In addition to these there are many other technical papers which have been of occasional assistance. Special acknowledgments for use of publications in the above and other journals are made in the proper places in this report.

VALUE OF STONE PRODUCED IN 1897 AND 1898.

The following table shows the value of the different kinds of stone produced in the United States during the years 1897 and 1898:

Value of different kinds of stone produced in the United States during the years 1897 and 1898.

Kind.	1897.	1898.
Granite	$8,905,075	*a* $9,324,406
Marble	3,870,584	3,629,940
Slate	3,524,614	3,723,540
Sandstone	4,065,445	4,724,412
Limestone	14,804,933	16,039,056
Bluestone	*b* 900,000	*b* 1,000,000
Total	36,070,651	38,441,354

a Includes trap rock valued at $927,961. *b* Estimated.

This table shows a gain in the value of the output of each kind of stone except marble. For some months after the middle of April, 1898, production declined very decidedly in almost all of the producing regions, particularly in New England. This was, of course, quite largely the effect of the war. During the fall a very noticeable revival in activity of production took place generally, December being perhaps the most active month of the year in many places. The early part of the present year has shown an activity which has not been paralleled since 1892. It does not seem at all hazardous to predict for 1899 a year of gratifying prosperity.

VALUE OF STONE PRODUCT IN 1898, BY STATES.

The following table shows the value of the various kinds of stone produced in 1898, by States:

Value of various kinds of stone produced in 1898, by States.

State.	Granite.	Sandstone.	Slate.	Marble.	Limestone.	Total.
Alabama		$27,882			$242,295	$270,177
Arizona		57,444			1,782	59,226
Arkansas		24,825			54,373	79,198
California	$247,429	358,908	$2,700	$40,200	229,729	878,966
Colorado	25,923	89,637			109,310	224,870
Connecticut	682,768	215,733			142,057	1,040,558
Delaware	677,754					677,754
Florida					91,330	91,330
Georgia	339,311		13,125	656,808	57,803	1,067,047
Idaho				4,400	3,080	7,480
Illinois		13,757			1,421,072	1,434,829
Indiana		45,342			1,686,572	1,731,914
Iowa		7,102			524,546	531,648
Kansas		19,528			305,605	325,133
Kentucky		72,525			83,960	156,485
Louisiana		200,500				200,500
Maine	1,032,621		199,237		1,283,468	2,515,326
Maryland	317,258	13,646	82,240	120,525	433,653	967,322
Massachusetts	1,650,508	91,287	958	38,210	174,822	1,955,785
Michigan		222,376			271,523	493,899
Minnesota	79,309	175,810	400		345,685	601,204
Missouri	78,423	48,795			735,275	862,493
Montana		3,683			63,196	66,879
Nebraska					78,493	78,493
New Hampshire	683,595					683,595
New Jersey	753,513	257,217	800		146,611	1,158,141
New Mexico		3,500				3,500
New York	516,847	566,133	48,694	342,072	1,533,936	3,007,682
North Carolina	79,969	9,100			1,605	90,674
Ohio		1,494,746			1,673,160	3,167,906
Oklahoma					3,000	3,000
Oregon		7,864			7,480	15,344
Pennsylvania	237,780	478,451	2,491,756	39,373	2,746,256	5,993,616
Rhode Island	320,242				10,215	330,457
South Carolina	169,518				34,000	203,518
South Dakota	17,443	9,000			26,858	53,301
Tennessee				316,814	182,402	499,216
Texas	4,685	77,190			70,321	152,196
Utah	3,545	15,752			11,721	31,018
Vermont	1,084,218		732,684	2,067,938	174,150	4,058,990
Virginia	136,180		150,946		182,852	469,978
Washington	9,700	15,575		3,600	140,239	169,114
West Virginia		14,381			56,167	70,548
Wisconsin	175,867	80,341			698,454	954,662
Wyoming		6,382				6,382
Total	9,324,406	4,724,412	3,723,540	3,629,940	16,039,056	37,441,354
Bluestone (*a*)						1,000,000
Grand total						38,441,354

a Estimated.

GRANITE.

The following table shows the value of the granite output by States:

Value of granite product, by States, in 1898.

State.	Value.	State.	Value.
California	$247,429	North Carolina	$79,969
Colorado	25,923	Pennsylvania	237,780
Connecticut	682,768	Rhode Island	320,242
Delaware	677,754	South Carolina	169,518
Georgia	339,311	South Dakota	17,443
Maine	1,032,621	Texas	4,685
Maryland	317,258	Utah	3,545
Massachusetts	1,650,508	Vermont	1,084,218
Minnesota	79,309	Virginia	136,180
Missouri	78,423	Washington	9,700
New Hampshire	683,595	Wisconsin	175,867
New Jersey	753,513	Total	9,324,406
New York	516,847		

The total value of the granite output for 1898 amounted to $9,324,406. This represents a decided gain over the last two years. This is due chiefly to increases in Connecticut, Delaware, New Hampshire, New Jersey, New York, and Vermont. In all States indications for increased business in 1899 are unquestionably good, as shown by much greater activity all over the country in the latter part of 1898 and the early part of the succeeding year. There will doubtless be larger gains in 1899 than for the last five years in most of the producing States.

The following table shows the value of the granite production in 1898, by States and uses:

VALUE OF GRANITE, BY STATES AND USES, IN 1898.

State.	Sold in rough.	Dressed for building purposes.	Dressed for monumental work.	Made into paving blocks.
California	$18,340	$33,143	$24,922	$46,103
Colorado	17,173	6,800	100	1,850
Connecticut	60,750	75,235	84,839	26,244
Delaware	1,758	1,314	600	13,171
Georgia	38,255	67,909	21,775	92,550
Maine	242,834	380,970	84,426	212,109
Maryland	87,760	65,602	10,500	33,341
Massachusetts	393,331	*a*543,213	203,487	127,483
Minnesota	10,626	18,846	29,557	10,800

a Includes $45,100 for bridge work.

Value of Granite, by States and uses, in 1898—Continued.

State.	Sold in rough.	Dressed for building purposes.	Dressed for monumental work.	Made into paving blocks.
Missouri	$8,610	$7,329	....	$29,805
New Hampshire	162,916	193,162	$247,642	47,650
New Jersey	61,546	35,218	400	77,579
New York	30,875	159,700	46,303	6,372
North Carolina	3,795	53,130	1,168	2,120
Pennsylvania	57,640	13,327	179	30,245
Rhode Island	43,505	40,987	204,739	19,510
South Carolina	5,773	28,800	13,090	8,409
South Dakota	2,925	9,432	....	4,600
Texas	3,570	789	....	....
Utah	3,293	152	100	....
Vermont	531,634	113,922	416,878	4,446
Virginia	27,251	12,000	15,200	14,641
Washington	8,500	....	....	1,200
Wisconsin	4,205	12,000	56,696	43,923
Total	1,826,865	1,874,980	1,462,598	854,151

State.	Curbing.	Crushed for roads.	Riprap.	Total.
California	$18,259	$104,217	$2,445	$247,429
Colorado	....	....	....	25,923
Connecticut	10,925	130,976	293,799	682,768
Delaware	4,299	30,417	626,195	677,754
Georgia	67,492	32,500	18,830	339,311
Maine	94,074	3,545	14,663	1,032,621
Maryland	27,747	83,888	8,420	317,258
Massachusetts	245,134	81,071	54,789	1,650,508
Minnesota	8,257	1,000	223	79,309
Missouri	23,921	4,900	3,858	78,423
New Hampshire	20,554	8,690	2,981	683,595
New Jersey	....	575,818	2,952	753,513
New York	1,231	270,962	1,407	516,847
North Carolina	17,050	2,400	306	79,969
Pennsylvania	17,218	117,262	1,909	237,780
Rhode Island	3,488	1,920	6,093	320,242
South Carolina	630	23,441	89,375	169,518
South Dakota	336	....	150	17,443
Texas	135	191	....	4,685
Utah	....	....	....	3,545
Vermont	12,134	5,204	....	1,084,218
Virginia	5,533	60,500	1,055	136,180
Washington	....	....	....	9,700
Wisconsin	4,990	54,023	30	175,867
Total	583,407	*a*1,592,925	1,129,480	9,324,406

a Includes $901,487 crushed trap rock, chiefly from New Jersey, New York, and Pennsylvania.

The following table shows a decline in the value of the output of paving blocks. This branch of the granite industry does not seem to be reviving.

Value of granite paving blocks made in 1897 and 1898, by States.

State.	1897.	1898.
California	$32,264	$46,103
Colorado		1,850
Connecticut	76,760	26,244
Delaware	7,073	13,171
Georgia	295,005	92,550
Maine	172,637	212,109
Maryland	3,328	33,341
Massachusetts	243,750	127,483
Minnesota		10,800
Missouri	47,646	29,805
New Hampshire	26,177	47,650
New Jersey	24,006	77,579
New York	26,900	6,372
North Carolina		2,120
Pennsylvania	11,708	30,245
Rhode Island	51,646	19,510
South Carolina	4,643	8,409
South Dakota	40,030	4,600
Vermont	16,770	4,446
Virginia	20,247	14,641
Washington	1,000	1,200
Wisconsin	38,827	43,923
Total	1,140,417	854,151

For the first time in these reports on stone, trap rock has been tabulated by itself. The value of this rock for road work and its increasing production for this purpose have made this separate showing desirable.

Value of trap rock produced in the United States in 1898, by States, and uses.

State.	Rough.	Crushed for roads or ballast.	Other purposes.	Total.
California		$50,346		$50,346
Connecticut		76,838	$661	77,499
Massachusetts		36,861		36,861
New Jersey	$14,871	414,654	2,732	432,257
New York		210,700		210,700
Pennsylvania	8,160	112,088	50	120,298
Total	23,031	901,487	3,443	927,961

VALUE OF THE GRANITE PRODUCT, BY STATES, FROM 1890 TO 1898.

The following table gives the value of the granite output, by States, for the years 1890 to 1898:

Value of the granite produced by each State, 1890 to 1898.

State.	1890.	1891.	1892.	1893.
Arkansas	(a)	$65,000	$40,000	....
California	$1,329,018	1,300,000	1,000,000	$531,322
Colorado	314,673	300,000	100,000	77,182
Connecticut	1,061,202	1,167,000	700,000	652,459
Delaware	211,194	210,000	250,000	215,964
Georgia	752,481	790,000	700,000	476,387
Idaho	....	....	....	....
Maine	2,225,839	2,200,000	2,300,000	1,274,954
Maryland	447,489	450,000	450,000	260,855
Massachusetts	2,503,503	2,600,000	2,200,000	1,631,204
Minnesota	356,782	....	360,000	270,296
Missouri	500,642	400,000	325,000	388,803
Montana	(a)	51,000	36,000	1,000
Nevada	(a)	....	....	3,000
New Hampshire	727,531	750,000	725,000	442,424
New Jersey	425,673	400,000	400,000	373,147
New York	222,773	225,000	200,000	181,449
North Carolina	146,627	....	150,000	122,707
Oregon	44,150	3,000	6,000	11,255
Pennsylvania	623,252	575,000	550,000	206,493
Rhode Island	931,216	750,000	600,000	509,799
South Carolina	47,614	50,000	60,000	95,443
South Dakota	304,673	100,000	50,000	27,828
Texas	22,550	75,000	50,000	38,991
Utah	8,700	....	15,000	590
Vermont	581,870	700,000	675,000	778,459
Virginia	332,548	300,000	300,000	103,703
Washington	(a)	....	....	....
Wisconsin	266,095	406,000	400,000	133,220
Total	14,464,095	13,867,000	12,642,000	8,808,934

a Granite valued at $76,000 was produced in Arkansas, Montana, Nevada, and Washington together, and this amount is included in the total.

Value of the granite produced by each State, 1890 to 1898—Continued.

State.	1894.	1895.	1896.	1897.	1898.
Arkansas	$28,100				
California	307,000	$348,806	$215,883	$167,518	$247,429
Colorado	49,302	35,000	36,517	44,284	25,923
Connecticut	504,390	779,361	794,325	616,215	682,768
Delaware	173,805	73,138	67,775	272,469	677,754
Georgia	511,804	508,481	274,734	436,000	339,311
Idaho		14,560	3,037	1,900	
Maine	1,551,036	1,400,000	1,195,491	1,115,327	1,032,621
Maryland	308,966	276,020	251,108	247,948	317,258
Massachusetts	1,994,830	1,918,894	1,656,973	1,736,069	1,650,508
Minnesota	153,936	148,596	155,297	92,412	79,309
Missouri	98,757	128,987	107,710	97,857	78,423
Montana	5,800				
Nevada	1,600	3,200	1,250	3,050	
New Hampshire	724,702	480,000	497,966	641,691	683,595
New Jersey	310,965	151,343	204,323	561,782	753,513
New York	140,618	68,474	161,167	422,216	516,847
North Carolina	108,993	75,000	40,017	59,236	79,969
Oregon	4,993	1,728	2,449	1,125	
Pennsylvania	600,000	300,000	159,317	349,947	237,780
Rhode Island	1,211,439	968,473	746,277	629,564	320,242
South Carolina	45,899	22,083	55,320	37,820	169,518
South Dakota	8,806	33,279	199,977	68,961	17,443
Texas				3,500	4,685
Utah			886	3,854	3,545
Vermont	893,956	1,007,718	895,516	1,074,300	1,084,218
Virginia	123,361	70,426	95,040	88,096	136,180
Washington				5,800	9,700
Wisconsin	166,098	80,761	126,639	126,134	175,867
Total	10,029,156	8,894,328	7,944,994	8,905,075	9,324,406

An inspection of this table shows a decline for Maine, which was probably due—in part, at least—to the uncertainties attendant upon the war with Spain. The same general idea perhaps accounts for the slight falling off in Massachusetts. The most important granite quarries in both these States are on or near the coast.

Quite decided gains are evident for Delaware, New Hampshire, New Jersey, New York, and Vermont.

The gain in Delaware is accounted for by the production of large quantities of stone for the Delaware breakwater.

In New Jersey the production of trap rock was unusually active.

One of the most interesting features revealed by this table is that Vermont now stands second as a granite-producing State. This place in the list has heretofore been held by Maine. It is not likely, however, that Vermont will continue to hold this place uninterruptedly when conditions become entirely normal. There has been quite a falling off in Rhode Island during the past year, but the depression in this State is doubtless only temporary, and 1899 will show decided gains.

THE GRANITE INDUSTRY IN INDIVIDUAL STATES.

CALIFORNIA.

In spite of the business depression consequent upon the partial failure of both fruit and grain crops in various sections the granite industry increased in magnitude to the extent shown by the valuations, $167,518 and $247,429 for the years 1897 and 1898, respectively.

Much of this increase was due to greater activity in road and street improvement. Considerable stone was crushed for roads. Basalt, rather than granite proper, constitutes quite an item in the total.

Indications for 1899 are favorable.

COLORADO.

Business in Colorado in 1898 was not as good as in 1897; the value of the product in 1897 was $44,284; in 1898, $25,923. Conditions for 1899 are somewhat doubtful.

CONNECTICUT.

The value of the output increased from $616,215 in 1897 to $682,768 in 1898. An important item in the totals for both years is the stone quarried and used for breakwater construction. Included also in the total valuation is $77,499 as the value of trap rock produced during the year.

Almost all of the producers appear to be encouraged as to the future outlook.

DELAWARE.

The rather startling increase from a valuation of $272,469 in 1897 to $677,754 in 1898 was due to largely augmented operations in the production of breakwater stone.

GEORGIA.

The value of the output in 1897 was $436,000; in 1898, $339,311. Although there has been a decline in activity of production, this does not seem likely to continue, as indications for increased output in 1899 are good.

MAINE.

Production in Maine is almost the same in value for 1897; the figures for 1897 and 1898 were, respectively, $1,115,327 and $1,032,621. Quite a number of the smaller operators suspended work, but some of the firms who quarried throughout the year report decided improvement over 1897. Prices seem to have been somewhat lower than in 1897. Indications in the early part of 1899 were good for markedly increased volume of business in 1899, although it does not seem likely that prices will very materially increase during the year.

MARYLAND.

The value of the output in 1897 was $247,948, while in 1898 the corresponding total was $317,258. Although there was an increase in output, there was some complaint of dull business among a number of the producers. The increase in output was due to larger business on the part of a few of the active concerns.

MASSACHUSETTS.

The value of the granite output falls slightly below the figure for 1897; the two values are $1,736,069 and $1,650,508. The production of building granite seems to have been more active than that of monumental stock. Indications for 1899 are good all over the State; reports for the early part of the year have a decidedly different tone from those of the past three or four years.

MINNESOTA.

Granite quarrying has not been very actively prosecuted for several years in Minnesota. The value of the output in 1898 shows a falling off as compared with 1897, but there are indications of improvement in volume of business for 1899. The figures for the two years were $92,412 and $79,309.

MISSOURI.

As in many other States, there was decided improvement in the granite business toward the end of 1898. On the whole, however, the value of the output fell behind that of 1897. The values for the two years were $97,857 and $78,423.

NEW HAMPSHIRE.

Granite production in New Hampshire since 1895 seems to have taken a turn in the direction of steady improvement. This is true of a number of producing regions in the State, and the industry bids fair to reach the magnitude of 1891 in the course of a year or two. The resources of the State in both building and monumental stock are varied and abundant. The value of the output in 1897 was $641,691, while in 1898 the corresponding figure was $683,595.

NEW JERSEY.

In the production of crystalline siliceous rocks New Jersey has made a decided upward stride in the past year. The value of the output in 1897 was $561,782, while in 1898 it was $753,513. Of this figure $432,257 represent the value of trap rock, largely consumed as crushed stone for road purposes. The tendency of prices for crushed trap rock has been downward, but the volume of business has been steadily increasing. The use of harder material in the construction of the hopper of the stone crusher has resulted in lowering the cost of crushing. The superiority of trap rock for use on roads seems to be much more generally appreciated than formerly. Some of the New Jersey trap rock crushes at over 37,000 pounds to the square inch.

NEW YORK.

The value of the granite product in New York increased from $422,216 in 1897 to $516,847 in 1898. Somewhat less than one-half of the total value is that of trap rock for road purposes; this is being more and more demanded as the crushed stone for the roads of the State. The outlook for 1899 is much better than for several years past.

NORTH CAROLINA.

The value of the output in 1897 was $59,236 and in 1898 $79,969. A granite which seems to be growing in popularity as curbing material is quarried in Rowan County, near the town of Faith. Mount Airy granite is also becoming widely known through the South as both a building and monumental material. It has been shipped as far north as Pittsburg and has also been used in buildings in Philadelphia and Baltimore.

PENNSYLVANIA.

Production of granite in Pennsylvania has been somewhat irregular since 1890, when the value of the output was $623,252. In 1897 the value was $349,947 and in 1898 $237,780. While comparatively little monumental granite is quarried in the State, there is an abundance of good granite for building and road purposes. Indications for 1899 are uniformly good, judging from the much greater activity in a number of localities in the latter part of 1898 and the early part of the present year.

RHODE ISLAND.

Rhode Island has for many years held a very prominent position among granite-producing States for the superiority of the granite for the finest public monuments. The stone which has been most effective in winning this reputation for the State is that quarried at Westerly and in that vicinity. Previous reports, particularly that for 1897, have set forth the excellencies of this granite for monumental work.

There was quite a decline in demand for some months after the middle of April, 1898, but in December a marked change for the better took place, giving much encouragement to some of the leading producers as to the probable output in 1899.

As a whole, the year 1898 fell behind 1897. The value of the output in the former year was $629,564, in the latter $320,242.

SOUTH CAROLINA.

Very much improved conditions as to demand are reported from a number of the leading producers for the year 1898. Prices, however, have not increased, and in some sections a falling off in this respect is reported.

The value of the product increased from $37,820 in 1897 to $169,518 in 1898.

SOUTH DAKOTA.

A decline in the output of a few of the leading producers caused a falling off in the total output from $68,961 in 1897 to $17,443 in 1898.

TEXAS.

But little was done in the way of granite production during the year. No very satisfactory indications as to the prospects for 1899 are at hand.

UTAH.

Although there is no dearth of valuable granite in Utah, there has never yet been a large output in the State.

VERMONT.

The history of the granite industry in Vermont for the past five years has been one of almost uninterrupted progress, so that the records of 1898 place Vermont in second position among the granite-producing States of the Union. This success has been due largely to the operations at Barre, where the stone quarried has made a national reputation as a monumental product. At this place all conditions seem to favor the economical production of monumental stock upon the large scale. Barre quarrymen seem to have been well able to stand the depression in prices for monumental stone which has characterized the past few years all over the country.

It is reported that the formation of a granite trust at Barre, which was extensively discussed in 1897, has been recently effected. An effort will be made to prevent the sale of anything but worthy material, thus protecting the reputation of the stone.

The value of the product in 1898 reached the highest figure yet attained, namely, $1,084,218; the figure for 1897 was $1,074,300.

VIRGINIA.

The value of the output in 1898 was $136,180, a notable gain as compared with 1897. Reports from the various producers indicate unusually bright prospects for 1899.

WASHINGTON.

Not much has ever been done in Washington in the way of granite quarrying, but in the last two years operations which bid fair to be permanent have been undertaken. The value of the output in 1898 was $9,700.

WISCONSIN.

The value of the granite output in 1897 was $126,134, and in 1898, $175,867. A decided gain is evident, and, furthermore, the indications for 1899 are better than for three or four years past. There is an abundance of fine granite in the State, as was well shown at the World's Fair.

MARBLE.

The following table shows the value of the output of marble in the United States for the year 1898, by States:

Value of marble product in 1898, by States.

State.	Value.	State.	Value.
California	$40,200	Pennsylvania	$39,378
Georgia	656,808	Tennessee	316,814
Idaho	4,400	Vermont	2,067,938
Maryland	120,525	Washington	3,600
Massachusetts	38,210	Total	3,629,940
New York	342,072		

The value of the output of marble in 1898 falls somewhat behind that of 1897, but, judging from the improvement which took place in the latter part of the year, the volume of business in 1899 will undoubtedly exceed that of either of the two preceding years. For cemetery work the output of 1898 exceeds that of 1897, but for other purposes there has been a falling off.

The following table shows the various uses to which the marble quarried in 1896, 1897, and 1898 was put:

Distribution and value of output in 1896; 1897, and 1898 among various uses.

	1896.	1897.	1898.
Sold by producers in rough state	$583, 690	$477, 856	$690, 240
Sold for outside building	1, 036, 163	1, 074, 646	968, 353
Ornamental purposes	65, 365	9, 010	23, 904
Cemetery work (monuments and tombstones)	813, 146	1, 547, 469	1, 613, 742
Interior decoration in buildings	329, 804	576, 983	304, 714
Other scattering uses	30, 968	184, 620	28, 987
Total	2, 859, 136	3, 870, 584	3, 629, 940

VALUE OF MARBLE PRODUCT BY STATES.

The following table shows the purposes for which the marble of the various productive States was sold by the quarrymen in 1896, 1897, and 1898:

Value of the marble product, by uses and States, in 1896, 1897, and 1898.

State.	Rough.	Building.	Ornamental.	Cemetery.	Interior.	Other.	Total.
1896.							
California	$4, 000						$4, 000
Georgia	171, 644	$258, 886		$98, 200	$63, 650	$25, 000	617, 380
Idaho	1, 500			4, 000			5, 500
Iowa	23, 460	10, 080	$6, 200				39, 740
Maryland		109, 000			1, 000		110, 000
Massachusetts	14, 763	56, 641		8, 000	3, 000	1, 500	83, 904
New York	69, 072	365, 737		41, 682	4, 471	3, 198	484, 160
Pennsylvania	3, 022	28, 500					31, 522
Tennessee	190, 103				190, 000	1, 270	381, 373
Vermont	106, 126	207, 319	59, 165	661, 264	67, 683		1, 101, 557
Total	583, 690	1, 036, 163	65, 365	813, 146	329, 804	30, 968	2, 859, 136
1897.							
California	8, 280	2, 625	4, 960	3, 015	27, 310	2, 500	48, 690
Colorado					82, 000	17, 600	99, 600
Georgia	198, 198	145, 875		157, 803	71, 200	25, 000	598, 076
Idaho				4, 500	500		5, 000
Maryland		130, 000					130, 000
Massachusetts	1, 026	58, 608	306	2, 300	16, 481	1, 000	79, 721
New York	11, 066	274, 626		61, 631	5, 308	2, 000	354, 631
Pennsylvania		56, 000		6, 683			62, 683
Tennessee	147, 679	4, 000		15, 625	259, 025	15, 625	441, 954
Vermont	111, 607	402, 912	3, 744	1, 295, 912	115, 159	120, 895	2, 050, 229
Total	477, 856	1, 074, 646	9, 010	1, 547, 469	576, 983	184, 620	3, 870, 584

Value of the marble product, by uses and States, in 1886, 1897, and 1898—Continued.

State.	Rough.	Building.	Ornamental.	Cemetery.	Interior.	Other.	Total.
1898.							
California	$10,800	$750	$17,100	$1,050	$10,500		$40,200
Georgia	271,723	142,000		147,000	84,700	$11,385	656,808
Idaho	100			4,000	100	200	4,400
Maryland		116,000	625		3,900		120,525
Massachusetts	1,210	25,000			12,000		38,210
New York	54,696	193,464	27	74,990	3,031	15,864	342,072
Pennsylvania	75	38,700		560		38	39,373
Tennessee	239,483	11,000			66,331		316,814
Vermont	108,553	441,439	6,152	1,386,142	124,152	1,500	2,067,938
Washington	3,600						3,600
Total	690,240	968,353	23,904	1,613,742	304,714	28,987	3,629,940

The following table gives the production of marble, by States, for the years 1890 to 1898, both inclusive:

Value of marble, by States, from 1890 to 1898.

State.	1890.	1891.	1892.	1893.
California	$87,030	$100,000	$115,000	$10,000
Georgia	196,250	275,000	280,000	261,666
Idaho				4,500
Maryland	139,816	100,000	105,000	130,000
Massachusetts			100,000	
New York	354,197	390,000	380,000	206,926
Pennsylvania		45,000	50,000	27,000
Tennessee	419,467	400,000	350,000	150,000
Vermont	2,169,560	2,200,000	2,275,000	1,621,000
Scattering	121,850	100,000	50,000	
Total	3,488,170	3,610,000	3,705,000	2,411,092

State.	1894.	1895.	1896.	1897.	1898.
California	$13,420	$22,000	$4,000	$48,690	$40,200
Colorado				99,600	
Georgia	724,385	689,229	617,380	598,076	656,808
Idaho	3,000	2,250	5,500	5,000	4,400
Iowa		13,750	39,740		
Maryland	175,000	145,000	110,000	130,000	120,525
Massachusetts		2,000	83,904	79,721	38,210
New York	501,585	207,828	484,160	354,631	342,072
Pennsylvania	50,000	59,787	31,522	62,683	39,373
Tennessee	231,796	362,277	381,373	441,954	316,814
Vermont	1,500,399	1,321,598	1,101,557	2,050,229	2,067,938
Washington					3,600
Total	3,199,585	2,825,719	2,859,136	3,870,584	3,629,940

The total for 1898 shows a falling off as compared with 1897. Quite a number of the smaller operators have been inactive during 1898; at the same time indications for increased output for the future seem to be unusually good. This is shown by the exceptionally large number of new enterprises which are now just getting under way in a number of States. The tendency toward the use of marble for outside building in Vermont, New York, Pennsylvania, and Tennessee is noticeably greater than heretofore, and doubtless this tendency will show itself in figures in the course of the next few years.

THE MARBLE INDUSTRY IN THE INDIVIDUAL STATES.

CALIFORNIA.

The value of the marble output in 1898 was $40,200, while in 1897 it was $48,000. There are at present more firms irregularly engaged in quarrying marble in California than ever before, but, owing to lack of sufficient capital in some cases and obstacles to transportation in others, not a great deal is now being accomplished, although there is material of high grade in several localities.

A new discovery of marble, said to resemble that from Tennessee, is reported to have been made recently at the headwaters of the Gualala River, 20 miles from the seacoast, to which there is said to be a good road. The owners are Messrs. R. Powell and George Madison.

It is also said that preliminary arrangements are being made to develop this material.

GEORGIA.

The value of the product increased from $598,076 in 1897 to $656,808 in 1898. This indicates that business has quite markedly revived as compared with the condition in the past few years. The product is largely used for building purposes and is shipped over a wide area of the country; the stone is now a familiar one to architects, contractors, and builders, and it is favorably received as a durable as well as hand some stone.

The number of firms operating is greater at present than ever before; some of them have only lately begun operations and have not yet gotten fully under way.

MARYLAND.

The output in 1897 was valued at $130,000; that of 1898 at $120,525. Almost all of the stone goes for building, for which purpose it has been used for many years in Baltimore and to a less extent in other cities. The outlook for 1899 is brighter than for several years past.

MASSACHUSETTS.

While the value of the total output of marble in Massachusetts declined from $79,721 in 1897 to $38,210 in 1898, nevertheless the outlook for future activity is very bright since seven different firms have recently commenced quarrying operations at Adams, Westfield, West Stockbridge, Ashley Falls, Sheffield, and Lee.

Future developments will be awaited with interest.

NEW YORK.

The value of the total output was $354,631 in 1897 and $342,072 in 1898. Two-thirds of the product was used in 1898 for building purposes. Prospects for 1899 seem to be much improved.

PENNSYLVANIA.

While the output of marble in this State has not greatly increased, the prospects for the future are exceedingly good, due largely to the creation of the Pennsylvania Marble and Granite Company, which has bought out the Avondale Marble Company, and is continuing the work already started by the latter firm of establishing at Avondale, Pennsylvania, the most completely equipped marble quarry in the United States. The equipment in the quarry consists partly of steam channelers of the Sullivan and Ingersoll makes, drills, gadders, a derrick of Oregon pine 105 feet 6 inches high, with a 90-foot boom, and capacity of 100 tons, operated in every movement by power, and a complete system of electric lighting for running the channeling machines at night. In the mill plant everything is operated by electrical power. Included in the plant are three of the so-called slide-motion gangs of exceptionally heavy construction, and capable of cutting with crushed steel from 5 inches per hour in the hardest granites to 24 inches in the softer stones. The tooth saw is used, and the plant has also a planer, lathe, traveling crane spanning the whole finishing department, automatic feed pumps, rubbing bed, etc.

A new quarry has been opened recently near Annville, Dauphin County. The product is used both for building and cemetery work.

TENNESSEE.

The value of the output in 1897 was $441,954. There has been quite a decline in 1898. This was due to the temporary cessation of active operations on the part of quite a number of the smaller concerns. These, however, will doubtless resume production in 1899, as indications for improvement were reported as very evident by those who continued in business throughout the year. Building operations are now quite freely undertaken with Tennessee marble as the outside structural material. Formerly interior decoration was the purpose to which most of the output was devoted.

UTAH.

In September, 1898, the Hobble Creek Marble Company, with headquarters at Salt Lake City, Utah, was organized and incorporated to develop marble property at Hobble Creek, in Utah County. The property consists of 840 acres. The stone has already been described in the report for 1896. Abundant water power is at hand so that quarry operations could be economically conducted. The quarry land is about 8 miles from the railway to Springville. The road to the railway is down grade, so that hauling would not necessarily be an unsurmountable obstacle.

VERMONT.

The value of the product in 1897 was $2,050,229, while in 1898 it was $2,067,938, or very nearly the same. About one-half of the product goes for cemetery work. The amount devoted to building is increasing to some extent every year.

ONYX MARBLE.

The literature concerning onyx marble is remarkably scant, and therefore the following extracts are given from a paper by Prof. Courtenay De Kalb, of the University of Missouri, Rolla, Missouri, published in Stone in November, 1898:

A sharp distinction must be drawn between the precious onyx, which is a cryptocrystalline variety of quartz, and the ordinary commercial "onyx," which is a deposit of carbonate of lime from aqueous solution. The true or precious onyx is distinguished arbitrarily from the agates by the perfect parallelism of the color bands, these bands consisting usually of alterations of white and black, white and brown, and white and red. It may be mentioned in passing that such perfect banding is so exceedingly rare that very few if any of the onyxes or cameos sold in our jewelry shops are from naturally colored stones, the artificial coloring of agates being a regular industry in Germany. The method is said to consist in saturating the more porous layers of the banded white or bluish slate-colored agate with honey, and then carbonizing this with sulphuric acid to produce the black and white variety. The red and white is produced by soaking in ferric chloride and precipitating with ammonia.

Characteristics.—The term onyx marble, as applied to calcareous deposits, must be still further limited, since many varieties exist. The general name of travertine will include all such deposits except the finely crystallized minerals calcite and arragonite. The oölites should also be excluded from this classification, although in their manner of formation these more nearly approach the true travertines. The familiar calcitic formations in caves (stalactites, stalagmites, "cave onyxes") may quite properly be classed among the travertines. That which entitles any of these to be called an onyx marble is the accidental circumstance of texture and beauty, fitting it to serve as an ornamental stone in decoration. It is therefore a commercial and not a scientific distinction.

The requisite qualities for a commercial onyx marble are: First, perfect, or nearly perfect, homogeneity of texture; second, absence of subcrystalline structure, so that no tendency to crystallization may be observable by the eye; third, freedom from porosity and cracks (although slight porosity may be corrected by "filling," and cracks, if not so deep and extensive as to weaken the stone, may often be highly colored and produce an acceptable artistic effect); fourth, translucency, the essential characteristic of a high-grade onyx marble, giving a deceptive appearance of "depth;" fifth, beauty of coloring—a matter of taste and fashion, for the most part, although the translucent white, delicate mignonette green, and fine translucent white, with dashes or veinlets of pink, are almost always in demand and bring the highest prices; and sixth, proper size of perfect blocks, the lowest limit for thickness being 1 inch, although slabs three-fourths of an inch thick are sometimes used, with a "backing" of other material, while for superficial area the line is drawn at 1 foot square, although here again smaller sizes, if very fine in color and texture, may be marketed.

The translucent white onyx marbles are very often confounded with and sold under the name of alabaster, the true alabaster being a translucent variety of gypsum, and far less durable, owing to its greater softness, than onyx marble. Again we find in commerce a stone called "agate onyx," which is a variety of onyx marble containing more or less foreign matter, chiefly alumina, and sometimes silica, approaching the agates in appearance, but generally inclining, in part or in whole, towards opacity. While being highly ornamental, particularly in connection with dark wood interior finishing, its application is more limited than that of the finer, translucent varieties.

Price.—Before leaving the commercial side of this matter, a few additional details may prove of some importance. The highest prices are obtained by a combination of desirable physical characters with large size of blocks or slabs. The poorer grades bring sometimes as little as 50 cents per cubic foot; onyx marble, in the rough at least, being invariably sold by this unit of size, whether in blocks or sawed into slabs. From this minimum prices range upward to $50 a cubic foot; and extremely fine blocks, suitable for columns, may command fancy figures, limited only by the size of the purchaser's purse and the vending genius of the dealer. It may be said, however, that the average size of good slabs is only 12 by 14 inches, and that slabs 18 by 36 inches and 2 by 4 feet in size are not uncommon.

Preparation.—The cost of sawing and polishing varies according as the polishing is done by the machine or the hand process. The sawing differs in no wise from that employed with other stones. The machine process is as follows: After being sawed the slabs are placed on a "rubbing bed," which consists of a circular cast-iron plate, from 8 to 15 feet in diameter, the older forms having a circular opening from 1 foot to 18 inches in diameter in the center. The plate is planed to a smooth surface and is mounted upon running gear so that it may revolve in a horizontal plane. Fixed arms, usually four in number, are sustained radially about one-fourth of an inch above the plate, either by an upright passing through the central opening or by a framework overhead (in the case of the newer solid forms of bed). The slabs of stone to be polished are placed upon the bed in front of the arms, and the bed is revolved slowly beneath them in such a direction as to hold them firmly against the arms. An abrading material, such as sand, sometimes mixed with "chilled shot" or crushed steel, with a constant supply of water, is fed upon the plate. If necessary, the stones are weighted to increase the friction. From this rubbing bed the slabs are removed to the emery bed, which is similar to the former, fine emery being used for abrasion. They are then rubbed down by hand with a fine, evenly grained sandstone, commonly called a "Scotch hone," with a sufficient supply of water, and smoothed off with pumice stone and water. The final polish is put on by rubbing the slabs upon a buffing bed, similar in form to the rubbing bed, but covered with a thick, specially prepared felt, upon which a small amount of "putty powder" (oxide of tin) is fed, to give a high gloss. The hand process consists in grinding on the rubbing bed as before, and then rubbing down by hand successively with Nova Scotia "blue stone," "red stone," "Scotch hone," and pumice stone, after which it is glossed with putty powder, or, in the case of cheaper "onyxes" and common marbles, with a mixture of two parts of oxalic acid and one part of tin oxide. This latter finish produces a sort of "skin-coat," which, upon fracture, looks as if the stone had been varnished. The edges of onyx marble tabletops, mantels, etc., are treated in this manner, even when the surface has been polished on machines. The use of common emery with white stones is objectionable, owing to its tendency to discolor them.

Occurrence.—The principal localities in this country where important deposits exist are California, Arizona, and Utah. In California the principal locality is in San Luis Obispo County, near Musick, in the Santa Lucia Mountains. Here the inclosing rock is sandstone, the onyx marble occurring in nearly vertical ledges 16 inches wide. The colors are white, with veins and "clouds" of red and smoky black or blue. Blocks 10 feet square are said to be available. In Solano County deposits occur near Suisun, Vacaville, and elsewhere. In San Bernardino County occurs a light-brown variety, and an emerald-green shade is reported from Siskiyou County, along with others from Soda Springs and Yreka. A ledge 12 feet thick is found 25 miles from Santa Ana, in Los Angeles County, and more or less is known to exist in Kern, Placer, and Tehama counties. Almost without exception, in California, a close connection can be traced between the onyx marble deposits and hot springs, or other mineral deposits known to have resulted from such waters. In Siskiyou County they occur along with hot springs which are depositing both onyx marble and porous travertine. Eruptive rocks also abound in their vicinity. At the Suisun marble quarries is a breccia of shale, sandstone, and volcanic ash, cemented by lime, and traversed by veins and bunches of aragonite (?).

In Arizona quite similar conditions obtain. The chief deposit is on Big Bug Creek, in Yavapai County, 25 miles southeast of Prescott. It is a surface formation, occupying a series of rounded knolls several hundred acres in extent, and is found in layers varying from a fraction of an inch to several inches in thickness, interbedded with a coarse breccia of schistose, granitic, syenitic, and dioritic fragments, cemented together by a sandy calcareous matrix. The country rock is also schistose, granitic, and dioritic. The onyx marble deposits themselves consist of irregular concentric layers, thinning out unevenly, with compact layers, frequently separated by porous ones. The colors vary. Some of the finest reseda green onyx marble in the world comes from these quarries. Their beauty is enhanced often by a peculiar wavy effect of alternating light and dark shades of green, but such colors are rarely uniform throughout large blocks. Amber, ocher yellow, and white masses are found; but the characteristic of these Arizona specimens, which is sure to appear in a slab of any considerable size, is a brilliant ocherous red, running into a perfectly opaque chocolate brown, constituting the variety known as agate onyx. The more highly colored specimens often yield as much as 5 per cent of ferric carbonate. This changes to the hydrated sesquioxide, producing the brown shades and destroying the compact structure of the stone.

At Cave Creek, Arizona, is another deposit of like character, as to formation and colors. One ledge is 10 feet thick, but has been shattered by earth movements. This is on the slope of a low hill, capped with basalt. The country rock consists of schists, with dikes of acid eruptives. Throughout this region are large areas of lava mesa, underlain by volcanic tufa. These yield the calcareous waters, which also contain more or less sodium sulphate. It is also worthy of note that in the Eureka mining district of Arizona there are other deposits of travertine below similar beds of tufa and lava.

Utah is becoming a producer of onyx marble, with prospects of increasing in importance, obtaining the stone from quarries to the west of Utah Lake. Directly above and in contact with the onyx marble is a blue limestone. The deposit rests upon clay, sand, and limestone. There are many evidences of earth movements, and the range in which the deposit occurs abounds in metalliferous veins. Six miles distant there is a hot spring issuing upon the surface at a temperature of 105° F. The predominating color of this onyx marble is orange, but green, pink, lemon, and other shades are procured. Slabs measuring 10 feet 6 inches by 5 feet 8 inches have been taken from these quarries and finished up. Sizes from 12 by 18 inches to 12 by 36 inches can be obtained in considerable quantities. Deposits are also reported from the vicinity of Fillmore, Millard County, ranging in color through lemon, orange, mahogany, and black. The onyx marble occurs mostly associated with limestones and quartzites, along a belt of warm springs, running through Millard, Beaver, and Iron counties. These springs occupy mainly a line of contact with eruptive rocks.

A fibrous, concretionary variety of onyx marble occurs near Rio Puerco, in Valencia County, New Mexico, and a similar deposit is reported from El Paso, Texas. This description would seem to place them among the "cave onyxes," concerning which much is heard in nearly all of the great limestone-bearing States in the Union.

These are merely stalactites and stalagmites, and in some cases masses of compact travertine, forming incrustations upon the walls and floors of caves. One of these deposits is at Eureka Springs, Arkansas, situated in the northeast part of Carroll County, near the Missouri line. A company operating works in Eureka Springs produces mostly small slabs, although mantel facings 12 by 24 inches in size are also worked out. The colors are chiefly white, with occasional tinges of red and pale green, rarely translucent, and often displaying the radiated fibrous structure so common in stalactites and stalagmites. Missouri has also produced small amounts from caves in Crawford and Pulaski counties. Sound blocks of large size, however, are infrequent, and efforts to work these deposits have proved unsuccessful. The colors are white and brown, varying from opaque to subtranslucent. Virginia has also yielded a small amount of this variety of onyx marble, coming from quarries in Rockingham County. This locality, from the insufficient accounts obtainable, would appear to offer peculiarities worthy of further investigation. There is reported to be one considerable mass of compact travertine, covered with débris, in which occur a large number of detached masses of the same material, one of which is of important dimensions, standing nearly vertical. Whether or not this is the result of a collapsed cave remains undetermined. In Missouri some of the largest masses of cave onyx are found thus in the débris of ancient caves which have fallen in. Some of these caves had been of enormous extent, so that deep ravines and very considerable valleys occupy the lines of the ruined caverns. Stalagmitic bosses may be found high up on the hillsides along these ravines, and the "float" abounds in weathered fragments of stalactites, stalagmites, and calcareous incrustations. In the process of weathering, the banded structure of the incrustations becomes very prominent, the more opaque layers projecting boldly, while the clearer layers are worn away, and acquire a chalky appearance in the body of the mass. The Arizona onyx marble weathers similarly, forming a finely striated surface, with the opaque red and brown layers protruding.

By far the most important source of onyx marble in the world to-day is the Republic of Mexico. The old localities are chiefly in the State of Puebla, between Vera Cruz and the city of Mexico. The famous "Pedrara" came from quarries near Tecali, 21 miles from the city of Puebla. Large blocks are no longer available there; but the manufacture of small ornaments by the natives is still an important industry in Puebla. Farther to the southeast, in the district of Tehuacan, is the quarry known as Antigua Salines, where the principal deposits form the face of a hill 250 feet high. Thirty-five miles west of Antigua Salines are the excellent quarries of La Sorpresa and La Mesa, the former yielding a semitranslucent to whitish stone, lacking, however, the brilliancy which distinguishes the product from Antigua Salines. These deposits are either superficial or included between masses of siliceous country rock, in the manner of veins. The old Tecali deposits are largely broken up, occurring in the form of bowlders in a matrix of red clay, overlying conglomerate. The region has been much disturbed by volcanic agencies, and hot springs are abundant.

The largest onyx quarries in the world to-day are those opened in 1892 by the New Pedrara Onyx Company, of New York, in the peninsula of Lower California. They are situated in a desert 40 miles from the Pacific Ocean and 2,300 feet above its level. There are two series of deposits, 3 or 4 miles apart, the larger one showing outcrops over 20 acres. They have been formed in a shallow arroyo, or ravine, between flat-topped ridges of horizontal Cretaceous strata, overlain a few miles distant by basaltic lavas. A writer in the Engineering and Mining Journal says: "Within the arroyo, and immediately under and between the layers of onyx, are soft limestones and conglomerates with lime cement, probably belonging to a series of Tertiary or recent beds deposited in an irregular lake that once filled a great interior valley which occupies the medial portion of the peninsula, parallel with its shores."[1]

[1] Engineering and Mining Journal, Vol. LVI, p. 31, July 8, 1893.

Beneath these Tertiary deposits lie granites and gneiss. The onyx marble was evidently deposited from the waters of warm springs, which extended in a line up and down the arroyo. Three distinct superimposed layers were formed, varying from 20 to 50 inches in thickness, showing that the springs were intermittent, the layers being separated by deposits of gravel cemented by lime.

Onyx marble is also reported from the State of Oaxaca, Mexico, but little is known concerning it.

Other foreign sources are Egypt and Algiers. The Egyptian quarries are at Benisouef, about 62 miles south of Cairo, on the Nile, and at Syout, 166 miles farther south. The stone ranges in color from white to amber-yellow, that from Syout being paler, inclining to gray. The product of both localities is known commercially as alabaster, and is of a very different quality from the Mexican varieties. It is said to be of stalagmitic origin.

The Algerian stone from the quarries of Ain-Tembaleck, near the river Issur, is found in irregular beds from a few inches to nearly 10 feet in thickness. The frequent appearance of a fibrous structure is significant.

Inferior stalagmitic marbles are quarried in many places in Italy, in the Jura Mountains in France, and in the vicinity of Stuttgart, in Germany. The caves of Gibraltar also furnish small masses of a banded brownish stalagmite, which is cut into ornaments for the tourist trade.

From the foregoing summary it appears that the deposits furnishing the superior onyx marble of commerce are found in regions which have been subjected to volcanic disturbance; that they are superficial deposits or vein-like inclosures, not connected in any manner with caves; that they are so frequently associated with active hot springs, or with other deposits manifestly resulting from hot springs, as to lead to a clear presumption that there must be a genetic relation between them and such springs; and, finally, that they occur associated with limestone rocks, or with rocks yielding large percentages of lime, such as diorite (usually 7 to 8 per cent of CaO), syenite (about 4 per cent of CaO), volcanic tufa (4 to 6 per cent of CaO), and dolerite (often as high as 10 to 11 per cent in CaO). It is also to be noted that the cave onyxes are usually either transparent or opaque, and do not exhibit that exquisite translucency recognized as the chief charm of the high-grade onyx marbles which have resulted from hot-spring deposition. The cave onyxes are, moreover, usually fibrous in structure, and are made up of concretionary layers, which can be scaled off like the skin of an onion. These latter peculiarities, however, are less likely to occur in the flat floor deposits of caves, while the concretionary structure is the more common attribute of stalagmites and the fibrous structure of stalactites. The fibrous structure may occur, however, in any situation, and is always perpendicular to the surface of deposition; and where this surface is curved, as in a stalactite or stalagmite, the fiber-like crystals extend from the center radially to the exterior, the axes passing without interruption through successive concentric layers, which may be so loosely adherent as to be split off with a light blow of the hammer.

In their other physical characters no difference seems to exist between cave onyxes and hot-spring onyx marbles. They are all calcites, as appears from their optical properties and their specific gravities, although many writers class them as varieties of aragonite. The distinction, however, is clear, both optically and by density, none of the cave onyxes or true onyx marbles rising as high as 2.9, which is the lowest limit for the density of aragonite. The large number of specimens from caves and hot-spring deposits in all parts of the United States and Mexico which the writer has examined show specific gravities ranging from 2.631 to 2.751. In composition they are exceedingly variable. The cave onyxes usually contain the smallest proportion of impurities, although the floor deposits are often rich in ferric oxide and alumina. Those from Virginia show as much as 2 per cent of magnesia, with small amounts of manganese; and one remarkable sample yielded nearly 2 per cent of lead sulphide and 4.62 per cent of antimony sulphide. A sample of green Arizona onyx marble gave 99.84 per cent of lime carbonate, and mere traces of iron and alumina.

From 2 to 8 per cent of iron and manganese is not uncommon; but, so far, no copper or nickel has been discovered in these stones, according to Professor Merrill.

The circumstances causing the great difference in texture and translucency between the cave onyxes and hot-spring onyx marbles have not yet been fully determined, and there is opportunity for trained observers to render valuable service in this particular. The greater degree of concentration of the hot solutions has been undoubtedly an important factor, and it may have been the determining one. Rapidity of flow also exerts an influence, the greater the velocity the more rapid the deposition, a circumstance first pointed out by Lyell in connection with the travertine deposits. In caves this becomes very conspicuous. On a sloping roof, for example, the stalactites increase in number and size toward the steeper portions, where the flow of the oozing waters is greatest, and incrustations form thickest upon the vertical walls, thinning out upon the floor, unless obstructions favor the building up of ledges, resulting in basins. In such cases the ledge grows upward and outward, but the incrustation again thins out upon the floor beyond, where the flow of the water is checked.

The source of the lime carbonate in cave waters is of course the surrounding limestone, taken up by the feebly solvent vadose circulation. They are consequently weak solutions, whereas the deep-seated plutonic waters, under high pressure and temperature, become highly charged with mineral matters. It is difficult to understand, however, that such waters rising from great depths should be so rich in lime carbonate and yet contain so small a proportion of other ingredients as to deposit onyx marbles running as high as 99 per cent in lime. The question seems a fair one, whether the other mineral matters may not have been deposited from these solutions in the course of their ascent, and whether they may not then have derived their lime carbonate from rocks near the surface. The frequent connection of such deposits with superficial limestones and other highly calciferous rocks tends to confirm this suspicion. That the other mineral matters should have been largely deposited below, leaving the lime carbonate still in solution, appears hardly tenable; for there is good reason to believe that mineral compounds are deposited in the inverse order of their respective heats of formation, or at least that there is an approximation to such an order, and if this be true lime carbonate should be deposited much earlier, and hence lower down, than a large proportion of the other substances which such waters would be expected to carry, its heat of formation being as high as 172.4.

It appears that the formation of the translucent compact variety of travertine, known as onyx marble, is therefore due to exceedingly rapid deposition of lime carbonate from highly concentrated solutions, probably in rapid motion. Absence of pressure seems to be another requisite, judging from the circumstance that deposits of lime carbonate occurring in deep situations, as shown in metalliferous veins, take the form of well-crystallized calcite. Further data concerning the character of the vein-like masses of onyx marble, such as those at Antigua Salines, at a considerable distance below the surface, would be desirable as bearing upon this point. Finally, it may be indicated that, guided by empirical knowledge, prospectors would do well to search for this valuable stone in volcanic regions where hot springs do now, or formerly did, exist in close association with superficial accumulations of limestones, or lime-bearing plutonic and igneous rocks.

MARBLE SLATE.

The following is an article on marble slate from the Bautechnische Zeitung, and translated in Stone for May, 1898.

Belgium exports a sort of black marble which is nothing else than prepared slate. Such black marble can be prepared in the following manner: The slate suitable for this purpose is first polished with a sandstone, so that no visible impression is made on it with the chisel; this is the rough polish. After this it is polished finely with artificial pumice stone and finally finished with extremely light natural pumice stone. The polished surface now presents a velvet-like, soft appearance. It is allowed to dry, and the surface heated thoroughly, whereupon the finely polished surface is impregnated with a heated mixture of oil and fine lampblack. This is allowed to remain for twelve hours. According to whether the slate used is more or less gray, the process is repeated until it loses its gray appearance. Now it is polished thoroughly with emery, which is taken on a linen rag, and finally finished with tin ashes, to which is added some lampblack. After the polishing is finished, wax dissolved in turpentine, to which some lampblack is also added, is spread on, and the polished plate warmed again. It is allowed to remain some time and then rubbed off vigorously with a clean linen rag. The slate thus treated now has a deep black appearance and looks like black marble. The polish is just as durable as the latter. The polished surfaces can be etched, engraved, gilded, and silvered, just as genuine marble.

SLATE.

CONDITION OF TRADE.

The general conditions of the slate industry for the entire country are better on the whole than they were in 1897. The total number of squares of roofing slate produced is less by 89,932 than in 1897, but the value per square has increased from $3.09 to $3.40. This increase in price per square has not been uniform. In some places there has been a decline, undoubtedly due to some extent to unfortunate business methods in competition.

The uses for slate are extending, and the number of important articles of daily use now made from this stone is surprisingly large; the value of milled stock, which includes all forms of finished slate except roofing slate, increased in value from $427,162 in 1897, to $582,150 in 1898.

In the report for 1897 it was predicted that foreign trade, acquired originally as the result of labor troubles in Wales, would be retained as a permanent acquisition after tranquillity had been restored. This has so far been the case, and it still looks as though exports would continue to form an important part of the total trade.

EXPORTS.

The following table shows the ports and customs districts from which and to which slate was exported since 1893. It is evident from the table that a great and sudden increase took place in 1896. The exports for 1896 amounted to $266,385, while those for 1895 amounted to $38,806. In 1897 the value of the exports was more than twice that for 1896, and in 1898 the value rose to $1,370,075, or more than five times the value in 1896. The acquisition of this export trade is an item of special interest in connection with stone, as it is the first significant attempt in this direction:

Exports of slate from United States, showing ports and customs districts from which and to which sent, from 1893 to 1898.

Ports and customs districts.	1893.	1894.	1895.	1896.	1897.	1898.
ROOFING SLATE.						
Baltimore, Maryland				$9,860	$101,581	$170,916
Bangor, Maine		$445		350		
Boston and Charlestown, Massachusetts	$1,086		$443	609	1,020	385
Newport News, Virginia					18,170	65,290
New York, New York	36,306	19,684	31,092	242,559	557,099	986,638
Passamaquoddy, Maine			192		120	
Philadelphia, Pennsylvania				2,300	94,865	136,916
Portland and Falmouth, Maine					270	
Brazos de Santiago, Texas	5					
Corpus Christi, Texas			105	174		1,761
New Orleans, Louisiana		587				
Paso del Norte, Texas		621				
Puget Sound, Washington						22
Buffalo Creek, New York	13,428	13,696	4,748	5,903	2,378	4,141
Champlain, New York	869	1,869	1,961	1,617	613	3,015
Detroit, Michigan			65	2,874	2,427	854
Huron, Michigan	200					
North and South Dakota	94	160				137
Vermont	24	133	200	139	1,569	
Total	52,012	37,195	38,806	266,385	780,112	1,370,075
France				12,000		
Germany			25	910	5,850	82,916
Netherlands					2,087	25
United Kingdom	1,400	4,800	3,000	197,440	695,980	1,213,377
Denmark						8,150
Norway and Sweden						270
Bermuda	1,046	336	1,550	2,312	1,395	157
Dominion of Canada:						
Nova Scotia, New Brunswick, etc	119	445	406	1,278	730	22
Quebec, Ontario, etc	14,615	15,858	6,974	10,533	6,977	8,147
Newfoundland and Labrador	32		13			
Central American States:						
Guatemala						1,755
Honduras		587				
Mexico	22	621	488	821	150	1,872
Miquelon, Langley, etc						35
West Indies:						
British		3,803	4,419	1,159	1,860	2,356
Haiti		330				26
Santo Domingo			10			
Spanish, Cuba		2,643	3,258	90		673
Colombia				259	100	
Guianas:						
British		712	702	440	165	600
Dutch	3,145		340		1,640	1,325
Peru	405					
Uruguay				417		807
China						110
East Indies—British				1,628	810	550
British Australasia	30,362	7,060	17,363	34,970	60,604	44,642
Hawaiian Islands				245	166	
British Africa	866		258	1,883	1,598	2,218
Portuguese Africa						42
Total	52,012	37,195	38,806	266,385	780,112	1,370,075

PRODUCTION.

The following table shows the output of roofing and milled slate in 1898:

Value of slate product in 1898, by States.

State.	Roofing slate.		Other purposes than roofing; value.	Total value.
	Squares.	Value.		
California	400	$2,700	....	$2,700
Georgia	3,450	13,125	....	13,125
Maine	29,834	131,752	$67,485	199,237
Maryland	18,332	80,786	1,454	82,240
Massachusetts	....	....	958	958
Minnesota	100	400	....	400
New Jersey	200	800	....	800
New York	7,160	46,744	1,950	48,694
Pennsylvania	571,256	2,097,735	394,021	2,491,756
Vermont	241,762	612,902	119,782	732,684
Virginia	43,745	142,446	8,500	150,946
Total	916,239	3,129,390	594,150	3,723,540

The following table shows the average value of roofing slate per square since 1890:

Average annual price per square of roofing slate for the entire country.

1890	$3.34	1895	$3.23
1891	3.49	1896	3.36
1892	3.56	1897	3.09
1893	3.55	1898	3.42
1894	3.11		

The average value per square for 1898 is the highest figure reached since 1893. The foreign demand has doubtless had much to do with the rise in value.

The following table shows the value of the production of slate, by States, during the years 1890 to 1898, inclusive:

Value of slate, by States, from 1890 to 1898.

State.	1890.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	3, 104	$18, 089	....	$18, 089
Georgia	3, 050	14, 850	$480	15, 330
Maine	41, 000	201, 500	18, 000	219, 500
Maryland	23, 099	105, 745	4, 263	110, 008
New Jersey	2, 700	9, 675	1, 250	10, 925
New York	16, 767	81, 726	44, 877	126, 603
Pennsylvania	476, 038	1, 641, 003	370, 723	2, 011, 726
Vermont	236, 350	596, 997	245, 016	842, 013
Virginia	30, 457	113, 079	....	113, 079
Other States *a*	3, 060	15, 240	....	15, 240
Total	835, 625	2, 797, 904	684, 609	3, 482, 513

State.	1891.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
Arkansas	120	$480	....	$480
California	4, 000	24, 000	....	24, 000
Georgia	3, 000	13, 500	....	13, 500
Maine	50, 000	250, 000	....	250, 000
Maryland	25, 166	123, 425	$2, 000	125, 425
New Jersey	2, 500	10, 000	....	10, 000
New York	17, 000	136, 000	40, 000	176, 000
Pennsylvania	507, 824	1, 741, 836	401, 069	2, 142, 905
Vermont	247, 643	698, 350	257, 267	955, 617
Virginia	36, 059	127, 819	....	127, 819
Total	893, 312	3, 125, 410	700, 336	3, 825, 746

a Includes Arkansas, Michigan, and Utah.

Value of slate, by States, from 1890 to 1898—Continued.

State.	1892.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	3,500	$21,000		$21,000
Georgia	2,500	10,625		10,625
Maine	50,000	250,000		250,000
Maryland	24,000	114,000	$2,500	116,500
New Jersey	3,000	12,000		12,000
New York	20,000	160,000	50,000	210,000
Pennsylvania	550,000	1,925,000	408,000	2,333,000
Vermont	260,000	754,000	260,000	1,014,000
Virginia	40,000	150,000		150,000
Total	953,000	3,396,625	720,500	4,117,125

State.	1893.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
Georgia	2,500	$11,250		$11,250
Maine	18,184	124,200	$15,000	139,200
Maryland	7,422	37,884		37,884
New Jersey	900	3,653		3,653
New York	69,640	204,776	206	204,982
Pennsylvania	364,051	1,314,451	157,824	1,472,275
Utah	75	450	400	850
Vermont	132,061	407,538	128,194	535,732
Virginia	27,106	104,847	12,500	117,347
Total	621,939	2,209,049	314,124	2,523,173

Value of slate, by States, from 1890 to 1898—Continued.

State.	1894.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	900	$5,850	....	$5,850
Georgia	5,000	22,500	....	22,500
Maine	24,690	123,937	$22,901	146,838
Maryland	39,460	150,568	2,500	153,068
New Jersey	375	1,050	....	1,050
New York	7,955	42,092	2,450	44,542
Pennsylvania	411,550	1,380,430	239,728	1,620,158
Vermont	214,337	455,860	202,307	658,167
Virginia	33,955	118,851	19,300	138,151
Total	738,222	2,301,138	489,186	2,790,324

State.	1895.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	1,500	$10,500	....	$10,500
Georgia	2,500	10,675	....	10,675
Maine	23,774	118,791	$21,363	140,154
Maryland	13,188	59,157	1,200	60,357
New Jersey	200	700	....	700
New York	13,624	90,150	1,725	91,875
Pennsylvania	426,687	1,437,697	210,054	1,647,751
Vermont	221,359	531,482	93,849	625,331
Virginia	27,095	92,357	19,000	111,357
Total	729,927	2,351,509	347,191	2,698,700

Value of slate, by States, from 1890 to 1898—Continued.

State.	1896.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
Georgia	4,597	$20,388	....	$20,388
Maine	23,078	99,831	$24,255	124,086
Maryland	15,557	70,194	1,948	72,142
Massachusetts	....	....	1,200	1,200
New Jersey	200	700	....	700
New York	16,002	78,612	3,880	82,492
Pennsylvania	431,324	1,391,539	334,779	1,726,318
Tennessee	160	640	780	1,420
Vermont	155,523	509,681	99,915	609,596
Virginia	26,863	92,163	15,700	107,863
Total	673,304	2,263,748	482,457	2,746,205

State.	1897.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	1,000	$7,000	....	$7,000
Maine	38,367	161,262	$39,855	201,117
Maryland	11,592	53,049	890	53,939
Minnesota	400	1,000	500	1,500
New Jersey	250	775	....	775
New York	9,197	52,799	1,000	53,799
Pennsylvania	657,692	2,034,958	330,341	2,365,299
Vermont	244,575	656,114	39,701	695,815
Virginia	38,375	130,495	14,875	145,370
Total	1,001,448	3,097,452	427,162	3,524,614

Value of slate, by States, from 1890 to 1898—Continued.

State.	1898.			
	Roofing slate.	Value.	Other purposes than roofing; value.	Total value.
	Squares.			
California	400	$2,700		$2,700
Georgia	3,450	13,125		13,125
Maine	29,834	131,752	$67,485	199,237
Maryland	18,332	80,786	1,454	82,240
Massachusetts			958	958
Minnesota	100	400		400
New Jersey	200	800		800
New York	7,160	46,744	1,950	48,694
Pennsylvania	571,256	2,097,735	394,021	2,491,756
Vermont	241,762	612,902	119,782	732,684
Virginia	43,745	142,446	8,500	150,946
Total	916,239	3,129,390	594,150	3,723,540

THE SLATE INDUSTRY IN INDIVIDUAL STATES.

CALIFORNIA.

While the production of slate in California fell off from a total valuation of $7,000 in 1897 to $2,700 in 1898, it would be a mistake to ascribe the decline to a falling off in demand; it was due rather to a transfer of one of the leading quarries to other hands and a consequent temporary cessation of operations. The statement was made in the case of one of the active operators that a much larger output could have been secured if a greater amount of operating capital had been available during the year. The prospects for 1899 are better than for several years.

GEORGIA.

Although there is an abundance of excellent slate in Georgia, particularly at Rockmart, quarrying operations fluctuate in activity from year to year, so that while in some years almost nothing is accomplished, in others production is quite brisk. In 1896 the value of the entire output was $20,388, while in 1897 very little was quarried. Demand for slate in the South has never yet been very active. The value of the output in 1898 was $13,125.

MAINE.

Production in 1898 amounted to a total valuation of $199,237, or practically the same as in 1897. The product is about equally divided between roofing and milled stock.

The fine quality of Maine slate is well known, and there are at present twice as many producers of it as there were a few years ago.

MARYLAND.

The Maryland slate quarries are near the State line dividing this State from Pennsylvania, and they include most of what is known as the Peach Bottom slate region of York County, Pennsylvania, and Harford County, Maryland. Nearly all the product goes for roofing, and amounted in value in 1898, to $82,240. The figure for 1897 was $53,939.

MASSACHUSETTS.

This State does not regularly produce slate, but, as in the year 1898, occasionally yields a trifling amount. At the present time (March, 1899) there is no quarrying concern in active operation.

NEW JERSEY.

The Pennsylvania slate belt extends just over the line into New Jersey. This fact accounts for a small annual production in this State.

NEW YORK.

New York State furnishes the only cherry red slate quarried in the world. The amount of this exceptional material in New York is not large, and owing to its attractive and unique color it commands the highest price for roofing purposes of any slate in the country. The value of the output in 1898 was $48,694. Since August, 1898, prices declined somewhat.

PENNSYLVANIA.

Two-thirds of the slate output of the United States is taken from quarries in Pennsylvania. The total value of all slate produced in the United States in 1898 was $3,723,540; to this total Pennsylvania contributed $2,491,756. Most of the product goes for roofing, but the value of milled stock is now rapidly increasing. The figure for value of milled stock in 1897 was $330,341; in 1898 it was $394,021. The industry is in a flourishing condition at present, owing in no small degree to the export trade, which began in 1896 and has continued since because of the increasing popularity of American slate abroad. Not only has foreign trade been retained, but the very general opinion expressed by producers is that exports have exceeded former years. Domestic trade has been but little better, although prices have improved on the whole.

VERMONT.

The total value of the product in 1897 was $695,815; in the past year this increased to $732,684. As was also the case among Pennsylvania producers, domestic trade was but little better, while exports were noticeably greater than in 1897. Prices declined somewhat during the year; for the past four years complaints about prices have been prevalent.

VIRGINIA.

The value of the output increased from $145,370 in 1897 to $150,946 in 1898. Most of the product is in the form of roofing slate, although a little milled stock is also turned out. Virginia slate is exported in about the same proportion as the product from Pennsylvania and Vermont.

SLATE BELT OF EASTERN NEW YORK AND WESTERN VERMONT.

The following is an abstract of a paper entitled The Slate Belt of Eastern New York and Western Vermont, by Prof. T. Nelson Dale, published in the Nineteenth Annual Report of the United States Geological Survey, Part III. The paper is a most valuable contribution to the literature of slate from both the scientific and the technological standpoint, and those interested, either specially in the slate of the region discussed or in slate in general, are referred to the complete paper.

In order that quarrymen generally, as well as slate producers, may profit by the economic features of this paper, they are presented here.

LOCATION AND AREA OF THE SLATE BELT.

The slate belt of eastern New York and western Vermont lies between the Taconic range on the east and Lake Champlain and the Hudson on the west, and chiefly between the Hoosic River, one of the eastern tributaries of the Hudson, on the south, and the towns of Benson and Hubbardton, in Vermont, on the north, or between latitudes 42° 58′ and 43° 45′, a stretch of about 55 miles; but slate is said to continue as far north as Cornwall, making an extreme length of 68 miles. As, however, good slate is hardly obtainable south of Shushan and Greenwich, in Washington County, the actual length of the slate belt is about 45 miles. Its width at the north is about 11 miles and at the south about 6 miles, averaging a little over 7 miles. The area in which slate of not a little economic value is known covers, therefore, about 320 square miles, which lie within the counties of Washington, New York, and Rutland, Vermont.

The slates are green of various shades, purple, variegated (that is, mixed green and purple), red, and also black. They are used for roofing and other purposes.

PREVIOUS WORK OF GEOLOGISTS.

Without undertaking to enumerate all the minor papers relating to portions of this region, attention is directed to the following more important and general pieces of work: That of Prof. Ebenezer Emmons and that of Prof. William W. Mather on the geological survey of New York State, published in 1843; that of Messrs. Hitchcock and Hager in their report on the geology of Vermont, published in 1861, which also included a geological map; Logan and Hall's general map of Canada and the northeastern part of the United States, dated 1866, which embodied the results both of the New York State survey and of the explorations of the Canadian survey within the United States; Prof. C. H. Hitchcock's geological map of New Hampshire and Vermont, 1877, in which all previous work in Vermont was correlated; the same author's sections across New Hampshire and Vermont, published in 1884; and finally Mr. C. D. Walcott's map of the Taconic region, published in 1888. Mr. McGee's map of New York State, compiled under the direction of Mr. James Hall in 1894, simply incorporated Mr. Walcott's work and left some doubtful areas blank.

While the presence of the Lower Silurian rocks was early recognized, Cambrian rocks were at first confounded with them. It was not until long after the discovery of an older series that it was placed in its present stratigraphical position in the Lower Cambrian. The work of the early surveys had the merit of covering a large territory in a general way at little expense. Nothing approaching scientific satisfactoriness was done, however, till the publication of Mr. Walcott's paleontological map in 1888, in which Cambrian and Silurian fossil localities were indicated, so that the geological boundaries of previous surveys could be corrected thereby; but even this still lacked an adequate topographical base. In 1893 Kemp and Marsters described the dikes of the Lake Champlain region, and included two of those of the slate belt.[1] As to economic geology, little has been done hitherto beyond the publication of several incomplete analyses of the slates and a few brief references to the slate quarries. These are mostly in the Vermont Survey Report. But the statistics of slate production have been for a number of years systematically collected and published by the Division of Mineral Resources of the United States Geological Survey.

[1] The trap dikes of the Lake Champlain region, by J. F. Kemp and V. F. Marsters: Bull. U. S. Geol. Survey, No. 107.

The following analyses were made by Dr. W. F. Hillebrand of the chemical laboratory of the United States Geological Survey:

THE "SEA-GREEN" ROOFING SLATE.[1]

CHEMICAL ANALYSES.

Constituents.	Specimens.[1]			
	A.	B.	C.	D.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2 (silica)	67.76	62.37	59.84	65.29
TiO_2 (rutile; titanium dioxide)	.71	.74	.74	....
Al_2O_3 (alumina)	14.12	15.43	15.02	....
Fe_2O_3 (ferric oxide)	.81	1.34	1.23	....
FeO (ferrous oxide)	4.71	5.34	4.73	....
MnO (manganese oxide)	.10	.22	.34	....
NiO, CoO (nickel and cobaltous oxide)	Trace?	Trace.	Trace.	....
CaO (lime)	.63	.77	2.20	....
BaO (baryta)	.04	.07	.09	....
MgO (magnesia)	2.38	3.14	3.41	....
K_2O (potassa)	3.52	4.20	4.48	....
Na_2O (soda)	1.30	1.14	1.12	....
Li_2O (lithia)	Str. tr.	Trace.	Str. tr.	....
H_2O (water below 110° C.)	.23	.34	.41	....
H_2O (water above 110° C.)	2.98	3.71	3.44	....
P_2O_5 (phosphoric oxide)	.07	.06	.09	....
CO_2 (carbon dioxide)	.40	.87	2.98	....
FeS_2 (pyrite)	.22	.06	.05	....
SO_3 (sulphuric oxide)	Trace.	Trace.	Trace.	....
C (carbon)	None.	Str. tr.	Trace.	....
Fl (fluorine)	....	....	.11	....
Total	100.07	99.80	100.28	....
S (total sulphur above)	.12	.032	.024	....

A (=D. XIV, 1895, 230a), Rising & Nelson's quarry No. 2, West Pawlet, Vermont; 13-foot bed. B (=D. XIV, 1895, 225f), Griffith & Nathaniel's quarry, 9 miles north of A, South Poultney, Vermont. C (=D. XIV, 1895, 256e), Wm. H. Hughes's quarry No. 10 (Brownell), 2 miles north of A, Pawlet, Vermont. D (=D. XIV, 1895, 35, 1), Auld & Conger's quarry, 8 miles north of A, in Wells, Vermont; 22-foot bed. Determination of silica only. These are all from the West Pawlet and South Poultney belt.

Specific gravity: C, 2.7910; D, 2.7627.

[1]Lower Cambrian, Horizon B, Olenellus zone.

MICROSCOPIC ANALYSIS.

The so-called "sea-green" slate, when freshly quarried, varies from a light gray to a slightly greenish gray. In some beds it is crossed by ribbons (beds) of a dark gray. The fresh cleavage surface has a more or less waxy luster. After a few years of exposure to the atmosphere the color assumes more or less of a yellowish-brown tinge. Cold dilute hydrochloric acid applied to the edge produces a slight effervescence.

Sections transverse to the cleavage show, in ordinary light, a very fine and regular cleavage, sometimes crossed by obscure traces of bedding, angular transparent grains, green (dichroic) scales, minute opaque spherules covered with crystal points, and from 0.003 to 0.02 mm. in diameter, which, under incident light, glisten like pyrite, some irregular opaque grains, dull yellowish under incident light, and of doubtful character, and, finally, a few lenses of transparent mineral grains. In some transverse sections a few "slate needles" (rutile, TiO_2) are visible.

The most noticeable feature of transverse sections under polarized light is that in rotation they become, so far as the matrix is concerned, alternately dark and light, behaving like a single mineral. The slate consists mainly of brilliant interlacing, but more or less parallel fiber-like scales of mica (muscovite-sericite), which produce the effect of a mass of gold embroidery. These fiber-like scales of mica surround and inclose more or less angular grains of quartz, with their longer axes parallel to the cleavage. Such grains measure from 0.052 to 0.347 mm. in length by 0.0043 to 0.035 mm. in width. Their usual dimensions are 0.035 by 0.013 mm. Perhaps less abundant than the quartz, although this proportion varies greatly, are carbonate rhombs and plates.

Scales of a chlorite like that already referred to in the Olive grit (Horizon A) occur interleaved with muscovite or talc. The scales under polarized light vary from a prussian or plum blue to a violet or olive, while the delicate bands polarize in brilliant hues. The entire scales measure up to 0.130 mm. In sections made at right angles to the grain and transverse to the cleavage these scales frequently lie at a very high angle or a right angle to the cleavage. The mineral called "a chlorite" in these descriptive notes has the following characteristics: Under incident light the scales are dark and stand out distinctly from the matrix, as do also any large scales of muscovite. In ordinary light the scales are dichroic (pale green and slightly greenish yellow), and frequently have delicate white bands parallel to their cleavage. Under polarized light such scales become bright lavender (violet) or a prussian blue or an olive, and extinguish parallel to the cleavage, while the white bands polarize in the brilliant colors characteristic of talc and muscovite. These scales occur both in the slate and the Olive grits. Other green dichroic scales, however, cut parallel to their cleavage are under polarized light almost isotropic. Still other pale-green scales, not perceptibly dichroic, remain dark or banded with prussian blue throughout one revolution. A coating of an undoubted chlorite from a slickensided surface in purple slate in Castleton, when scraped off and examined under the microscope, showed the dichroism distinctly, and under polarized light remained green in a complete revolution. It gelatinized in boiling sulphuric acid. Attempts to dissolve the "chlorite" scales of the thin sections of slates in hot sulphuric acid were not successful, possibly owing to wrong manipulation. The double refraction of the bands of muscovite was, however, more conspicuous after than before the application of the acid. The usual appearance of the mineral in the slate sections is the first described above. The sections are transverse to the foliation of the mineral, and the differences in colors may then be due to differences in the thickness of the sections or to a slight obliquity of the scale within the slate.

There are also muscovite scales, often bent, possibly fragmental like the quartz, occasional fragments of feldspar (lime-soda-feldspar) up to 0.043 by 0.052 mm. and, more rarely, small fragments of zircon. Apatite was not detected, although, judging from the analyses, it may occur. The lenses of transparent grains prove under polarized light to consist of cryptocrystalline quartz.

Sections parallel to the cleavage in ordinary light show a pale brownish indefinite groundmass with irregular transparent fragments and rhombs. Some of the rhombs have a colorless, some a black, nucleus, which does not seem to be pyrite. Pyrite occurs as before. Under higher powers vast numbers of needle-like crystals, "slate needles" (rutile), appear. These needles measure from 0.0017 to 0.009 mm. in length, rarely attaining 0.012, and 0.0024 mm. in diameter. They average from about 1,000 to 1,850 per square millimeter of the sections, which amounts to from about 25,000 to about 47,000 to the square inch. These sections, under polarized light, do not polarize as one mineral, but bring out on a dark groundmass[1] the quartz fragments, plagioclase fragments, and the carbonate plates and rhombs. These rhombs measure from 0.003 to 0.015 and even to 0.052 mm. in diameter. They sometimes consist of two crystals, an inner rhomb and an outer one, but having a different orientation, possibly in twinned position. In some cases the central rhomb has fallen out, leaving a black center under crossed nicols. Here and there a muscovite scale appears and under high power the orange-yellow rutile needles. The conspicuous features in parallel sections under polarized light are the brilliantly double refracting carbonate rhombs and the quartz grains.

THE DISCOLORATION OF THE SEA-GREEN SLATES.

As is well known, the sea-green slates pass, on a few years' exposure, from a greenish gray to a brownish gray. In exceptionally bad beds the change is from a pale bluish (chloritic) green to a dark yellowish

[1] Some European writers insist on the presence of an isotropic mineral in roofing slates.

brown, producing a marked contrast when fresh and weathered pieces are placed side by side. In those slates in which discoloration is pronounced the fresh slate surface effervesces somewhat rapidly with cold dilute hydrochloric acid, as they all do slightly on the edges. In order to ascertain the cause of the discoloration a thin section was made across the discolored surface of a slate which had been exposed for three years. The section showed that while the rhombs of carbonate within the body of the slate were transparent in ordinary light, those at the edges were changed to the color of burnt sienna, i. e., to the characteristic limonitic staining. These particular rhombs measured 0.047 mm. in diameter. Dr. Hillebrand succeeded in showing this still better. A cleavage surface, discolored by a three-years' exposure, was affixed to the glass slide and the other side was ground down the requisite amount. This section showed a multitude of rhombs—from 0.004 to 0.030 mm., but generally from 0.008 to 0.013 mm. in diameter—entirely or partially altered to limonite. In some cases there was a yellowish-brown zone of alteration surrounding an unaltered nucleus. By applying dilute hydrochloric acid to a section (parallel to cleavage) of the undiscolored slate placed under polarized light the brilliant rhombs are dissolved more or less rapidly and the dark matrix with a few mica scales alone remains. Dr. Hillebrand regards the rhombs as an isomorphous mixture of dolomite and siderite, i. e., a carbonate of lime, magnesia, and iron, in which the iron oxidizes into limonite. His chief reason for supposing them to be a dolomite rather than calcite is their behavior toward cold acids, which, together with other reasons, are detailed in his remarks appended to this paper. Calcite, however, is abundant both in the veins and in the beds of quartzite in the slate. Bischof attributed the discoloration of certain German slates to the formation of limonite from a protoxide, and endeavored to restore their original color by immersing them in dilute hydrochloric acid, but he found that although this proved effective, new discoloration took place within a short time.[1]

"HARD" AND "SOFT" SEA-GREEN SLATES.

The microscopic and chemical tests to determine the cause of this difference were inconclusive. It seems probable, however, that the "soft" slates are due to a greater percentage of carbonate and the "hard" ones to the large size of the quartz grains rather than to the greater percentage of silica.

[1] Lehrbuch der chemischen und physicalischen Geologie, Vol. II, pp. 350–351, footnote. The only way to prevent the discoloration would be to coat the slates with something which would protect them from oxidation.

THE "UNFADING GREEN" ROOFING SLATE.[1]

CHEMICAL ANALYSES.

The following analyses were made in the laboratory of the United States Geological Survey by Dr. W. F. Hillebrand:

Chemical analyses of green roofing slates.

Constituents.	Specimens. *a*	
	E.	F.
	Per cent.	*Per cent.*
SiO_2 (silica)	59.27	59.48
TiO_2 (titanium dioxide, rutile)	.99	1.02
ZrO_2 (zirconia)	....	Trace?
Al_2O_3 (alumina)	18.81	18.22
Fe_2O_3 (ferric oxide)	1.12	1.24
FeO (ferrous oxide)	6.58	6.81
MnO (manganous oxide)	.13	.07
NiO (nickelous oxide)	Trace?	Trace.
CoO (cobaltous oxide)	Trace?	....
SrO (strontia)	....	Trace?
CaO (lime)	.42	.56
BaO (baryta)	.05	.05
MgO (magnesia)	2.21	2.50
K_2O (potassa)	3.75	3.81
Na_2O (soda)	1.88	1.55
Li_2O (lithia)	Trace.	Trace.
H_2O (water below 110° C.)	.32	.17
H_2O (water above 110° C.)	3.98	4.05
P_2O_5 (phosphoric oxide)	.11	.10
CO_2 (carbon dioxide)	.21	.39
FeS_2 (pyrite)	.15	.13
SO_3 (sulphuric oxide)	Trace.	....
C (carbon)	None.	None.
Fl (fluorine)	....	.08
Total	99.98	100.23
S (total sulphur included above)	.08	.07
Specific gravity of E	2.795	....

a E (=D. XIV, '95, 314F), Eureka quarries, 3½ miles north of Poultney, in Poultney Township, Vermont. F (=D. XV, '96, 645a), Valley Slate Company quarry, 2½ miles north of Poultney, in Poultney Township, Vermont.

[1] Lower Cambrian, Horizon B; Olenellus zone.

MICROSCOPIC ANALYSIS.

The "unfading green" slate is a pale greenish gray with less luster on the cleavage surface than the sea green. Several years' exposure produces little or no change in color.[1] Cold dilute hydrochloric acid does not produce any effervescence when applied to the hand specimen. Sections across the cleavage in ordinary light show considerable inequality in texture, coarser and finer bands alternating with one another, the coarser with imperfect cleavage. Even where the cleavage is more regular there is still much irregularity in the size of the particles. There are not a few grains and lenses of pyrite, some irregular opaque grains, dull yellowish in incident light and of doubtful character, green dichroic scales up to 0.039 by 0.006 mm., which, in sections transverse to "the grain," lie edgewise across the cleavage, and finally, slate needles (rutile) from 0.003 to 0.008 mm. in length, and some granular lenses.

Similar sections under polarized light show a matrix of fibrous muscovite (sericite), polarizing as one mineral and inclosing angular quartz grains from 0.013 to 0.043 by 0.004 to 0.017 mm., rarely 0.07 by 0.017 mm., with inclusions; also rarely grains of plagioclase. There is much less carbonate than in the "sea-green" slate, some brilliant scales of muscovite. In sections transverse to the grain many of the more minute scales of muscovite lie at right angles to the cleavage. Finally, some lenses of cryptocrystalline quartz.

Sections parallel to the cleavage, under ordinary light, show the usual brownish matrix and abundance of slate needles measuring from 0.003 to 0.009 by 0.0003 to 0.0006 mm., some specks of pyrite 0.0043 by 0.022 mm., and large pyrite octahedra surrounded by a rim of chlorite scales, rarely a transparent scale (muscovite).

Under polarized light the parallel sections show the same carbonate rhombs, but in very much smaller number than in the fading "sea-green" slates, size 0.026 to 0.065 mm., quartz grains 0.008 to 0.043 mm., and muscovite straps from 0.015 to 0.060 mm. in length.

The reason these slates are "unfading" is manifestly because they have fewer rhombs of carbonate of iron and lime and magnesia. The sections also show why they cleave less perfectly than the "sea-green" slates.

SLATE-PENCIL SLATE.

In the unfading green slate portion of the belt, about 1¼ miles north of Bomoseen and a little east of the lake, is an abandoned quarry where certain greenish slates were obtained and made into slate pencils. In Europe slate pencils have long been made by utilizing a secondary cleavage, which breaks the rock up into squarish sticks which are easily rounded. Here, however, the method was to take tile-shaped blocks of slate and carve out, first on one side, then on the other, by means of set gauges, a whole series of hemicylindrical pencils which readily broke apart into roundish pencils. A microscopic section of this rock shows essentially the same composition as the unfading green

[1] In repairing roofs covered with this slate the fresh slate makes a slight contrast with the old.

slates, excepting that sections parallel to the cleavage show no carbonate whatever, but a greater abundance and larger scales of muscovite (probably clastic), some limonite (?) specks, and a cleavage perhaps not quite so good as that of the Eureka quarries. The usual quartz, sericite, chlorite, rutile needles, and lenses are present.

THE PURPLE AND VARIEGATED ROOFING SLATES.[1]

CHEMICAL ANALYSES.

The following analyses were made by Dr. W. F. Hillebrand in the laboratory of the United States Geological Survey:

Analyses of purple and variegated roofing slates.

Constituents.	Specimens. *a*			
	G.	H.	I.	H^2.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2 (silica)	61.63	60.96	60.24	....
TiO_2 (titanium dioxide)	.68	.86	.92	....
ZrO_2 (zirconia)	....	Trace?	Trace?	....
Al_2O_3 (alumina)	16.33	16.15	18.46	....
Fe_2O_3 (ferric oxide)	4.10	5.16	2.56	5.28
FeO (ferrous oxide)	2.71	2.54	5.18	2.36
MnO (manganous oxide)	.09	.07	.07	....
NiO (nickelous oxide)	Trace?	Trace.	Trace.	....
CoO (cobaltous oxide)	Trace?	Trace.	Trace.	....
CaO (lime)	.50	.71	.33	....
BaO (baryta)	.06	.04	.03	....
MgO (magnesia)	2.92	3.06	2.33	....
K_2O (potassa)	5.54	5.01	4.09	....
Na_2O (soda)	1.26	1.50	1.57	....
Li_2O (lithia)	Str. tr.	Trace.	Str. tr.	....
H_2O (water below 110° C.)	.31	.17	.18	....
H_2O (water above 110° C.)	3.24	3.08	3.81	....
P_2O_5 (phosphoric oxide)	.16	.23	.11	....
CO_2 (carbon dioxide)	.41	.68	.08	....
FeS_2 (pyrite)	.04	None.	.16	....
SO_3 (sulphuric oxide)	Trace.	....	....	....
C (carbon)	None.	None.	None.	....
Total	99.98	100.22	100.12	....
S (total sulphur above)	.02	.07	.087	....
Specific gravity	2.8064	....	2.8053	....

a G (=D. XIV, '95, 260a), purple roofing slate, McCarty quarry, east of center of Lake Saint Catherine, South Poultney, Vermont. H (=D. XV, '95, 760a), purple roofing slate, Francis & Sons quarry, nearly a mile south of Hydeville, in Castleton, Vermont. I (=D. XV, '95, 314), variegated roofing slate, from Eureka quarry, 3¼ miles north of Poultney, in Poultney Township, Vermont, "unfading green" area. H^2 (=D. XIV, '95, 614a), dark reddish bed a few inches thick in purple of sea-green area, west of Lake Saint Catherine; determination of iron oxides only.

[1] Lower Cambrian, Horizon B, Olenellus zone.

MICROSCOPIC ANALYSIS.

The "purple" slate is a dark purplish brown. The "variegated" is like the "sea green" or "unfading green," but is irregularly patched with purplish brown. The discoloration of the purple is less marked than that of the "sea green." It effervesces more or less with cold dilute hydrochloric acid.

Sections of the purple across the cleavage seen in ordinary light show a cleavage corresponding in fineness to that of the "sea green." Numerous very minute reddish specks of hematite (Fe_2O_3) and exceptionally a hexagonal scale of the same are conspicuous. Under polarized light such sections are seen to consist of a matrix of fibrous muscovite polarizing as one mineral, with the usual quartz fragments, carbonate rhombs, chlorite scales, muscovite straps, and rarely a fragment of plagioclase feldspar and of zircon.

Sections parallel to the cleavage under ordinary light show rutile needles (TiO_2) and very minute and irregularly shaped red dots of hematite. Under polarized light the quartz fragments, carbonate rhombs, chlorite scales, and muscovite straps are brought out. The chief microscopic difference between the purple and the "sea green" seems to be the presence in the purple of the additional mineral, hematite, and the scarcity of pyrite, and the somewhat smaller number of carbonate rhombs.

The variegated slate from the Eureka quarries does not effervesce with cold dilute hydrochloric acid applied to the edges, and in the irregularity of its cleavage resembles the "unfading green" from the same quarry. Even transverse sections show the irregular distribution of the hematite dots which produce the mottled appearance. There are also specks of pyrite and large flakes of chlorite throughout.

Under polarized light quartz appears up to 0.047 and even 0.071 mm. There are lenses of quartz a millimeter long, and muscovite and chlorite scales without definite arrangement, about which the sericite matrix bends. Many muscovite and chlorite scales in other parts of the slide lie at an angle to the cleavage. A few slender prisms of tourmaline appear.

Sections parallel to the cleavage also show the irregular distribution of the hematite dots, which measure from 0.001 to 0.0035 mm. in diameter, and the usual rutile needles. There are also spherules of pyrite from 0.007 to 0.027 mm. in diameter. The same sections under polarized light bring out the quartz, the carbonate rhombs, and the chlorite and muscovite scales.

THE RED ROOFING SLATE.[1]

CHEMICAL ANALYSES.

The following analyses were made in the chemical laboratory of the United States Geological Survey, the complete analyses by Dr. W. F. Hillebrand, the partial ones by Mr. George Steiger:

Constituents.	Specimens. *a*					
	J.	K.	L.	M.	K[2].	N.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2 (silica)	67.61	67.55	56.49	63.88		
TiO_2 (titanium dioxide)	.56	.58	.48	.47		
Al_2O_3 (alumina)	13.20	12.59	11.59	9.77		
Fe_2O_3 (ferric oxide)	5.36	5.61	3.48	3.86	7.10	1.02
FeO (ferrous oxide)	1.20	1.24	1.42	1.44	1.00	1.67
MnO (manganous oxide)	.10	.19	.30	.21		
NiO (nickelous oxide)	Trace?	Trace.	Trace.	Trace.		
CoO (cobaltous oxide)	Trace?	Trace.	Trace.	Trace.		
CaO (lime)	.11	.26	5.11	3.53		
BaO (baryta)	.04	.31	.06	.05		
MgO (magnesia)	3.20	3.27	6.43	5.37		
K_2O (potassa)	4.45	4.13	3.77	3.45		
Na_2O (soda)	.67	.61	.52	.20		
Li_2O (lithia)	Trace.	Trace.	Str. tr.	Str. tr.		
H_2O (water below 110° C)	.45	.40	.37	.27		
H_2O (water above 110° C)	2.97	3.03	2.82	2.48		
P_2O_5 (phosphoric oxide)	.05	.10	.09	.08		
CO_2 (carbon dioxide)	None.	.11	7.42	5.08		
FeS_2 (pyrite)	.03	.04	.03	Trace.		
SO_3 (sulphuric oxide)	Trace.	Trace.	Trace.			
C (carbon)	None.	None.	None.	None.		
Total	100.00	100.02	100.38	100.14		
S (total sulphur)	.016	.02	.016			
Specific gravity			2.7839		2.8085	

a J (= D. XIV, '95, 358d), red slate, H. H. Matthews's quarry, 1 mile west of Poultney, in Hampton, Washington County, New York; K (= D. XIV, '95, 201e), red slate, Empire Red Slate Company's quarry, 1 mile north of Granville, in Granville, Washington County, New York; L (= D. XIV, '95, 397e), red slate, National Red Slate Company's quarry, 1 mile north-northwest of Raceville, in Granville, Washington County, New York; M (= D. XIV, '95, 397a), red slate, same locality as L, but near a green and purple spot; K[2] (= D. XIV, '95, 201b), red slate, same as K, but finer grained; N (= D. XIV, '95, 284a), purple bed in red slate at Fair Haven Red Slate Company's quarry (not worked), 2 miles north of Truthville, in East Whitehall, Washington County, New York. For presence of chromium and vanadium in these see Dr. Hillebrand's appendix in Prof. Dale's paper.

[1] Ordovician (Lower Silurian), Horizon Irs (Hudson red and green slate).

MICROSCOPIC ANALYSIS.

The "red slate" is a decidedly reddish-brown, not so dark generally as the purple, and becomes still brighter on exposure. An outcrop of it, even at a distance, is a conspicuous object on account of its color. It is not infrequently speckled with minute protuberances or "eyes." Some of this slate effervesces with cold dilute hydrochloric acid.

Thin sections across the cleavage show in ordinary light much irregularity in the size of the transparent particles, and therefore of the cleavage. These particles measure from 0.015 to 0.06 by 0.006 to 0.03 mm. Multitudes of red dots (hematite, Fe_2O_3), from 0.01 down to much less than 0.001 mm., and a greater or lesser abundance of lenses, up to 0.032 by 0.15 mm., of fine granular material of a slightly bluish color. Under polarized light such sections polarize as one mineral, but not so brilliantly as cross sections of the Cambrian slates, either because the muscovite is in part obscured by the pigment of Fe_2O_3 or because there is less of it and this slate approaches a clay slate. The transparent grains prove to be partly quartz fragments, partly carbonate in rhombs or irregular plates up to 0.047 mm., rarely grains of plagioclase feldspar. There are also chlorite scales up to 0.075 by 0.036 mm., and, exceptionally, a fragment of zircon. The granular lenses under high power resolve themselves into a matrix which closely resembles in color and structure thin sections of the small beds of rhodochrosite (carbonate of manganese) heretofore referred to as occurring in these same slates.[1] This matrix consists, however, in part of cryptocrystalline quartz, and contains rhombs of carbonate and considerable muscovite. One of the slides has a lens one-half millimeter long, containing a rhomb partly of calcite and partly of chlorite.

Sections parallel to the cleavage in ordinary light, under an enlargement of 1,100 diameters and immersion, show the hematite dots in circular or irregularly oval outlines, measuring from 0.0004 to 0.009 mm., and, under polarized light, quartz grains 0.043 by 0.029 mm.; carbonate, chlorite scales, and tourmaline prisms up to 0.005 by 0.001 mm.

Associated with the red slate is generally a little purple slate, sometimes speckled, but not of commercial consequence. Under the microscope this shows the same composition as the red, excepting that there is less of the iron pigment and possibly more chlorite. Analysis N, on page 51, shows from 2½ to over 4 per cent less Fe_2O_3 and about one-third of 1 per cent more FeO. The specks or lenses consist of cryptocrystalline quartz or rhodochrosite, and are surrounded by the meshes of sericite. Rarely a zircon fragment occurs.

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[1] For analysis see p. 61.

THE BRIGHT-GREEN ROOFING SLATE.[1]

The following analysis (specimen O = D. XIV, '95, 397c), by Dr. W. F. Hillebrand, is of a bright-green speckled slate from the National Red Slate Company's quarry, 1 mile north of Raceville, in Granville, Washington County, New York:

CHEMICAL AND MICROSCOPIC ANALYSIS.

Constituents.	Specimen O.	Constituents.	Specimen O.
	Per cent.		*Per cent.*
SiO_2 (silica)	67.89	Na_2O (soda)	.77
TiO_2 (titanium dioxide)	.49	Li_2O (lithia)	Trace.
Al_2O_3 (alumina)	11.03	H_2O (water below 110° C.)	.36
Fe_2O_3 (ferric oxide)	1.47	H_2O (water above 110° C.)	3.21
FeO (ferrous oxide)	3.81	P_2O_5 (phosphoric oxide)	.10
MnO (manganous oxide)	.16	CO_2 (carbon dioxide)	1.89
NiO (nickelous oxide)	Trace?	FeS_2 (pyrite)	.04
CoO (cobaltous oxide)	Trace?	SO_3 (sulphuric oxide)	Trace.
CaO (lime)	1.43	C (carbon)	None.
BaO (baryta)	.04	Total	100.08
MgO (magnesia)	4.57	S (sulphur, total)	.022
K_2O (potassa)	2.82		

Specific gravity = 2.7171.

These are generally interbedded with the red slates, and probably, in places, merge into them along the strike. The color is a light bluish green, more decidedly greenish than the Cambrian slates. The green is peculiarly bright by lamplight. The surface is also sometimes speckled. It effervesces very slightly with cold dilute hydrochloric acid. It is said not to fade readily.

Thin sections across the cleavage show a cleavage not remarkably good on account of the large size of the particles, and more inferior when the slate is speckled. The speckling is due to lenses of granular material which measure up 0.375 by 0.128 mm. There are some grains of pyrite. Under polarized light such sections show the usual polarization of the matrix as one mineral more brightly than the red slates do, quartz grains up to 0.065 mm., chlorite scales up to 0.043 mm., carbonate up to 0.056 mm. The lenses consist of cryptocrystalline quartz, with some very minute rhombs of carbonate and scales of chlorite.

Sections parallel to the cleavage under ordinary light show the lenses with more of a roundish outline, from 0.077 to 0.385 mm. in diameter, rutile needles, and dots of pyrite.

Thin sections under polarized light yield quartz fragments 0.084 by 0.056 mm., carbonate rhombs from 0.002 to 0.03 mm., chlorite scales, tourmaline prisms, zircon, actinolite (?).

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[1] Ordovician (Lower Silurian), Horizon Irs (Hudson red and green slate).

THE BLACK ROOFING SLATES.[1]

CHEMICAL ANALYSIS.

The following analysis (specimen P = D. XIV, '95, 305d) of black slate from the American Black Slate Company's quarry, one-fourth mile east of Benson Village, Rutland County, Vermont, was also made by Dr. W. F. Hillebrand.

Constituents.	Specimen.	
	P.	(a)
	Per cent.	*Per cent.*
SiO_2 (silica)	59.70	55.880
TiO_2 (titanium dioxide, rutile)	.79	1.270
Al_2O_3 (alumina)	16.98	21.849
Fe_2O_3 (ferric oxide)	.52	....
FeO (ferrous oxide)	4.88	9.033
MnO (manganous oxide)	.16	.586
NiO (nickelous oxide)	Trace?	....
CoO (cobaltous oxide)	Trace?	Trace.
CaO (lime)	1.27	.155
BaO (baryta)	.08	....
MgO (magnesia)	3.23	1.495
K_2O (potassa)	3.77	3.640
Na_2O (soda)	1.35	.460
Li_2O (lithia)	Str. tr.	....
H_2O (water below 110° C.)	.30	3.385
H_2O (water above 110° C.)	3.82	
P_2O_5 (phosphoric oxide)	.16	....
CO_2 (carbon dioxide)	1.40	....
FeS_2 (pyrite)	1.18	.051
SO_3 (sulphuric oxide)	Trace.	.022
C (carbon)	.46	1.794
Total	100.05	99.620
S (total sulphur included above)	.63	....
Specific gravity	2.7748	....

a This analysis is inserted for comparison. It is by Andrew S. McCreath, Second Geological Survey Pennsylvania, Report of Progress, 1877, Vol. CCC, pp. 269, 270, 1880; Peach Bottom slates (black) from J. Humphreys & Co.'s quarry, one-half mile east of Delta, York County, Pennsylvania. The footing given is 99.800.

[1] Ordovician (Lower Silurian) or Lower Cambrian, Horizon G or D.

MICROSCOPIC ANALYSIS.

This slate is quite black. The luster is not so bright as that of the Maine slates, but similar to that of the Pennsylvania slates. It effervesces with cold dilute hydrochloric acid.

Sections across the cleavage in ordinary light show a fairly good cleavage and abundance of minute opaque spherules, which, under incident light, glisten like pyrite. They are sometimes in rows along the cleavage. There are also slate needles and transparent grains. Under polarized light the sericite matrix polarizes as one mineral; quartz fragments and carbonate in plates and lenses appear.

Sections parallel to the cleavage under ordinary light show a cloudy grayish matrix with transparent minerals, large and small black dots and blotches, and slate needles in abundance from 0.0017 to 0.0952 mm. in length. The pyrite spherules measure from 0.0017 to 0.007 mm. Under polarized light these sections show carbonate rhombs 0.0043 to 0.035 mm., quartz grains 0.013 to 0.030 mm., and muscovite scales.

MICROSCOPIC ANALYSIS OF "MILL STOCK."

There remains yet to be described those slates which are designated as "mill stock." In consequence of their less perfect cleavage they are not well adapted for roofing slates, but are sawn up for a great variety of other purposes—blackboards, billiard tables, tiles, mantles, vats, tablets, etc.

They are purple or green or red. The purple is frequently paler than that of the roofing slates and spotted with green, while the green is fully as bright and sometimes brighter than that of the "unfading-green" roofing slates. The red is the Ordovician red. No chemical analyses of these were undertaken, but the following results were obtained from microscopic analyses of specimens of purple and green from the Scotch Hill quarries, 2 miles north-northeast of Fairhaven; from the Meadow quarry, one-fourth mile east of Fairhaven; from the Lake Bomoseen Slate Company's quarry, at Cedar Point, in Castleton; and from the J. Jones quarry, 2½ miles north of Castleton village. These are all of Lower Cambrian age (Horizon B).

Sections of the green across the cleavage in ordinary light show a cleavage greatly inferior to that of the "sea-green" roofing slates, and somewhat inferior to that of the Eureka "unfading green." There is an unusual abundance of large green dichroic scales (chlorite), many of which lie at right angles to the cleavage; also large transparent angular grains, some octahedra of pyrite, and rutile needles.

Under polarized light such sections polarize as one mineral, owing to the matrix of sericite and the cleavage. The chlorite flakes measure up to 0.087 by 0.043 mm., and are interleaved with muscovite (or talc). The quartz fragments measure up to 0.060 by 0.036 mm. Muscovite scales occur in various orientations.

Sections parallel to the cleavage show under ordinary light the usual abundance of rutile needles and under polarized light the quartz grains, chlorite scales, muscovite scales, and some carbonate rhombs. The large chlorite scales are conspicuous under incident light. The purple mill stock is similar to the green, with the exception of the additional dots of hematite (Fe_2O_3).

The specific gravity of purple mill stock from Cedar Point was found to be 2.83, and of green mill stock from the J. Jones quarry 2.84, both a little higher than any of the roofing slates.

THE SPOTTED SLATES.

The spots in roofing slates have long attracted attention.[1] In this region the purple slates often have green spots of circular or oval, but frequently of irregular outline. These spots sometimes occur only along lines of bedding and correspond or pass into green "ribbons." In places, however, an entire bed of purple slate several feet thick is irregularly spotted throughout. The red slates are also often spotted. The spots are frequently circular or oval and measure from a fraction of an inch to several inches in diameter and of pale-green color with or without a purple border. Some of the spots, however, have no symmetry whatever. In order, if possible, to throw some new light on this subject a few thin sections were prepared across small spots in directions parallel to and across the cleavage, and in the case of the spotted red slates chemical analyses were made by Dr. Hillebrand of the green center of the spot, of its purple rim, and of the outer red slate.

MICROSCOPIC ANALYSES.

An elliptical green spot, 1 by $\frac{3}{4}$ inch, in purple Cambrian slate from the Lake Bomoseen Slate Company's quarry, at Cedar Point, Castleton, Vermont, in a section cut parallel to cleavage, shows, in the green part, muscovite scales lying in all directions, large chlorite scales, quartz fragments, carbonate rhombs, and a few irregular spherules of pyrite. In the center is some opaque noncalcareous matter partly surrounded by an aggregation of spherules of pyrite in a cloud of rutile needles. There are also cracks filled with secondary sericite. In the surrounding purple the same elements recur, but the pyrite is much more abundant, measuring up to 0.021 mm. There are also many dots of Fe_2O_3 from less than 0.003 to 0.009 mm. and rutile needles up to 0.012 mm. in length.

[1] Comparative view of the cleavage of crystals and slate rocks, by John Tyndall: Phil. Mag., vol. 12, July, 1856. On the disposition of iron in variegated strata, by George Maw: Quart. Jour. Geol. Soc., Vol. XXIV, p. 379; also on variegated Cambrian slates, by the same author: Pl. XIV, figs. 29, 31, 32, London, 1868. Les schistes de Fumay, by Gosselet: Ann. Soc. Géol. du Nord, Vol. X, pp. 63–86, Lille., 1884; same author, L'Ardenne, 1888, p. 35. Text-book of Geology, by Archibald Geikie, 3d ed., p. 343, (2) 1893. Lehrbuch der Petrographie, by F. Zirkel, 2d ed., Vol. III, pp. 296–297, 1894.

An elliptical green spot, 3 inches long, with a purple rim, in Ordovician red slate from the National Red Slate Company's quarry north-northwest of Raceville (Specimen D. XIV, '95, 397a), when cut transversely to the cleavage, measures a half inch in thickness and shows a black streak 1 inch long in the center. The central streak consists of strings of minute irregular lenses of cryptocrystalline quartz and possibly carbonate of manganese (rhodocrosite) containing spherules of pyrite. The green part consists of a mass of fibers of muscovite, which polarize as one mineral, with much carbonate and many lenses, and also quartz grains. In the purple rim there is a decrease of carbonate, and the hematite fragments begin to appear and become still more abundant in the surrounding red slate itself.

A green spot in Ordovician red slate (D. XIV, '95, 201c) from the Empire Red Slate Company's quarry, a mile north of Granville, cut parallel to the cleavage, shows slate needles (TiO_2) up to 0.043 mm. long, carbonate rhombs up to 0.030 mm., chlorite scales up to 0.030 mm., angular quartz grains up to 0.039 mm., and prisms of tourmaline up to 0.021 by 0.002 mm. The surrounding red slate, that of Analysis K, page 51, has been described in the general description on page 52.

Another spot, almost circular, 0.44 inch in diameter, from a piece of red slate (D. XIV, '95, 201l) from the same quarry, cut parallel to the cleavage, shows a central dot 0.03 inch in diameter, consisting mainly of carbonate and of a dense brown material. About this is a zone about 0.1 inch wide, of elliptical shape, of carbonate, with some fibrous quartz along the margin. Then comes a zone 0.08 inch wide, of green slaty material, containing angular quartz grains, muscovite scales, rutile needles, nodules of pyrite, and thinly disseminated areas and rhombs of carbonate; then a very narrow zone made up entirely of carbonate and pyrite. Outside of this, another green slate zone 0.08 inch wide, like the first, but with very little carbonate. The angular quartz grains measure up to 0.030 mm. There are also slender tourmaline prisms. Outside of all comes the red slate, full of Fe_2O_3 pigment. Chlorite was not detected in the green zones, but it may be present in minute scales.

CHEMICAL ANALYSES OF SPOTS IN RED SLATE.

The specimen (Q, R) analyzed by Dr. Hillebrand came from the same quarry as the large spot described on page 58. It was a green spot with purple rim, in red slate. The analysis of the red slate M, on page 51, is repeated for comparison.

Chemical analyses of spotted red slate.

Constituents.	Specimens. *a*		
	M.	Q.	R.
	Per cent.	*Per cent.*	*Per cent.*
SiO_2 (silica)	63.88	64.59	65.44
TiO_2 (titanium dioxide, rutile)	.47	.51	.52
Al_2O_3 (alumina)	9.77	10.23	9.38
Fe_2O_3 (ferric oxide)	3.86	1.79	1.09
FeO (ferrous oxide)	1.44	1.19	1.06
MnO (manganous oxide)	.21	.26	.32
NiO (nickelous oxide)	Trace.	Trace.	Trace.
CoO (cobaltous oxide)	Trace.	Trace.	Trace.
CaO (lime)	3.53	4.07	4.53
BaO (baryta)	.05	.05	.06
MgO (magnesia)	5.37	5.12	4.92
K_2O (potassa)	3.45	3.70	3.57
Na_2O (soda)	.20	.23	.22
Li_2O (lithia)	Str. tr.	Str. tr.	Str. tr.
H_2O (water below 110° C.)	.27	.28	.25
H_2O (water above 110° C.)	2.48	2.29	2.10
P_2O_5 (phosphoric oxide)	.08	.08	.08
CO_2 (carbon dioxide)	5.08	5.84	6.55
FeS_2 (pyrite)	Trace.	Trace.	.04
Total	100.14	100.23	100.13

*a*M (=D. XIV, '95, 397a), red slate, 1 mile north-northwest of Raceville, in Granville, Washington, County, New York, about a spot; Q, purple rim of the spot; R, green portion of the spot.

Dr. Hillebrand adds this observation:

Calculation shows that with no CO_2 there would be only enough CaO for the P_2O_6, and, further, that the result would be no MnO. How much FeO, if any, exists as carbonate is not indicated. If, after allowing for apatite, for $MnCO_3$, and $CaCO_3$, the remainder of the CO_2 is charged to MgO, we find the proportions shown in the columns below.

	M.	Q.	R.
CaO_3	6.14	7.11	7.93
$MgCO_3$ (in part $FeCO_3$)	4.22	4.77	5.36
$MnCO_3$	.38	.47	.57

DISCUSSION OF THE SPOTS.

From Dr. Hillebrand's analyses it would appear that there is a decrease of the carbonates of lime and manganese and magnesia and of silica and rutile from the center of the spot outward and an increase of Fe_2O_3 in the same direction.

The main results of the microscopic and chemical analyses agree even as to the relative amount of pyrite. The difference in color from the green to purple to red is manifestly due to the differences in the amount of hematite. Pyrite, rutile, carbonate, and tourmaline are more abundant within the spots than without them.

The green fossil impressions in purple slate may throw some light on the origin of these spots. In this case the effect of organic matter, whether the carbonaceous matter of the lining of an annelid boring or from a marine alga, has been to diminish the quantity of Fe_2O_3 in the slate, and possibly to increase the amount of chlorite.[1] Gosselet regards the spots as the result of the reduction of the hematite (Fe_2O_3) by decaying organisms to the ferrous oxide (FeO) and its removal as an organic salt or as a carbonate. He observes that the green spots in purple tiles wear less readily than the rest of the tile, because they contain more quartz, and this SiO_2 he attributes to infiltration.[2]

In the spots examined from the New York and Vermont slates the marked decrease of Fe_2O_3 is accompanied by a marked increase of carbonate of lime, iron, and manganese,[3] and of SiO_2, also by a slight increase, in some of the thin sections at least, of FeS_2. Carbonates are also characteristic of the spots in some European slates.[3] The increase of the carbonates may be directly connected with the production of CO_2 by decaying organisms and the consequent decrease of the Fe_2O_3. Not impossibly the organism may have had a calcareous exoskeleton which was dissolved and then redeposited as crystalline $CaCO_3$. The infiltration of SiO_2 and the formation of chalcedony may be purely secondary, and likewise the deposit of FeS_2, or there may have been some precipitation of FeS_2 about the decaying organism, as seems to have been the case in some fossils. At any rate, the rim of intermediate composition would be the zone in which chemical reaction was less effective.

In view of all these facts and indications, the spots may be safely regarded as probably produced by chemical changes in the sediments consequent upon the decay of organisms.

If this be the correct view, the green ribbons, which traverse both purple and red slate, would correspond to small deposits of decomposing organic material that effected similar changes in the Fe_2O_3 of the

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[1] See Tyndall, Maw, Gosselet, Geikie, and Zirkel, as indicated by titles given in footnote on p. 56.

[2] Maw (loc. cit.) had analyses made of dark greenish ribbons in the Welsh blue slates, and found that the ribbons contained 6 per cent more SiO_2, 7 per cent more Al_2O_3, 4½ per cent more MgO (=7 times as much), but 4 per cent less Fe_2O_3, 1 per cent less FeO, and 3½ per cent less K_2O than the adjacent blue beds. Under the microscope the green ribbons showed more feldspar and chlorite. He attributes these differences to change in sedimentation.

[3] See Zirkel, loc. cit.

argillaceous sediments. Where a bed of quartzite forms the center of such a ribbon quartzose sedimentation must have taken place also, and possibly may have been the very condition which proved favorable to marine life.

MINERALS ASSOCIATED WITH THE SLATES.

As the minerals of visible size associated with the slates throw light on the nature and origin of the microscopic constituents of the slate itself, they will now be described.

Quartz is the most common accessory mineral. It is usually segregated in the veins already described, but occurs also as an infiltrated cement between the quartz grains in the beds of quartzite or in veins traversing the quartzite. In both of these modes it is crystallized whenever cavities admit of it.

Next in abundance is *calcite*, occurring also in veins with or without quartz, or as delicate films on joint planes, or as a sediment in the beds of quartzite. The quartzite beds sometimes contain minute rhombs which effervesce readily with hydrochloric acid and weather a limonite brown, and are therefore probably a double carbonate of iron and lime.

Squarish or oval concretions an inch by three-fourths of an inch and one-half inch thick, consisting of radiating crystalline lamellæ of *barite* with the intervening spaces filled with slate and calcite and with many minute cubes of pyrite round about, occur in the Cambrian green slates of Middle Granville. Barite also occurs with calcite in crystalline films on joint planes in both Cambrian and Ordovician slates.

Chlorite is common in quartz veins or almost alone makes up small veins, or coats slickensided joint or bedding planes.

Pyrite occurs in cubes up to one-fourth inch across or in botryoidal concretions, coated with fibrous quartz (chalcedony) or with calcite or, more rarely, chlorite. This coating of chalcedony is often confined to some of the sides, filling a space produced by motion or compression, as described by Renard. Pyrite may collect in the vicinity of calcareous and quartzose veins or beds or form dendritic crystallizations on cleavage planes or minute cubes on joint faces. That this mineral is pyrite and not marcasite is shown by its not decomposing readily after long exposure on the slate dumps.[1]

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[1] See in this connection Alexis A. Julien, On the variation of decomposition in the iron pyrites; its cause, and its relation to density. Annals N. Y. Acad. Sci., Vol. III, pp. 365-403; Vol. IV, pp. 125-221 and Pls. VIII, IX; 1886, 1887.

Beds of *carbonate of manganese* (rhodochrosite) a half inch thick, with calcite and quartz, occur in the red Ordovician slates. An analysis of this, made by Mr. George Steiger, yielded the following:

Analysis of rhodochrosite.

Constituents.	Per cent.
Al_2O_3	0.68
Fe_2O_3	.14
FeO	1.13
MnO	32.22
NiO and CoO	.10
CaO	3.81
MgO	2.61
CO_2	25.06
Insoluble matter, including all silica from dissolved silicates	32.75
Total	98.50

Under the microscope thin sections of this bed show, under polarized light, a fine-grained bluish-brown matrix identical in color and texture with that of the small lenses in the red slate and with some of the lenses in the green slate; also large areas of calcite and some quartz.

Rarely a little *galenite* occurs in the quartz veins of both Cambrian and Ordovician slates. It will be observed that all these minerals, excepting the last, have already been mentioned as occurring in the slates, as shown either by the chemical or microscopic analyses.

SLATES FROM OTHER REGIONS.

It is not within the scope of this report to make a comparative study of slates, either for economic or scientific purposes, but a selection from the published analyses of various slates is here given, and the results of microscopic analyses by the writer of a few sections of slate from Wales, Pennsylvania, and Maine are added, and a few comparisons drawn.

Very few complete analyses of roofing slates are given in scientific literature. Several of the rarer elements are usually omitted in the determinations. FeO and Fe_2O_3 are not distinguished, nor CaO and CO_2, so that several of the percentages are more or less misleading.

The following, however, are the most reliable and complete analyses readily accessible:

Selected analyses of slates from other regions.

Constituents.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
SiO_2 (silica)	58.30	61.57	65.63	61.43	67.56	59.35	55.880	55.06	60.68
TiO_2 (titanium dioxide)	.23	1.31	.94	.73		1.00	1.270		.59
Al_2O_3 (alumina)	21.89	19.22	20.20	19.10	12.23	13.56	21.849	22.55	21.20
Fe_2O_3 (ferric oxide)	7.05	6.63	2.72	4.81	2.87	1.10		1.97	5.68
FeO (ferrous oxide)	2.57	1.20	.85	3.12	6.99	4.75	9.033	5.96	.46
CaO (lime)	.39	.22	.19	.31	.27	5.20	.155	1.30	1.71
MgO (magnesia)	1.09	2.00	1.54	2.29	3.03	3.60	1.495	2.92	.88
K_2O (potassa)	2.45	3.63	3.81	3.24	1.76	1.77	3.640	3.82	3.64
Na_2O (soda)	1.18	.93	.71	.83	1.28	1.48	.460	2.17	2.09
CO_2 (carbon dioxide)						4.45			
C (carbon)					3.11		1.794		.07
MnO (manganous oxide), P_2O_5 (phosphoric oxide), SO_3 (sulphuric oxide)					.10	.31	.608		.16
H_2O	4.61	3.25	3.17	3.52	1.00	3.41	3.385	4.35	2.88
FeS_2							.051		
Total	99.76	99.96	99.76	99.38	100.20	99.98	99.620	100.10	100.04
Specific gravity	2.81							2.78	

I. Gray roofing slate, best quality, Delabole, Camelford, Cornwall; two analyses by J. A. Phillips, London, Edinb. & Dublin Phil. Mag., 4th ser., No. 27, pp. 95-96, Feb., 1871.

II. Purple roofing slate, Fumay, Ardennes, northwest France; by A. Renard, Recherches sur la composition et la structure des phyllades ardennais; Bull. Mus. Roy. d'Hist. Nat. de Belgique, Vol. I, p. 239, 1882.

III. Green roofing slate beds from purple, Fumay, Ardennes, as above.

IV. Blue-gray roofing slate, La Richolle quarry, Rimogne, Ardennes, northwest France; by Klement, pub. by A. Renard, op. cit. supra, p. 233.

V. Roofing slate (probably black, Devonian), Westphalia; by H. von Dechen; Roth, Allgem. und chem. Geol., II, pp. 586, 587, 1884. (107.)

VI. Roofing slate (color not given, Devonian), Frankenberg, near Goslar, in Prussia; by A. von Groddeck; Jahrb. pr. Geol. Landesanst., 1885-86; quoted in Roth, Allgemeine chem. Geol., II, pp. 586, 587.

VII. Black roofing slates ("Peach Bottom") from J. Humphreys Co.'s quarry, half a mile east of Delta, York County, Pennsylvania; by Andrew S. McCreath, in 2d Geol. Surv. Pa., Report of Progress, 1877, Vol. CCC, pp. 269, 270, 1880. The footing given in original is 99.800. (Repeated from p. 54.)

VIII. Bluish roofing slate of Carboniferous agé, Mohradorf, near Wigstadl, Austrian Silesia; by Nikolic, in Tschermaks, Min. Mitth., 1871, p. 207; quoted by Roth, op. cit. supra, pp. 588-589.

IX. Blue slate, Glyn quarries, Llanberis, Wales; analysis made at Museum of Practical Geology, London, for George Maw, Geol. Mag. London, 1868, Vol. V, p. 128.

MICROSCOPIC ANALYSES OF SLATES FROM OTHER REGIONS.

Dark purple (so-called "red") roofing slate from Penrhyn, Wales.—Does not effervesce with cold dilute hydrochloric acid. A section across the cleavage in ordinary light shows an irregular orientation of particles and not a little irregularity in their size. The cleavage is inferior to that of the Vermont "mill stock" slate, although the irregularity in size of particles is no greater. Under polarized light this section does not polarize as one mineral, or polarizes very faintly so. It is a clay slate. The minerals are muscovite (sericite), quartz up to 0.037 mm., chlorite up to 0.093 mm., pyrite, hematite. A section parallel to cleavage shows muscovite scales, quartz grains up to 0.187 mm., chlorite scales from 0.1 up to 0.24 mm., hematite dots from 0.0005 to 0.017 mm.; rutile needles not very plentiful. The absence of carbonate is noticeable. Many of the dots which appear black in center of section are reddish under incident light and translucent at edge of section, and are therefore hematite.

Black roofing slate from Festiniog, Wales.—Does not effervesce with cold dilute hydrochloric acid. A section across the cleavage shows a much better cleavage and fewer coarse particles than the Penrhyn section. It polarizes as one mineral under polarized light, yet the orientation of the particles is not so regular as in the "sea-green" of Vermont and New York. The constituent minerals are muscovite (sericite), quartz fragments up to 0.065 mm., chlorite scales up to 0.09 mm., plagioclase feldspar up to 0.027 mm. Sections parallel to the cleavage show the entire absence of carbonate, abundance of rutile needles, and the other minerals just named.

The specific gravity of this slate, tested by the same methods as the American roofing slates, was found to be 2.751.

Purple (so-called "red") roofing slate from Cilgwyn Nantlle, in Wales.—Effervesces with cold dilute hydrochloric acid. The transverse section shows a cleavage about as good as that of the Festiniog slate. The parallel section shows much more and more brilliant Fe_2O_3 than that of the Penrhyn slate. The hematite dots measure from 0.0005 up to 0.01 mm. There are quartz grains, plagioclase grains, chlorite scales up to 0.047 mm., and carbonates up to 0.035 mm.

Black roofing slate ("Lehigh"), Pennsylvania.—The specimen, after being exposed for several years, had become discolored to a brownish gray on the surface. It effervesces with cold dilute hydrochloric acid applied to the unweathered edge. Sections across the cleavage show a fair cleavage. The matrix polarizes as one mineral, but not very brilliantly, owing probably to the abundance of carbonate. A piece of the weathered surface attached to a slide and the other side ground down, as was done in the case of the "sea-green" slates (p. 46), shows the surface covered with carbonate rhombs more or less completely altered to limonite, showing that the cause of the discoloration is the same as in the "sea-green" slates of eastern New York and western Vermont. Ordinary parallel sections show quartz grains up to 0.056 mm., chlorite scales up to 0.205 mm., carbonate rhombs up to 0.056 mm., spherules of pyrite from 0.002 to 0.019 mm., needles of rutile and carbonaceous particles.

Black roofing slate from quarry of the Bangor Slate Company, Easton, Pennsylvania.—This effervesces on the edges with cold dilute hydrochloric acid. The constituents, arranged in the order of their relative abundance, are: Matrix of muscovite (sericite), carbonate in rhombs from 0.009 to 0.065 mm., and also in irregular plates (these rhombs sometimes have an opaque spherule as a nucleus), then quartz fragments up to 0.075 mm., pyrite and rutile, and black specks, probably carbonaceous; lastly, chlorite up to 0.075 mm.

Black roofing slate from the Brownville and Monson quarries, Piscataquis County, Maine.—This has a lustrous surface, does not discolor on exposure, does not effervesce with cold dilute hydrochloric acid. Sections at right angles to the cleavage polarize brilliantly as one mineral and show an unusual fineness in the particles, but there are a few lenses of pyrite measuring nearly 0.01 inch, and more numerous and pretty regularly disseminated black tabular crystals measuring 0.086 by 0.004 mm., with their long axes in the cleavage foliation. As a magnet applied to the powdered slate attracts these crystals, they are magnetite ($FeOFe_2O_3$), probably distorted octahedra. The quartz grains in transverse sections measure up to 0.043 by 0.013 mm. Sections parallel to the cleavage show magnetite octahedral faces up to 0.10 mm., pyrite, biotite scales up to 0.093 and even 0.12 mm. quartz grains, hemimorphic prisms of tourmaline, chlorite rarely, few, if any, rutile needles, no carbonate whatever. Some secondary fibrous quartz (chalcedony) surrounds the magnetite plates and the biotite scales.

The absence of carbonate and the consequent permanence of color, the very micaceous matrix and regular cleavage make this a very superior slate. It is a true phyllite.[1]

SUMMARY OF CHEMICAL COMPOSITION OF THE SLATES.

By taking the average of the analyses, wherever several were made of one kind of slate, and throwing together the rarer elements and the water below 110° C. we arrive at the following as the general chemical composition of the roofing slates of this region:

Analyses of roofing slates of eastern New York and western Vermont.

Constituents.	Sea green. (3) *a*	Unfading green. (2)	Bright green. (1)	Variegated (Eureka). (1)	Purple. (2)	Red. (4)	Black. (1)	General average.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*
SiO_2 (silica)	63.33	59.37	67.89	60.24	61.29	63.89	59.70	62.24
TiO_2 (titanium dioxide)	.73	1.00	.49	.92	.77	.52	.79	.87
Al_2O_3 (alumina)	14.86	18.51	11.03	18.46	16.24	11.80	16.98	15.41
Fe_2O_3 (ferric oxide)	1.12	1.18	1.47	2.56	4.63	4.56	.52	2.29
FeO (ferrous oxide)	4.93	6.69	3.81	5.18	2.62	1.33	4.88	4.21
CaO (lime)	1.20	.49	1.43	.33	.60	2.25	1.27	1.08
MgO (magnesia)	2.98	2.36	4.57	2.33	2.99	4.57	3.23	3.14
K_2O (potassa)	4.06	3.78	2.82	4.09	5.27	3.95	3.77	3.96
Na_2O (soda)	1.22	1.71	.77	1.57	3.81	.50	1.35	1.21
CO_2 (carbon dioxide)	1.41	.30	1.89	.08	.54	3.15	1.40	1.25
FeS_2 (pyrite)	.11	.14	.04	.16	.04	.02	1.18	.24
H_2O (water above 110° C.)	3.37	4.01	3.21	3.81	3.16	2.82	3.82	3.47
C (carbon)	Trace.	....	....	....	....	....	.46	0 or .46
Sundry and water below 110° C.	.69	.51	.66	.39	.56	.77	.70	.62
Total	100.01	100.05	100.08	100.12	100.09	100.13	100.05	....
Specific gravity *b*	2.776	2.795	2.717	2.805	2.806	2.796	2.774	2.783

a Figures in parentheses indicate the number of analyses averaged.

b Hull (op. cit.) gives the specific gravity of the Welsh slates as ranging from 170 to 180 pounds per cubic foot—i. e., 2.65 to 2.88. Festiniog, black, proves to be 2.751 (see p. 63). Analyses I and VIII, on p. 62, give 2.81 and 2.78 for a Cornish and an Austrian slate. Bayley (op. cit.) gives 2.851 for the Monson (Maine) slates.

[1] See a description of the microscopic characters of the Maine slates, by W. S. Bayley, in Bull. U. S. Geol. Surv., No. 150, pp. 311–313, which reached the author of this paper after his manuscript was completed. Professor Bayley gives a general analysis of this slate by L. M. Norton, showing .52 of CaO.

REMARKS ON THE ANALYSES.

If analysis K_2 of red slate on p. 51 be included with the four others, the per cent of Fe_2O_3 in the red slates would range from 3.48 to 7.10 per cent, and average 5.08. Comparing, then, the amount of Fe_2O_3 in the several slates we shall find that it steadily increases from the variegated to the purple and to the red, as the microscopic sections show.

On the other hand, there is a decrease of FeO in passing from the unfading green to the variegated, sea green, bright green, purple, and red. This decrease corresponds to and is probably consequent on the decrease of chlorite, a hydrous silicate of MgO and FeO.

There is more lime (CaO) and carbon dioxide (CO_2) in the red than in any of the other slates. This CO_2 occurs in part as calcite or dolomite, but also as rhodochrosite (carbonate of manganese), as shown by the analysis of the small bed (p. 62); and the close resemblance thereto of the lenses under the microscope. There is less CaO and CO_2 in the unfading green and in the variegated analyzed than in any of the slates.

There is less pyrite (FeS_2) in the red, and most in the black.

Dr. Hillebrand finds the following amounts of NH_3 in the slates analyzed: Black (specimen 305d), 0.04; sea green (specimen 225f), 0.025, and (specimen 256e), 0.008; unfading green (645a), 0.035; purple (760a), 0.0075; red (specimen 358d), 0.005; bright green (specimen 397c), 0.015. Whether this ammonia occurs as a nitride of some metal or is of organic origin could not be determined. Traces of chlorine were found when looked for; boron was not tested for. Vanadium and chromium are probably present, in all the red slates at least.

SUMMARY OF MINERAL COMPOSITION OF THE SLATES.

In the following brief descriptions both the chemical and microscopic analyses have, to a large extent, been utilized. Besides the minerals named some kaolin (hydrous silicate of alumina) is possibly also present in all the slates.

Sea green.—Largely muscovite (potash mica), quartz, chlorite, carbonate (dolomite with siderite), pyrite, with very little lime-soda feldspar, still less zircon, rutile, cryptocrystalline quartz lenses.

Unfading green.—The same as above, but much less carbonate; more pyrite and chlorite.

Bright green.—Similar to sea green, but less carbonate; more quartz lenses and chlorite, little pyrite, tourmaline, zircon.

Variegated (Eureka).—Like the unfading green, but with irregular areas over which hematite (Fe_2O_3) is thickly disseminated.

Purple.—Like the sea green, but with less carbonate, less FeS_2, and more thickly and evenly disseminated Fe_2O_3 than in the variegated.

Red.—Not so largely muscovite (potash mica), very thickly disseminated Fe_2O_3. More carbonate, but less $FeCO_3$ and less FeS_2 than in any of the preceding. Quartz, carbonate of manganese, chlorite, very little plagioclase, feldspar, zircon, little rutile, tourmaline.

Black.—Matrix like the other slates of potash mica. Carbonates about as abundant as in sea green, quartz, less Fe_2O_3 and more FeS_2 than in any of the others. Rutile, coal, or graphite.

Mill-stock purple and green.—Like the unfading green and the purple, but with more chlorite in the green.

DIFFICULTIES IN SLATE QUARRYING.

The difficulties in all slate quarrying are numerous, and particularly so in this region. In the first place, the conditions of sedimentation and pressure here have varied so that a series of slate beds does not preserve its character for any great distance. Differences in composition, in hardness and softness, or in cleavage may occur unexpectedly along the strike. In the next place, the folding is so close that it is not easy to ascertain where a bed ought to recur on the east or the west. Then the stresses to which the slate mass has been subjected have been so various that irregular fissures, resulting in as irregular veins of quartz, occur at the most unexpected points.

The east-and-west jointing is sometimes so abundant as to cut up the slate into blocks of too small a size to quarry. Masses so cleft are called "posts." "Hogbacks" may also appear unexpectedly, or faults, or dikes, not to mention "false cleavage" (slip-cleavage) or lenticular beds of quartzite. The amount of overlying gravel or of weathered or shattered rock ("top rock") to be removed and the proportion of waste to product are also vital matters.[1] Besides these are the questions as to the drainage of the quarry, as to a convenient place for the "dumps," and as to the means of transporting the product. The cost of slate at some of the quarries is increased by the necessity of removing the dumps of former workings, which, for want of capital, were placed close to the quarry and on good slate. Sometimes the only way to remove these dumps is to throw the material into the quarry and hoist it up again. Several of these difficulties could be set aside by a more generous use of common sense or capital. Others, however, are not so easily disposed of; but even these may be somewhat diminished by understanding their nature and origin, and by the application of a few simple geological principles not infrequently neglected by quarrymen. The following suggestions may be of service in this way.

[1] Davies states that this ranges from 5 to 28 per cent, 8 per cent being considered a fair proportion. Watrin, referring to the Ardennes slate, gives the total waste as from 70 to 75 per cent in weight, of which from 20 to 25 occurs in quarrying and 50 in splitting and trimming.

BEDDING AND CLEAVAGE, HOW DISTINGUISHED.

Wherever the slates are traversed by "ribbons," gray in the green slates, or green in the purple and red, or marked changes in color occur and persist through a thickness of several feet, or wherever strips of quartzite or limestone occur at intervals and continue longitudinally for several hundred feet, quarrymen of any experience know that they have to do with beds, and that the quality of the slate of any one bed may be expected to continue along that bed unless some change should occur in the character of the cleavage. The quality of the slate is primarily dependent upon the character of the sediment. This changes less frequently in horizontal than in vertical directions. The changes in the character of the materials brought into the sea and deposited at one time throughout a moderately large area were fewer than between those brought in at different times at any one spot. Cleavage, being the result of a later compression, may traverse sediments of slightly different compositions with little change in direction, but will be very much affected by great changes in the material or the grain of the sediment. The prime factor is, then, the bed, the second one the cleavage.

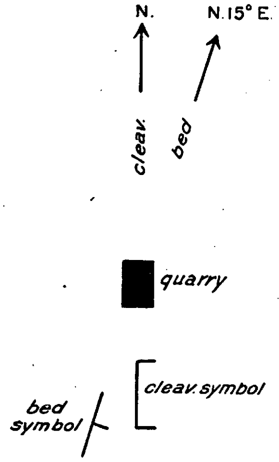

FIG. 1.—Diagram illustrating divergence in strike of slate bedding and cleavage.

In the southern part of the slate belt, as between West Pawlet and Poultney, where beds of quartzite or limestone are few and inconspicuous and the difference of color is slight, the distinction between bedding and cleavage is not so easily made. Quarrymen and prospectors sometimes regard them as identical when they differ. Where the strikes of the bedding and cleavage are divergent, if that of the cleavage be mistaken for that of the bedding a new opening may easily be made at the wrong point and the looked-for bed may be missed. (See fig. 1.) In such places the readiest means of distinguishing cleavage and bedding are:

(1) The fossil impressions (trails or algæ, sometimes called "wavers") are always on a bed surface.

(2) Minute plicated beds of calcite and quartz indicate bedding.

(3) A microscopic section transverse to the cleavage, if other means fail, may indicate the amount of divergence between the bedding and the cleavage.

In some places, however, bedding and cleavage are identical in both strike and dip.

"FLINTS"—THEIR NATURE AND CAUSE.

Beds of quartzite, often calcareous, micaceous, pyritiferous, should never be confounded with veins of quartz. They are both indiscriminately designated by the quarrymen as "flints." The former are sediments, mainly of quartz sands, and, although varying considerably in thickness, are generally more persistent than the veins which, as has been already shown, are chemical infiltrations into fractures produced at a much later time in consequence of various stresses. Ordinarily the quartzite has a more granular and less glassy surface than the vein quartz. A microscopic section under polarized light will almost always show the difference when ordinary means fail. The importance in not confounding the quartzite beds and the quartz veins lies in this—that while the quartzite beds indicate the direction and thickness of adjacent beds of slate, and thus prove helpful, the quartz veins constitute perhaps the most fortuitous and pernicious element in slate quarrying in this region. The strains which the slate masses have suffered have been so various, that it is almost impossible to foretell the probable presence, course, extent, or thickness of a quartz vein. A few things should, however, be noted. While the fractures which occasioned the veins are to be looked upon somewhat as accidental, they are the result of stresses affecting large areas or of the complex interactions of pressure in a few definite directions. The course of a vein which is tapering out should be taken with a compass, and another should be somewhat expected in the same line or in directions parallel to it, or at right angles to it.

RELATIONS OF JOINTS, DIKES, AND HOGBACKS.

In proximity to a dike joints may be expected parallel to the sides of the dike and in large number, so as to form "posts." The more frequent courses of the dikes within the slate belts are, as shown by the general map, N. 25° to 40° E. and N. 50° to 70° W., more rarely east and west.

Certain systems of joints, the diagonal ones, N. 30° to 40° E. and N. 45° to 50° W., and the dip joints, N. 70° W., therefore correspond to the usual courses of the dikes, and where such joints occur in any frequency dikes should be anticipated. The observed courses of the "hogbacks" (shear zones) are N. 37° to 55° E., and also, but less frequently, N. 55° W., and north, also east and west (see pp. 213, 288). As these break up the cleavage, they must be due to a movement more recent than the pressure which induced the cleavage.

From the similarity of the courses of the diagonal joints and many of the dikes, and also of many of the hogbacks, there would seem to be a close relationship in their origin. They may all have been produced by the same stress at the same time—in some cases the strain resulting in a hogback, in others in a diagonal joint—and these joints, when very deep, may have given rise to dikes. The practical application of this is that the possibility of such a relationship should lead the quarryman, whenever he finds diagonal jointing, to suspect the proximity of hogbacks and dikes with a similar course, and so with either a hogback or a diagonal dike, and this suspicion may sometimes save expenditure of time and labor.

THE USE OF A GEOLOGICAL MAP AND COMPASS IN PROSPECTING FOR SLATE.

Both the general map and the quarry maps are designed to be of practical utility. The coloring shows where the Cambrian green and purple and the Ordovician red slates may be looked for or not looked for. The general map, if carefully studied, will show where the continuation of certain slate belts may be expected. The dovetailing of the Cambrian and Ordovician areas, as has been explained, represents to a certain extent structural relations and not mere "accidents" of erosion. Thus, the Jamesville Cambrian belt is closely related to the Cambrian belt which lies west of South Granville.

On the quarry maps the course of bedding and cleavage has been shown at several quarries by special symbols. The scale of these maps is sufficiently large to admit the entry of many more quarries and symbols. By using a small geological compass to determine the strike of any bed of good slate at any of the located quarries, and transferring it to the quarry map by means of a protractor, the probable direction of the recurrence of the bed can be ascertained, and so with joints, hogbacks, or dikes. Such a compass should be provided with sights, spirit levels, movable ring to set off magnetic variation, and have a clinometer attachment to indicate angle of dip.

Where, as at West Pawlet, the slate is closely folded, a succession of repetitions of the same series of beds may be looked for in an east and west direction at varying intervals. The possibility of the pitching of the axis of a fold in a northerly or southerly direction should be looked out for. In such cases older or newer beds are traversed in following the direction of the pitch. Where an Ordovician belt abruptly terminates a Cambrian one on the north or south, the Cambrian one must ordinarily be supposed to plunge under the Ordovician one.

From the relations already explained, quarrymen need not be surprised, here and there as the excavation proceeds, to come upon the Ordovician red and bright-green slates at the bottom of a sea-green or unfading green quarry, or to come upon these Cambrian slates at the bottom of a red slate quarry.

Quarrymen are very skilled in detecting the presence of good slate from the peculiar appearance of the weathered edge surface, and that skill appears to have been their only guide in prospecting in this region. It would be well if this skill were reenforced by the use of the following method in exploration:

First. Make reference to a geological map for the areas in which the various slates may occur.

Second. Determine on quarry map or general map the good slate beds already exploited.

Third. Make compass determination of the strike of such beds.

Fourth. Explore along that strike.

Fifth. Explore at right angles to that strike to see if the series is repeated by folding.

Sixth. Trench at promising localities across the strike to expose as large a series as possible.

Seventh. When surface indications are favorable, make an opening large enough to determine angle of dip of both bed and cleavage and to obtain specimens sufficient for tests.

Eighth. Bore with diamond or steel-shot drill at 45° to cleavage dip so that the core will split up into elliptical pieces sufficiently larger than diameter of core to be conveniently tested.

Ninth. Measure thickness at right angles to bedding planes on the core.

METHODS OF TESTING SLATE.

Methods of testing the elasticity, absorption, fissility, and resistance of roofing slates have been in use for many years, and many more or less complete chemical analyses of slate have been published. In recent years, however, more exact methods of reaching these results have been devised. All such methods have here been brought together. If parts of one specimen, fairly representing the average quality of the product of any quarry or prospect, or if parts of each of a series of specimens, fairly representing all the different varieties and qualities there obtained, were to be subjected respectively to the tests described, such a slate or slates may be said to have been for all economic purposes exhaustively investigated. Several of these tests are of so simple a character as to be very easily applied. This list of methods is largely compiled from Böttinger, Fresenius, Hutchins, Jannetaz, Merriman, Reverdin and De la Harpe, Sorby, Umlauft, and J. F. Williams.[1] Although they all offer valuable suggestions, the most useful papers on the subject are those of Fresenius, Umlauft, and Merriman.

Sonorousness.—One of the first and most time-honored tests of roofing slate is to suspend a good-sized piece of the usual thinness and tap it with some hard object. If it posesses the molecular structure of a slate it will yield what might be termed a semimetallic or semivitreous ring. It is because of this property that when at the quarries refuse slates are thrown upon the dumps the sound produced is not unlike that made by the smashing of a large quantity of crockery.

Cleavability.—This test should be applied by an experienced workman. The block should be freshly quarried, unfrozen, and moist. The

[1] Full titles are given in the Economic Bibliography, included in Prof. Dale's paper. A useful bibliography of purely technical works on building stone, by Geo. P. Merrill, appears in the Annual Report of the Smithsonian Institution for the year ending June 30, 1886, pp. 519-520.

chisel should be very thin and about two inches wide. The cost of slate is closely related to the degree of its cleavability.

Cross fracture ("sculping").—This is to determine the character of the "grain." This test should also be applied by an experienced hand to a large block several inches thick, with a stout chisel and a long-handled, heavy mallet. Jannetaz[1] published a method for determining with scientific precision the direction of the grain in slate when it is but obscurely shown on the cleavage surface. The slate is sawn in a direction parallel to its cleavage and one of the sawn surfaces is made exceedingly smooth and covered with an even and very thin coat of grease. The point of a red-hot platinum wire is applied to the slate opposite the center of the greased surface. The greased area reached by the heat will, in cooling, leave an oval outline, the long axis of which will show the direction of the grain, the heat having traveled more rapidly within the slate in the direction of the grain than in any other. He also made a disk of slate 5 inches in diameter of ordinary thickness, with a central perforation. This disk was fastened by the extremities of the diameter parallel to the grain and afterwards by that at right angles to the grain, and was made to vibrate by tapping the side of the perforation. The sound produced when the disk was fastened by the diameter at right angles to the grain was louder than when fastened by that parallel to it. In other words, the direction of the grain was that in which elasticity and vibration were greatest.

Character of cleavage surface.—The cleavage surface should be examined with an ordinary magnifying glass. A superior slate should scale along the cleavage surface into very thin chips with translucent edges. If the grain is pronounced it will appear in fine transverse lines. If false cleavage, which is fatal, be present, it can usually be detected on the cleavage surface. Ribbons, which are sometimes lines of weakness, should be noted. There is great difference in the smoothness of the surface in slates of different regions. Ordinarily the constituent minerals ought not to be visible. Minute lenses or crystals are not necessarily detrimental, but they retain dust and thus afford a foothold for mosses and other cryptogams, which gather moisture and thus aid the decomposition of the slate.

Presence of lime.—This can be determined by the application of cold dilute hydrochloric acid to the edges of a freshly quarried slate. Rapid effervescence implies presence of carbonate of lime; slow, that of a lesser quantity of it or of dolomite—carbonate of lime and magnesia.

Color and discoloration.—The color of the freshly quarried slate should be noted and compared with that of pieces exposed for several years to the weather, either on a roof or on the quarry dumps, or with that at the top of the quarry close to the gravel, although this last comparison may not always be perfectly conclusive. The value of slates is somewhat affected by the extent of their discoloration.

[1] Relations entre la propagation de la chaleur et l'élasticité sonore dans les roches, 1877, p. 417.

Presence of clay.—This should be tested by breathing upon a fresh and clean piece of slate and observing whether there is any argillaceous odor. The very best slate will not emit any such odor.

Presence of marcasite.—A slate containing lenses or crystals of a pale-yellowish metallic mineral which on exposure decomposes, forming a yellowish-white film and rusty spots, is poor.[1]

Strength.—See Merriman's paper[2] for apparatus and method used in determining the modulus of rupture in pounds per square inch, which he finds in the best slates should range from 7,000 to 10,000 pounds. See also J. F. Williams's[3] tests of compression and elastic limit applied to purple, red, and green slates from Rutland and Washington counties. His results show a limit of compression ranging from 8,040 to 24,760 pounds per square inch, and an elastic limit at from 4,850 to 10,260 pounds. Campbell and Donald[4] give 20,000 pounds as the crushing weight for one cubic inch of slate. Wilkinson, in his Practical Geology of Ireland, gives 30,730 pounds as the crushing weight of the Killaloe slates.[5] Watrin[6] gives the maximum crushing weight of some French slates as 2,000 kilograms per square centimeter, but 1,700 as the average.

Toughness or elasticity.—Merriman finds the ultimate deflection in certain Pennsylvania slates, when placed on supports 22 inches apart, to range from 0.270 to 0.313 inch. Certain blue-black slates in Eldorado County, California, when split seven to the inch and 18 inches square, and fastened solidly at the two ends, are said to bend 3 inches in the center without any sign of fracture.[7] J. F. Williams[3] tested beams of slate from Rutland and Washington counties, 1 inch square and 10 inches long, with supports 6 inches apart. Bending without breaking was effected by from 770 to 1,200 pounds, and when the supports were placed 3 inches apart by from 1,710 to 2,400 pounds. The great elasticity of the slates of eastern New York and western Vermont is apparent to anyone visiting the shanties where the splitting is done.

Density, or specific gravity.—This is determined in the usual way, by weighing a piece of the slate in and out of water and dividing its weight out by the difference between its weight in and out. The specific gravity will be considerably affected by the amount of magnetite or pyrite. Merriman's tests of Pennsylvania slates give 2.761 to 2.817. Meyer's Konversations-Lexikon, 1894, gives 2.8 to 2.9 as the normal specific gravity of a good roofing slate.[8]

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[1] See On marcasite and pyrite; a comparative study of the chemical behavior of pyrite and marcasite, by A. P. Brown: Proc. Am. Phil. Soc., Vol. XXXIII, pp. 225-243, 1894.

[2] Op. cit. An extended abstract of Merriman's paper in the U. S. Geological Survey report on stone for 1897, and some data obtained by Prof. W. O. Crosby as to the strength of the Maine slates are presented.

[3] Op. cit.

[4] Encycl. Brit., ninth ed., 1887.

[5] Quoted by Hull; op. cit.

[6] Op. cit., pp. 192, 193.

[7] California State Mining Bureau, Twelfth Report of State Mineralogist J. J. Crawford, September 15, 1894, p. 400.

[8] See also p. 62.

Porosity.—This is best determined by drying, then weighing, then immersing for twenty-four hours and weighing again, in order to ascertain the percentage of water absorbed. Merriman takes a piece 3 by 4 inches, with rough edges, dries it in an oven at 135° F. for twenty-four hours, cools to the normal temperature of room, weighs, and immerses it for twenty-four hours, and weighs again. His tests of Pennsylvania slate showed from 0.099 to 0.303 per cent of absorption. Porosity is sometimes roughly indicated by immersing a roofing slate edgewise one-half in water and observing how far the water ascends by capillary attraction. In good slates it ought to rise but very little.

Reverdin and De la Harpe[1] state that slates are liable to deterioration from the chemical action of gases arising from woodwork beneath the slate, as well as from the action of the atmosphere, and that they are also liable to an increase of porosity by the physical action of changes of temperature and by the unequal conductivity of heat in the direction of cleavage and of grain. They state that the porosity in a fresh slate should be below 0.1 per cent and after treatment less than 0.2 per cent. Their somewhat elaborate method is this: For determining porosity as produced by acids, the slate is treated with 10 per cent cold acetic acid and the flask is made vacuous from time to time. The piece is then washed, dried, weighed, and immersed in diphenylamine in a thick-walled tube 12 by 3½ centimeters. The tube is exhausted, heated two hours in oil bath at 170° C., air pressure is restored, and heating continued for four to five hours at 150° C., after which the test pieces are removed, the diphenylamine wiped off with ether, and the increase in weight taken.

For determining porosity as produced by changes of temperature, the slate is heated in a wrought-iron tube for half an hour to 300° C., and the tube is then suddenly cooled by a stream of water for half an hour. This process is repeated twenty-four times, and the slate is then impregnated with diphenylamine and the procedure is as in previous tests.

Fresenius is accredited with a method of testing the effect of heat and cold on slate by saturating it with water and putting it for twenty-four hours in a freezing mixture and heating another from 250° to 350° C. for five or six hours and then immersing it in water. The porosity, strength, and elasticity of the pieces so treated should then be tested. Böttinger points out that the greater the porosity of a slate the more damaging is the action of frost likely to be.[1]

Corrodibility.—An important quality in roofing slates is their resistance to the acids of the atmosphere, particularly in cities, where gases increase its destructive power. Fresenius in 1868[1] suggested testing the weathering qualities of a slate by immersing it for three days in dilute sulphurous acid in a closed vessel. At the end of that time poor slates are softened or broken up into thin laminæ or easily fractured, while good ones preserve both their density and hardness.

[1] Op. cit.

Merriman for the same purpose prepared a solution consisting of 98 parts of water, 1 part of hydrochloric acid, and 1 part of sulphuric acid. Pieces of slate 3 by 4 inches were carefully weighed, then immersed in the solution for sixty-three hours, then dried for two hours in the air of the laboratory, and weighed again. The loss in weight ranged from 0.374 to 0.619 per cent.

Microscopic analysis.—One of the most satisfactory tests of slate is the examination of a thin section of it under the microscope. A cubic inch thus tested will suffice to show the character of the cleavage, the presence of false cleavage, if any, the probable durability or indurability of the color, as well as the presence of any mineral constituents likely to affect its general durability. The specimen should be carefully selected, so as to fairly represent the general quality of the bed. It should be fresh, unfrozen, and about an inch thick across the cleavage. At least two sections should be prepared—although the more the better—one parallel to the cleavage and another at right angles to it, never diagonal to it. The sections should be exceedingly thin, much more so than ordinary sections of eruptive rocks, and the slide cover should be of the very thinnest kind, to admit the use of the highest objectives. Both slides should be examined first in ordinary light, then in polarized light with powers ranging from 140 to 700 diameters. The transverse section will show the quality of cleavage, the false cleavage, if any, and under polarized light will, as pointed out by Sorby and others, show whether the specimen is a slate or a shale or something between the two by the entire matrix becoming, in a true slate, four times dark and four times light in complete rotation. Sections parallel to the cleavage reveal the amount of carbonate and indicate the probable amount of discoloration by exposure. Both sections under incident light will show pyrite if any exists.

Chemical analysis.—This, in order to give a correct idea of the composition of the slate, should not be partial but complete.[1] Such an analysis should then be compared with complete analyses of the best slates of like color, and before a final conclusion is reached as to the value of the slate its microscopic analysis and the results of the tests of its strength, elasticity, porosity, and corrodibility should be considered in connection with its chemical analysis. Merriman concludes from six different kinds of tests applied to each of 24 specimens of old Bangor and Albion (Pennsylvania) slates, as well as from the results of several general chemical analyses, that—

> The strongest slate stands highest in weathering qualities, so that a flexural test affords an excellent index of all its properties, particularly if the ultimate deflection and the manner of rupture be noted. The strongest and best slate has the highest percentage of silicates of iron and alumina, but is not necessarily the lowest in carbonates of lime and magnesia. Chemical analyses give only imperfect conclusions regarding the weathering qualities of slates and do not satisfactorily explain their physical properties.[2]

[1] See, on the advantage of complete analysis, Principles and methods of analysis applied to silicate rocks, by W. F. Hillebrand, Bull. U. S. Geol. Survey, No. 148; Analyses of rocks and analytical methods, Clarke and Hillebrand, pp. 1-64, 1897.

[2] Op. cit.

Reverdin and de la Harpe[1] also call attention to the fact that good slate may have a high per cent of calcium carbonate and that others free from it may be poor, and that the presence of pyrite is not necessarily a bad indication, for it may not decompose. This statement needs modification, however, by adding that marcasite even in small quantities is very deleterious, for it decomposes very readily.[2]

Besides these tests there are a few others which are of scientific rather than economic importance. Umlauft suggests heating small splinters of slate under the blowpipe to determine the presence of pyrite and carbon and to ascertain the relative fusibility of different slates; also the test with bead of borax or phosphate of soda and ammonia to determine the presence of iron. He recommends putting a splinter of slate in pure hydrochloric acid in a watch glass and after evaporation examining the precipitate microscopically; also, the application of the same treatment to a splinter after fusion with the blowpipe. He recommends also the application of the ordinary mineralogical tests for hardness; e. g., scratching the slate with calcite and fluorite.

Hutchins finds that the presence of chlorite minerals can be detected by heating the slate to dull redness, thus dehydrating and discoloring those minerals, then preparing a thin section of the slate so treated and comparing it with sections of the normal rock.

GLOSSARY OF GEOLOGICAL AND QUARRY TERMS.

As this report may be consulted for economic or other purposes by persons unfamiliar with geological science, a number of the commoner geological (mostly structural) terms used in it are here explained, and for the benefit of geologists some of the terms in common use among the quarrymen of the region are translated into scientific ones. Some of these quarry terms were given by Speer in the Report of the Tenth Census, but the list has been enlarged.

ANTICLINE. The arch part of a folded bed.

BACK JOINT. Joint plane more or less parallel to the strike of the cleavage and frequently vertical.

BED. A continuous mass of material deposited under water at about one time.

BLIND JOINT. Obscure bedding plane.

BOTTOM JOINT. Joint or bedding plane horizontal or nearly so.

BRECCIA. Rock made up of angular fragments produced by crushing and then recemented by infiltrating mineral matter.

CLASTIC. Constituted of rocks or minerals which are fragments derived from other rocks.

CLEAVE. Slaty cleavage.

DIAGONAL JOINTS. Joints diagonal to the strike of the cleavage.

DIP. The degree and the direction of the inclination of a bed, cleavage plane, joint, etc.

DIP JOINT. Vertical joints about parallel to the direction of the cleavage dip.

DIKE. Molten material erupted through a narrow fissure.

END JOINT. Vertical joint about parallel to the direction of the cleavage dip.

EROSION. The "wear" of a rock surface by natural mechanical or chemical agencies.

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[1] Op. cit.

[2] See under tests, p. 73.

False cleavage. A secondary slip cleavage superinduced on slaty cleavage.

Fault. A fracture resulting in a dislocation of the bedding or cleavage, one part sliding up or down, or both changing positions along the fracture.

Flints. A term applied alike to quartz veins or beds of quartzite.

Grain. An obscure vertical cleavage usually more or less parallel to the end or dip joints.

Hogbacks. Zones of shearing.

Pitch. The inclination of the axis of a fold of rock.

Post. A mass of slate traversed by so many joints as to be useless. This term is also used to denote bands of hard rock.

Ribbon. A line of bedding or a thin bed appearing on the cleavage surface and sometimes of a different color.

Sculping. Fracturing the slate along the grain, i. e., across the cleavage.

Shear zone. Hogback.

Slant. Longitudinal joint more or less parallel to cleavage and often slickensided.

Slickensides. Surface of bed or joint plane along which the rock has slipped, polishing and grooving the surfaces.

Slip. Occasional joint crossing the cleavage, but of no great continuity. Slips are not infrequently fault planes.

Slip cleavage. Microscopic folding and fracture accompanied by slippage; quarrymen's "false cleavage."

Split. Slaty cleavage.

Stratification. Bedding, in distinction from cleavage.

Strike. Direction at right angles to the inclination of a plane of bedding, cleavage, jointing, etc.

Strike joint. Joint parallel to the strike of the cleavage.

Syncline. The trough part of a fold of rock.

Top. The weathered surface of a slate mass, or the shattered upper part of it.

Wavers. Annelid trails.

Wild rock. Any rock not fit for commercial slate.

SANDSTONE.

PRODUCTION.

The following table shows the output of sandstone in the United States for the year 1898:

Sandstone production in 1898, by States.

State.	Value.	State.	Value.
Alabama	$27,882	Montana	$3,683
Arizona	57,444	New Jersey	257,217
Arkansas	24,825	New Mexico	3,500
California	358,908	New York	566,133
Colorado	89,637	North Carolina	9,100
Connecticut	215,733	Ohio	1,494,746
Illinois	13,758	Oregon	7,864
Indiana	45,342	Pennsylvania	478,451
Iowa	7,102	South Dakota	9,000
Kansas	19,528	Texas	77,190
Kentucky	72,525	Utah	15,752
Louisiana	200,500	Washington	15,575
Maryland	13,646	West Virginia	14,381
Massachusetts	91,287	Wisconsin	80,341
Michigan	222,376	Wyoming	6,382
Minnesota	175,810	Total	4,724,412
Missouri	148,795		

The following table gives the value of the sandstone output, by States, for the years 1890 to 1898:

Value of sandstone, by States, from 1890 to 1898.

State.	1890.	1891.	1892.	1893.
Alabama	$43,965	$30,000	$32,000	$5,400
Arizona	9,146	1,000	35,000	46,400
Arkansas	25,074	20,000	18,000	3,292
California	175,598	100,000	50,000	26,314
Colorado	1,224,098	750,000	550,000	126,077
Connecticut	920,061	750,000	650,000	570,346
Florida	(*a*)	....	....	....
Georgia	(*a*)	....	2,000	....
Idaho	2,490	....	3,000	2,005
Illinois	17,896	10,000	7,500	16,859
Indiana	43,983	90,000	80,000	20,000
Iowa	80,251	50,000	25,000	18,347
Kansas	149,289	80,000	70,000	24,761
Kentucky	117,940	80,000	65,000	18,000
Maryland	10,605	10,000	5,000	360
Massachusetts	649,097	400,000	400,000	223,348
Michigan	246,570	275,000	500,000	75,547
Minnesota	131,979	290,000	175,000	80,296
Missouri	155,557	100,000	125,000	75,701
Montana	31,648	35,000	35,000	42,300
Nevada	(*a*)	....	....	....
New Hampshire	3,750	....	....	....
New Jersey	597,309	400,000	350,000	267,514
New Mexico	186,804	50,000	20,000	4,922
New York	702,419	500,000	450,000	415,318
North Carolina	12,000	15,000	....	....
Ohio	3,046,656	3,200,000	3,300,000	2,201,932
Oregon	8,424	....	35,000	....
Pennsylvania	1,609,159	750,000	650,000	622,552
Rhode Island	(*a*)	....	....	....
South Dakota	93,570	25,000	20,000	36,165
Tennessee	2,722	....	....	....
Texas	14,651	6,000	48,000	77,675
Utah	48,306	36,000	40,000	136,462
Vermont	(*a*)	....	....	....
Virginia	11,500	40,000	....	3,830
Washington	75,936	75,000	75,000	15,000
West Virginia	140,687	90,000	85,000	46,135
Wisconsin	183,958	417,000	400,000	92,193
Wyoming	16,760	25,000	15,000	100
Total	10,816,057	8,700,000	8,315,500	5,295,151

a Sandstone valued at $26,199 was produced by Rhode Island, Nevada, Vermont, Florida, and Georgia together, and this sum is included in the total.

Value of sandstone, by States, from 1890 to 1898—Continued.

State.	1894.	1895.	1896.	1897.	1898.
Alabama	$18,100	$31,930	$48,000	$3,000	$27,882
Arizona		20,000	10,000	15,000	57,444
Arkansas	2,365	13,228	1,400	3,161	24,825
California	10,087	11,933	7,267	4,035	358,908
Colorado	69,105	63,237	58,989	60,847	89,637
Connecticut	322,934	397,853	426,029	364,604	215,733
Georgia	11,300		1,250		
Idaho	10,529	6,900	16,060		
Illinois	10,732	6,558	15,061	14,250	13,758
Indiana	22,120	60,000	32,847	35,561	45,342
Iowa	11,639	5,575	12,351	14,771	7,102
Kansas	30,265	93,394	18,804	20,953	19,528
Kentucky	27,868	25,000		40,000	72,525
Louisiana				8,000	200,500
Maryland	3,450	16,836	10,713		13,646
Massachusetts	160,231	339,487	304,361	194,684	91,287
Michigan	34,066	159,075	111,321	171,127	222,376
Minnesota	8,415	74,700	202,900	158,057	175,810
Missouri	131,687	100,000	51,144	57,583	48,795
Montana	16,500	31,069	3,250	25,644	3,683
New Jersey	217,941	111,823	126,534	190,976	257,217
New Mexico	300	2,700			3,500
New York	450,992	415,644	223,175	544,514	566,133
North Carolina		3,500	13,250	11,500	9,100
Ohio	1,777,034	1,449,659	1,679,265	1,600,058	1,494,746
Oregon					7,864
Pennsylvania	349,787	500,000	446,926	380,813	478,451
South Dakota	9,000	26,100	37,077		9,000
Tennessee			4,100		
Texas	62,350	97,336	36,000	30,030	77,190
Utah	15,428	5,000	7,860	7,907	15,752
Virginia	2,258				
Washington	6,611	14,777	11,090	16,187	15,575
West Virginia	63,865	40,000	24,693	47,288	14,381
Wisconsin	94,888	78,000	65,017	33,620	80,341
Wyoming	4,000	10,000	16,465	11,275	6,382
Total	3,955,847	4,211,314	4,023,199	4,065,445	4,724,412

Inspection of this table shows that the output has increased over 1897, for which year the value was $4,065,445, while for 1898 it was $4,724,412.

THE SANDSTONE INDUSTRY IN THE INDIVIDUAL STATES.

ALABAMA.

As compared with 1897 the past year shows an increase from $3,000, as the value of the output in 1897, to $27,882 in 1898. This was due in part to the erection of coke ovens in the latter year. Prospects are much better than they have been for years.

ARIZONA.

Owing to increased consumption of sandstone for railroad bridges, the output increased in value from $15,000 in 1897 to $57,444 in 1898. The stone is of good quality, red in color, and weighs 158 pounds to the cubic foot.

ARKANSAS.

Increased consumption of sandstone for riprap raised the value of the output from $3,161 in 1897 to $24,825 in 1898.

CALIFORNIA.

Exceptional use of sandstone for jetties in California accounts largely for the production of an amount valued at $358,908.

COLORADO.

Business was much better in 1898 than in 1897, the valuation having increased from $60,847 to $89,637. Prospects for the future are unquestionably good. Most of the producers speak in a more hopeful tone than for several years past.

CONNECTICUT.

Although 1898 was a much better year for sandstone in most of the productive States, it was not so for Connecticut. The value of the output in 1897 was $364,604, and for 1898 $215,733. This is accounted for by a variety of causes, among which strikes may be especially mentioned. There seems to be no good reason, however, for a continuation of the reduced production.

ILLINOIS.

But little was accomplished in sandstone production during the year. The output, however, never has been large.

INDIANA.

Demand for sandstone was very decidedly better with some of the larger producers than in 1897. As a consequence the output increased from a valuation of $35,561 in 1897 to $45,342 in 1898. Indications for 1899 are excellent.

IOWA.

Sandstone quarrying has never amounted to much in Iowa. The value of the output in 1898 was $7,102.

KANSAS.

Values were $20,953 and $19,528, respectively, for 1897 and 1898. The product was largely used for flagstone.

KENTUCKY.

Conditions improved markedly during the year, resulting in an increase from a valuation of $40,000 in 1897 to $72,525 in 1898.

LOUISIANA.

Sandstone was quarried for jetty work at Sabine Pass, Texas, from quarries in Louisiana during 1898. These operations constituted an important factor in the production of a total amount of sandstone valued at $200,500.

MARYLAND.

No sandstone at all was reported for Maryland in 1897, while in 1898 an amount valued at $13,646 was quarried.

MASSACHUSETTS.

Business was poor among the sandstone producers of the State during 1898. The most important quarries are at East Long Meadow. The producers seem somewhat discouraged; the conditions are similar to those which have prevailed among the producers of sandstone in Connecticut. The product was valued at $91,287 in 1898.

MICHIGAN.

A number of large concerns in Michigan report a very much better business in 1898, so that the valuation increased from $171,127 in 1897 to $222,376 in 1898.

MINNESOTA.

The value of the output in 1897 was $158,057; in 1898, $175,810. Much improved conditions are reported by almost all of the producers, included among whom are the operators of the unique jasper quarries in Pipestone County.

MISSOURI.

The output of sandstone fell slightly below that of 1897. There are but few quarries of sandstone in the State. The output of 1898 was valued at $48,795.

NEW JERSEY.

The value of the sandstone product in 1897 was $190,976. Producers report conditions generally better for 1898. The value of the output for the latter year was $257,217.

NEW YORK.

An improvement is characteristic of the year 1898, when a product valued at $566,133 was quarried. The value of the output in 1897 was $544,514. Prospects for 1899 are excellent.

OHIO.

The value of the sandstone output in 1897 was $1,600,058. In 1898 production declined to a valuation of $1,489,579. Quite a number of the smaller operators ceased operation altogether during the year, and less business was done by a number of the largest producers. It seems quite certain, however, that a larger volume of business will be done in 1899.

OREGON.

A small amount of sandstone quarrying was done in 1898; the production of sandstone is somewhat irregular from year to year.

PENNSYLVANIA.

Production increased from a valuation of $380,813 in 1897 to $478,451 in 1898. A full account of the sandstone industry in Pennsylvania was published in the report for 1896.

SOUTH DAKOTA.

There is plenty of good red sandstone in South Dakota, but comparatively little is as yet quarried—$9,000 worth in 1898.

TEXAS.

The value of the output was doubled in 1898, increasing from $30,030 in 1897 to $77,190.

UTAH.

But little sandstone quarrying is done in Utah, although there is an abundance of good material there, some of which has been tested scientifically and by practical use.

WASHINGTON.

The value of the output in 1898 was $15,575—about the same as in 1897. Bellingham Bay stone, quarried at Chuckanut, is one of the most interesting from the commercial standpoint. This stone has been thoroughly tested at the Watertown Arsenal.

WEST VIRGINIA.

Production fell off from a valuation of $47,288 in 1897 to $14,381 in 1898. Among a number of quarries in the State are some that have achieved a high reputation as bridge stone.

WISCONSIN.

The value of the output in 1898 was $80,341; this is the highest figure reached since 1894.

WYOMING.

But little was done in 1898.

LIMESTONE.

PRODUCTION.

The following table shows the production of limestone in the United States in 1898, by States and uses:

Production of limestone in the United States in 1898, by States, and uses.

State or Territory.	Building purposes.	Paving and road making.	Riprap.	Made into lime.	Stone sold to lime burners.	Flux.	Total.
Alabama	$27,000	$4,500	$600	$115,482	$300	$94,413	$242,295
Arizona	1,200			582			1,782
Arkansas	14,675	900	7,070	31,728			54,373
California	91	21,983		189,525	*a* 8,533	9,597	229,729
Colorado	21,433		6,000	27,125	72	54,680	109,310
Connecticut				141,245		812	142,057
Florida		36,300	37,470	17,560			91,330
Georgia				57,803			57,803
Idaho	50		500	2,530			3,080
Illinois	788,548	396,302	73,374	127,156	600	35,092	1,421,072
Indiana	1,083,571	253,731	16,046	190,540	4,500	138,184	1,686,572
Iowa	280,832	87,079	39,507	116,715	413		524,546
Kansas	147,548	102,342	51,073	4,642			305,605
Kentucky	20,040	42,185	591	10,873		10,271	83,960
Maine				1,279,226	4,242		1,283,468
Maryland	10,768	155,714	276	263,449	3,231	215	433,653
Massachusetts	7,316	326	66	160,692	5,200	1,222	174,822
Michigan	21,266	43,809	3,000	79,648	110,000	13,800	271,523
Minnesota	272,009	21,579	24,306	27,236	380	175	345,685
Missouri	238,553	145,498	36,985	297,401		16,838	735,275
Montana				7,200		55,996	63,196
Nebraska	46,256	29,501	896	1,600		240	78,493
New Jersey	250	1,666		118,760	175	25,760	146,611
New York	553,614	413,410	12,064	482,936	28,027	*b* 43,885	1,533,936
North Carolina			450	1,155			1,605
Ohio	221,440	260,957	51,345	911,482	17,936	210,000	1,673,160
Oklahoma Territory	3,000						3,000
Oregon	2,000			5,000	480		7,480
Pennsylvania	190,394	256,961	24,613	1,201,352	107,410	965,526	2,746,256
Rhode Island				10,215			10,215
South Carolina		500	500	33,000			34,000
South Dakota				613		26,245	26,858
Tennessee	21,197	34,011	355	120,448	3,213	3,178	182,402
Texas	7,039	487	1,633	38,531	100	22,531	70,321
Utah	3,996			3,600		4,125	11,721
Vermont	1,000	400		172,750			174,150
Virginia	180	16,250		83,087	4,515	78,820	182,852
Washington				136,129	1,581	2,529	140,239
West Virginia	1,017	403		49,813	4,934		56,167
Wisconsin	167,875	111,726	30,694	367,720	483	19,956	698,454
Total	4,154,158	2,438,520	419,414	6,886,549	3,061,325	1,834,090	16,039,056

a Sold to sugar refineries.
b Includes $15,742 used for chemical purposes, pulp mills, glass factories, etc.

The following table shows the value of limestone, by States, since 1890:

Value of limestone, by States, from 1890 to 1898.

State or Territory.	1890.	1891.	1892.
Alabama	$324,814	$300,000	$325,000
Arizona	(a)		
Arkansas	18,360	20,000	18,000
California	516,780	400,000	400,000
Colorado	138,091	90,000	100,000
Connecticut	131,697	100,000	95,000
Florida	(a)		
Georgia	(a)		
Idaho	28,545		5,000
Illinois	2,190,607	2,030,000	3,185,000
Indiana	1,889,336	2,100,000	1,800,000
Iowa	530,863	400,000	705,000
Kansas	478,822	300,000	310,000
Kentucky	303,314	250,000	275,000
Maine	1,523,499	1,200,000	1,600,000
Maryland	164,860	150,000	200,000
Massachusetts	119,978	100,000	200,000
Michigan	85,952	75,000	95,000
Minnesota	613,247	600,000	600,000
Missouri	1,859,960	1,400,000	1,400,000
Montana	24,964		6,000
Nebraska	207,019	175,000	180,000
New Jersey	129,662	100,000	180,000
New Mexico	3,862	2,000	5,000
New York	1,708,830	1,200,000	1,200,000
Ohio	1,514,934	1,250,000	2,025,000
Oregon	(a)		
Pennsylvania	2,655,477	2,100,000	1,900,000
Rhode Island	27,625	25,000	30,000
South Carolina	14,520	50,000	50,000
South Dakota	(a)		
Tennessee	73,028	70,000	20,000
Texas	217,835	175,000	180,000
Utah	27,568		8,000
Vermont	195,066	175,000	200,000
Virginia	159,023	170,000	185,000
Washington	231,287	25,000	100,000
West Virginia	93,856	85,000	85,000
Wisconsin	813,963	675,000	675,000
Wyoming	(a)		
Total	19,095,179	15,792,000	18,342,000

a Limestone valued at $77,935 was produced in Oregon, Georgia, Florida, Arizona, South Dakota, and Wyoming. The value is included in the total.

Value of limestone, by States, from 1890 to 1898—Continued.

State.	1893.	1894.	1895.
Alabama	$205,000	$210,269	$222,424
Arizona	15,000	19,810	24,159
Arkansas	7,611	38,228	47,376
California	288,626	288,900	322,211
Colorado	60,000	132,170	116,355
Connecticut	155,000	204,414	154,333
Florida	35,000	30,639	10,550
Georgia	34,500	32,000	12,000
Idaho	1,000	5,315	7,829
Illinois	2,305,000	2,555,952	1,687,662
Indiana	1,474,695	1,203,108	1,658,976
Iowa	547,000	616,630	449,501
Kansas	175,173	241,039	316,688
Kentucky	203,000	113,934	154,130
Maine	1,175,000	810,089	700,000
Maryland	....	350,000	200,000
Massachusetts	156,528	195,982	75,000
Michigan	53,282	336,287	424,589
Minnesota	208,088	291,263	218,733
Missouri	861,563	578,802	897,318
Montana	4,100	92,970	95,121
Nebraska	158,927	8,228	7,376
New Jersey	149,416	193,523	150,000
New Mexico	....	4,910	3,375
New York	1,103,529	1,378,851	1,043,182
North Carolina	....	....	....
Ohio	1,848,063	1,733,477	1,568,713
Oklahoma Territory	....	....	....
Oregon	15,100	....	970
Pennsylvania	1,552,336	2,625,562	3,055,913
Rhode Island	24,800	20,433	....
South Carolina	22,070	25,100	....
South Dakota	100	3,663	4,000
Tennessee	126,089	188,664	156,898
Texas	28,100	41,526	62,526
Utah	17,446	23,696	22,503
Vermont	151,067	408,810	300,000
Virginia	82,685	284,547	268,892
Washington	139,862	59,148	75,910
West Virginia	19,184	43,773	42,892
Wisconsin	543,283	798,406	750,000
Wyoming	....	....	650
Total	13,947,223	16,190,118	15,308,755

Value of limestone, by States, from 1890 to 1898—Continued.

State.	1896.	1897.	1898.
Alabama	$180,921	$221,811	$242,295
Arizona	18,470	11,522	1,782
Arkansas	30,708	44,222	54,373
California	143,865	308,925	229,729
Colorado	65,063	79,256	109,310
Connecticut	138,945	178,410	142,057
Florida	16,982	18,889	91,330
Georgia	29,081	32,000	57,803
Idaho	5,662	15,538	3,080
Illinois	1,261,359	1,483,157	1,421,072
Indiana	1,658,499	2,012,608	1,686,572
Iowa	410,037	480,572	524,546
Kansas	158,112	208,889	305,605
Kentucky	135,967	40,815	83,960
Maine	608,077	742,877	1,283,468
Maryland	264,278	181,637	433,653
Massachusetts	118,622	126,508	174,822
Michigan	109,427	215,177	271,523
Minnesota	228,992	236,397	345,685
Missouri	802,968	1,018,202	735,275
Montana	83,927	37,300	63,196
Nebraska	10,655	42,359	78,493
New Jersey	134,213	141,646	146,611
New Mexico	....	....	....
New York	1,591,966	1,697,780	1,533,936
North Carolina	....	....	1,605
Ohio	1,399,412	1,486,550	1,673,160
Oklahoma Territory	....	....	3,000
Oregon	1,600	....	7,480
Pennsylvania	2,104,774	2,327,870	2,746,256
Rhode Island	11,589	11,555	10,215
South Carolina	26,000	30,000	34,000
South Dakota	3,126	3,895	26,858
Tennessee	157,176	113,774	182,402
Texas	77,252	57,258	70,321
Utah	9,358	9,250	11,721
Vermont	147,138	165,657	174,150
Virginia	182,640	192,972	182,852
Washington	83,742	126,877	140,239
West Virginia	59,113	61,546	56,167
Wisconsin	552,921	641,232	698,454
Wyoming	....	....	....
Total	13,022,637	14,804,933	16,039,056

THE LIMESTONE INDUSTRY IN THE INDIVIDUAL STATES.

ALABAMA.

The output of limestone in Alabama in 1898 was valued at $242,295. This is the largest figure reached since 1892. The figure for 1897 was $221,811. The limestone is mostly used for lime burning and blast-furnace flux. The value of the lime made was $115,482 and the blast-furnace flux $94,413. The resumption of production by a number of blast furnaces during the year was one of the causes for increased output. The value of the flux produced was more than twice as great as that of the product of 1897, while the value of the lime produced declined somewhat. Indications for 1899 are reported as encouraging by several large producers.

ARIZONA.

Very little was done in 1898, the product being valued at only $1,782.

ARKANSAS.

The value of the limestone output increased from $44,222 in 1897 to $54,373 in 1898. Most of the product is burned into lime, the value of which was $31,728. Almost all of the remainder was used for building.

CALIFORNIA.

The value of the limestone product in 1898 was $229,729; of this sum, $189,525 was the value of the lime made. The year can not be regarded as a prosperous one, since the output in 1897 was valued at $308,925.

COLORADO.

The total value of the output was $109,310. The value of the flux produced was $54,680. The remainder was about equally divided between lime and building purposes. During the early part of the year business was poor, but a sudden improvement characterized the latter part. Indications for 1899 are fair.

CONNECTICUT.

Connecticut has for a long time been prominent as a lime-producing State, particularly so on account of the fine quality of the lime made. All of the product was burned into lime. The abundance of granite in the State is probably the reason why no limestone is used for building.

FLORIDA.

For a long time Florida was entirely omitted from the list of stone-producing States, but in 1898 it appears with quite an increase over any former year, namely, a production valued at $91,330. This was almost equally divided between road making and riprap. A small quantity was burned into lime.

GEORGIA.

The limestone quarried in Georgia was entirely burned into lime, the value of which in 1898 was $57,803. This is more than has ever been accomplished in the State in any one year before. The stone interests in Georgia center in its granite and marble more than in any other kind of stone.

IDAHO.

The value of the product in 1898 was $3,080, practically all of which was the value of lime made.

ILLINOIS.

The value of the limestone output in Illinois declined from $1,483,157 in 1897 to $1,421,072 in 1898. More than one-half of this value is that of stone used for building. This comes largely from quarries at Lemont and Joliet. One-third of the amount went for paving and road making, while the remainder was divided between lime flux and riprap. Some years ago Illinois produced more limestone for building purposes than any other State in the Union, but in recent years it has been succeeded by Indiana, owing to the large production of the Bedford oolitic stone. The early part of the year was characterized by poor business, but a decided revival took place in the last few months, making the outlook for 1899 much more encouraging. Labor troubles at Joliet interfered with production quite materially. Almost all of the producers in the Joliet and Lemont regions report improved conditions, particularly for the latter part of the year.

INDIANA.

Indiana is of especial interest among the States producing limestone, from the fact that it stands first in the list for the amount of stone devoted to building purposes. The value of the total output in 1898 was $1,686,572. Of this amount over $1,000,000 represents the value of the building stone, which comes largely from the celebrated Bedford region, which yields oolitic stone. It is scarcely necessary to say that the Bedford oolitic stone is popular over a wide range of the United States as a stone of light color.

IOWA.

The value of the limestone output in 1898 was $524,546, a gain of about $44,000 over 1897. About half of the product went for building purposes, one-fourth is the value of lime made, while the remainder went mainly for paving and road making. The cooperation of the Iowa State Geological Survey aided very materially in the collection of the Iowa statistics.

KANSAS.

The value of the output increased from $208,889 in 1897 to $305,605 in 1898. One-half the product went for building purposes, one-third for paving and road making, and the remainder went mainly for riprap, a small quantity only being made into lime. The output was the largest since 1895. Indications for 1899 are very good.

KENTUCKY.

The output of limestone in Kentucky was practically doubled in 1898 as compared with 1897. Most of the product went for road making; the rest was divided between lime and building.

The most interesting limestone in the State, from the standpoint of building, is the Bowling Green oolite, which, however, is at present not quarried in very large quantity. Quite a number of the producers report encouraging prospects for 1899.

MAINE.

All of the limestone quarried in Maine is burned into lime.

The total value of all the lime produced was $1,279,226. Maine stands at the head of the lime-producing States of the Union, Pennsylvania standing second with an output of $1,201,352. The lime of Maine comes chiefly from Rockland and vicinity and Thomaston, where a particularly pure limestone is quarried. The number of casks of lime produced was 2,057,052. An average value of 62 cents per cask is thus indicated. The value of the output is somewhat less than twice that of 1897. It is therefore very evident that the industry was in a flourishing condition throughout the year, but the best conditions prevailed toward the close of the year. The tendency of prices was downward.

MARYLAND.

The value of the total output of limestone in Maryland was $433,653. More than half of this is the value of lime made; the rest of the output was devoted mainly to paving and roadmaking. There was a very marked increase over the output for 1897, which was valued at $181,637.

MASSACHUSETTS.

The total value of the output in 1898 was $174,822. Of this figure $160,692 is the value of lime made. It is therefore evident that most of the stone is burned into lime.

MICHIGAN.

The value of the limestone output of Michigan for 1898 is $271,523. About two-thirds of this was burned into lime and the rest was divided into building and paving. The value of the output in 1897 was $215,177; quite a decided increase is thus evident.

MINNESOTA.

The output of limestone in Minnesota is the largest since 1892, and about 50 per cent greater than 1897. The figures for 1898 are $345,685. Most of the stone is devoted to building purposes. Most of the reports speak very encouragingly of the outlook for 1899.

In the December, 1898, number of De Lestry's Western Magazine appeared an article on the building stones of Winona, Minnesota. The stone quarried here is a dolomite varying in color from buff to light gray, though there are also found layers nearly white in color. Its crushing strength is said to be 16,250 pounds per square inch and weight per cubic foot 153.1 pounds. The stone has been used in buildings at Winona since 1862. It has also been adopted for sidewalks. For all purposes to which it has been applied it has given entire satisfaction, both for durability and appearance. A number of churches and public buildings have been built of it.

MISSOURI.

The value of the limestone output of Missouri declined from $1,018,202 in 1897 to $735,275 in 1898. The value of the lime made is $297,401, while the value of stone devoted to building was $238,553. The remainder was divided up among paving and roadmaking, riprap and flux. Many of the producers report much improved business for the latter part of the year and the first of 1899. Doubtless the current year will show considerable gain.

MONTANA.

Aside from $7,200 worth of lime, the entire output of limestone in 1898 went for fluxing purposes. The industry has never been large in Montana, and most of the product goes as a flux each year.

NEBRASKA.

Quite a notable increase marked the year 1898. The value of the output for 1897 was $42,359; in 1898, $78,493. This was divided between building and roadmaking, but little being burned into lime.

NEW JERSEY.

For several years past the value of the limestone output in New Jersey has been quite constant. Most of it is burned into lime, while the rest is used for blast-furnace flux. The value of the product in 1898 was $146,611.

NEW YORK.

The value of the limestone output in New York fell off from $1,697,780 in 1897 to $1,533,936 in 1898. The stone is about equally divided between building purposes, paving and roadmaking, and lime.

OHIO.

The value of the output in Ohio—$1,673,160—is the highest attained since 1894. A decided gain over 1897 has been made. The figures for 1897 were $1,486,550. The output is for the greater part burned into lime, the value of which in 1898 was $911,482. For paving and roadmaking the value of stone used was $260,957; for building purposes, $221,440, and for flux, $210,000. In magnitude of output of limestone Ohio stands second, Pennsylvania being first, with an output of nearly three millions. The lime industry in Ohio is a very extensive one, and the quality of lime made is in many cases very superior. Most of the producers report decidedly improved business.

PENNSYLVANIA.

Pennsylvania stands first for the magnitude of its limestone output, the value of which in 1898 was $2,746,256, a decided gain over 1897, when the value was $2,327,870. The value of the lime made during the year 1898 was $1,201,352. The value of flux was $965,526. For paving and roadmaking the value of crushed stone was $256,961. Quite a large proportion of the lime made is used for agricultural purposes.

RHODE ISLAND.

Rhode Island has never produced much limestone in any year, it being distinctively a granite State. About $10,000 worth of lime is annually produced.

SOUTH CAROLINA.

About $30,000 worth of output is secured in South Carolina every year. This figure represents the value of lime, with the exception of a very small amount for roadmaking.

SOUTH DAKOTA.

The only purpose for which limestone is quarried in South Dakota appears to be flux. The value of the output in 1898 was $26,858.

TENNESSEE.

There was a very encouraging increase in the value of output in Tennessee in 1898, the total reaching $182,402, against $113,774 in 1897. Most of the product is burned into lime.

TEXAS.

The value of the limestone output in Texas in 1898 was $70,321. This was about equally divided between lime and blast-furnace flux.

VERMONT.

The value of the total output in 1898 in Vermont was $174,150. Practically all of this was the value of lime made.

VIRGINIA.

The limestone industry in Virginia has not yet regained its former prosperous condition, as the output is still markedly below what it was in 1894. It was about equally divided between lime and blast-furnace flux. Reports indicate that better conditions will prevail during 1899 than have been known in several years.

WASHINGTON.

Something of a gain was made during 1898, namely, from $126,877 in 1897 to $140,239 in 1898. Almost all of this figure represents the value of lime made.

WEST VIRGINIA.

The value of the limestone output in 1898 was $56,167. Very nearly all of this is the value of lime made. The industry has not varied a great deal in general prosperity for the last five or six years, although it is much lower than 1892.

WISCONSIN.

The limestone industry in Wisconsin is one of considerable magnitude, the total value of the output being generally about three-quarters of a million. About one-half of this value is the value of lime made. The other half is divided between building purposes and road making.

TESTS AND ANALYSES OF STONE.

In the selection of all kinds of material for structural use it is becoming more and more customary to test such material, and to make the final selection on the basis of results so secured. It is, of course, unnecessary to state that if a given material has already demonstrated its fitness for a certain use by years of experience with it in that capacity, no results of scientific test should be considered as in any way capable of offsetting these results of actual experience; but in a country as young as the United States enough time has not yet elapsed in the use of stone as a building material to afford, in more than a few cases, a sufficient amount of such knowledge as results from long-continued use. As an example of a stone already sufficiently well known not to require further special tests, Quincy granite may be cited. This stone, by its hardness and susceptibility to high polish, and the contrast offered between polished and hammered surface, has demonstrated its fitness for use as a monumental stone. Similar statements might be made in regard to Westerly granite and other long-quarried and well-known materials.

When, however, a new material comes up for consideration it is desirable to learn of its qualities by quicker processes than those which depend upon actual use. There have, therefore, been devised a number of methods of testing stone which may be quickly carried out and which are of various degrees of value, according to the nature of the stone tested and the use to which it is to be put. The practice of making these tests of stone is of such comparatively recent date that it can hardly be said that the particular tests are so well understood as to be beyond criticism either in regard to the nature of the test itself or in the method of carrying it out. There is, moreover, a great lack of agreement among testing experts, both as to what tests should be applied to a given stone and as to details in the methods of applying these tests. In some cases physical tests seem to be all that are necessary to furnish the needful information without any chemical analysis whatever. In other cases it is quite generally conceded that physical tests should be supplemented by more or less complete chemical analyses. At the present time the uses to which stone is put are quite different from those involving it as a structural material. Thus limestone is used in enormous quantities for burning into lime and as a flux in metallurgical operations. Limestone for such uses may be taken from the same quarry that furnishes building stone, and is thus quarried by the same methods as apply to the production of the building stone. It can not therefore well be considered apart from that which is devoted to structural use. If limestone is to be burned into lime it is of course evident that the physical strength of the stone so used is of no moment whatever, but a knowledge of the chemical composition is absolutely essential. The same idea applies to limestone to be used as a blast-furnace flux.

Again, although a stone to be used for structural purposes may show great physical strength, it may, nevertheless, contain minerals which by decomposition from atmospheric agencies may develop in the entire mass weaknesses that would in course of time make the use of the stone undesirable. To detect the presence of such minerals chemical analysis may be resorted to in some cases, or, better still, this, together with a microscopical examination of thin sections, by which it is possible to detect minerals as such, even though the amount present may be extremely minute. The application of microscopical examination as a means of studying stone in relation to its technical applications is of recent date and as yet is used only to a limited extent.

Among the tests most commonly applied to stone which is to be used for structural purposes is the crushing-strength test. This gives in general a good idea not only of the power of the stone to support without fracture the superstructure that may rest upon it, but also of the homogeneity and all-round durability of the material. Other tests of value include transverse strength, porosity, corrodibility, specific gravity, and resiliency.

A study of the tests presented in detail in this report will, it is believed, convince any intelligent engineer that there is need for an agreement among the members of the engineering profession as to the tests which are called for by each kind of stone, and also an understanding as to the best manner of carrying out each individual test.

The tests in the following pages have been obtained in most instances from the stone producers direct. It will be noticed that in nearly every case the source of the stone, the name of the producer, and the name of the expert who made the test have been given. Quite a number of tests have been omitted from the report because of lack of knowledge as to the source of the stone or as to the name of the expert.

For convenience of reference the tests have been arranged according to the State in which the stone was quarried.

TESTS AND ANALYSES OF STONE IN INDIVIDUAL STATES.

ALABAMA.

The following table gives a number of results of analysis of limestones and lime:

Analyses of limestone quarried in Alabama.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.							
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Calcium oxide, CaO.	Silica, SiO_2.	Carbon dioxide, CO_2.		Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*	*Per cent.*
Anniston Lime Works Co.	Anniston	Etowah	Wm. Makemson, Anniston, Ala	98.76	Trace	0.36	....	0.74	....	....	99.86
A. P. Birch	Blount Springs	Blount	Dr. W. B. Phillips, Birmingham, Ala.	99.10	....	.40	....	.50	....	....	100.00
Longview Lime Works (No. 1).	Longview	Shelby	Eugene A. Smith, State geologist	99.11	0.75	.13	....	*b*.39	....	....	100.38
Longview Lime Works (No. 2).	do	do	do	99.16	.75	Trace	....	*b*.15	....	....	100.06
Franklin Quarry Co	Russellville	Franklin	J. C. Foster	97.00	1.40	.70	....	.90	....	....	100.00
T. L. Fossick & Co	Sheffield	do	Chemist Watertown Arsenal (Nov. 20, 1895).	....	....	....	54.20	.50	42.61	Fe_2O_3 1.45; MgO_2 1.23	99.99
Do	Siluria	Shelby	do	98.91	.58	.63	....	.10	....	....	100.22
Shelby Iron Co.	Shelby	do	C. F. Chandler, New York	99.13	.12	....	....	.23	....	Fe_2O_3 Trace; P_2O_5 Trace	*a*100.00
J. F. Landt	Stanley	Taladega	Albert Noble, Anniston, Ala	55.95	40.90	1.47	....	*b*1.34	....	....	99.66

a Includes also Al_2O_3 0.21 per cent, organic matter, water, loss, and undetermined 0.31 per cent. Specific gravity, 2.84.

b Insoluble in acids.

Analyses of lime from Alabama limestone.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.							
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Silica, SiO_2.		Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*	*Per cent.*
Standard Lime Co	Fort Payne	Dekalb	Alfred D. Brainerd. Birmingham, Ala.	....	....	....	96.12	0.11	1.69	SO_3 Trace. P_2O_5 0.01	*b*100.00
Longview Lime Works	Longview	Shelby	Wm. C. Stubbs, director Louisiana Sugar Experiment Station, New Orleans.	....	....	0.26	98.44	.98	*a* 0.18	CO_2 0.32	100.18
Do	do	do	A. L. Metz, chemist Louisiana State board of health.	1.55	0.56	.21	97.30	....	*a*.37	....	99.99

a Insoluble in acids. *b* Manganese dioxide, trace. *c* Includes 1.99 per cent as water, loss, and undetermined, P. 0.06 per cent and S. 0.2 per cent.

ARIZONA.

Sandstone.—The following information was submitted by the Arizona Sandstone Company, operating quarries at Flagstaff, Coconino County. The crushing-strength tests were made at the navy-yard, Washington, District of Columbia, in June, 1889:

Crushing tests of sandstone from Flagstaff, Coconino County.

No.	Dimensions.	Cracked at—	Crushed at—
	Inches.	*Pounds.*	*Pounds.*
1	2.01 by 2.03 by 1.98	23,000	23,490
2	2.00 by 2.02 by 2.00	24,000	25,110
3	2.00 by 2.01 by 2.01	25,000	25,490
4	2.00 by 2.00 by 2.00	22,100	22,440

The following analytical results were obtained by Prof. F. W. Clarke, of the United States Geological Survey:

Analysis of sandstone from Flagstaff, Coconino County.

	Per cent.
Silica (insoluble in acid), SiO_2	79.15
Soluble silica, SiO_2	.04
Alumina, Al_2O_3	1.30
Ferric oxide, Fe_2O_3	2.45
Ferrous oxide, FeO	None.
Lime, CaO	7.76
Magnesia, MgO	.23
Carbon dioxide, CO_2	5.77
Water (H_2O) at 110° C	.32
Water at red heat	2.94
Total	99.96

Specific gravity 2.346
Weight per cubic foot (dry) .... pounds.. 142
Percentage of water absorbed (saturated) 3.76

ARKANSAS.

Granite.—The following table of tests gives results obtained at the mechanical laboratory of the Rensselaer Polytechnic Institute at Troy, New York. The testing machine used was a Tinius Olsen of 50,000 pounds capacity. The specimens were compressed between pieces of bookbinders' board three-sixteenths inch in thickness.

Results of tests of Arkansas syenites.

No.	Description of specimens.	County.	Area of surface.	Actual crushing load.	Pressure per square inch.	Reduced to correspond to pressure per square inch in two-inch cubes.	Ratio of absorption—1 to —.	Specific gravity at 60° F.
			Sq. in.	*Pounds.*	*Pounds.*	*Pounds.*		
1	Light-colored elæolite syenite, slightly decomposed	Saline	2.34	48,000	20,500	22,350	761	2.62
2	"Gray granite," a very light-colored elæolite syenite	Pulaski.	2.25	33,750	14,000	16,000	83	2.45
3	Brownish elæolite porphyry, occurs in narrow dikes	....do	1.42	30,000	21,000	24,980	161	2.52
4	"Light-blue granite" (syenite)	....do	1.64	47,000	28,700	33,280	....	....
5	"Light-blue granite" (syenite), somewhat darker	....do	1.07	22,800	21,500	26,820	....	....
6	"Light-blue granite" (syenite), still darker	....do	1.57	35,950	22,900	26,745	1,673	2.64
7	"Medium-blue granite" (syenite)	....do	1.50	43,500	29,000	34,150	....	....
8	"Dark-blue granite" (syenite porphyry)	....do	1.57	43,800	27,900	32,630	4,530	2.69
	Mean of last five specimens. Average for "blue granite"	....do	....	....	26,000	30,740	....	....

The following analysis of the stone, quarried by Mr. Mark Liles, at his quarries at Beaver, Carroll County, was made at the Navy Department at Washington, District of Columbia:

Analysis of limestone quarried at Beaver, Carroll County.

	Per cent.
Silica, SiO_2	8.66
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	4.77
Calcium carbonate, $CaCO_3$	48.48
Magnesium carbonate, $MgCO_3$	33.58
Calcium sulphate, $CaSO_4$	.42
Water alkalies, etc	4.09
Total	100.00

The following analysis of stone, quarried by the Crescent White Lime Works, at their quarries at Johnson, Carroll County, was made by Prof. G. L. Teller, of the Arkansas Industrial Institute, at Fayetteville:

Analysis of limestone quarried at Johnson, Carroll County.

	Per cent.
Material insoluble in acid	0.39
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	.17
Calcium carbonate, $CaCO_3$	99.34
Moisture	.10
Total	100.00

The crushing strength was found to be 15,500 pounds to the square inch, by Professor Martin, of the same institution.

CALIFORNIA.

Granite.—The following is a statement of results obtained at the Watertown Arsenal on granite from the quarries of the Rocky Point Granite Works at Exeter, Tulare County:

Tests of granite from Exeter, Tulare County.

[Shearing test.]

Number.	Shearing dimensions.	Shearing area.	Transverse fracture developed.	Shearing strength.	
				Total.	Per square inch.
	Inches.	*Square inches.*	*Pounds.*	*Pounds.*	*Pounds.*
302	4.04 by 6 by 2	48.48	42,500	117,300	2,419

Analysis of granite from Exeter, Tulare County.

	Per cent.
Silica, SiO_2	75.35
Oxide of iron, Fe_2O_3	3.94
Oxide of aluminum, Al_2O_3	13.69
Oxide of calcium, CaO	2.97
Oxide of magnesium, MgO	.06
Oxide of sodium, Na_2O	1.14
Oxide of potassium, K_2O	2.85
Total	100.00

Transverse test of Exeter, Tulare County, granite.

[Ends supported 20 inches apart, loaded at the middle.]

Number.	Description.	Dimensions.		Ultimate strength.	
		Breadth.	Depth.	Total.	Modulus of rupture.
		Inches.	*Inches.*	*Pounds.*	*Pounds.*
432	Light colored	4.03	6.07	9,170	1,853

Coefficient of expansion=0.00000461 per inch.

The following is a statement of mechanical tests made at the Watertown Arsenal by Maj. J. W. Reilly on the granite quarried by the Rocklin Granite Company at their quarries at Rocklin, Placer County:

Tests of granite quarried at Rocklin, Placer County.

[Tests by compression, granite cubes, pyramidal fractures.]

No. of test.	Marks.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
		Height.	Compressed surface.				Total.	Per sq. inch.
		Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
9819	No. 1	3.96	3.96	3.96	15.68	332,000	342,100	21,817
9820	No. 2	3.94	3.97	3.96	15.72	329,000	340,900	21,686
9821	No. 3	3.96	3.96	3.97	15.72	271,000	311,400	19,809

Marble.—The following analysis of Inyo marble, quarried by the Inyo Marble Company at their quarries in Inyo County, near Owens Lake, was made at the State University:

Analyses of the Inyo County marble.

	Per cent.
Carbon dioxide, CO_2	47.353
Iron	.017
Calcium oxide, CaO	31.012
Magnesium oxide, MgO	21.791
Total	100.173

The following is from the State Mining Bureau report for 1890:

An analysis by Dr. W. D. Johnson and Mr. C. A. Ogden of a specimen of the purest white marble from the Inyo quarries shows that it is a typical and exceptionally pure dolomite. The composition of the sample analyzed was as follows:

	Per cent.
Carbonate of lime, $CaCO_3$	54.25
Carbonate of magnesium, $MgCO_3$	44.45
Iron and silica (clay)	.60
Total	99.30

Crushing strength of the marble is given as 29,000 pounds per square inch.

The following data as to the composition and properties of the marble of Colton, San Bernardino County, were obtained by Prof. E. W. Hilgard, of the University of California:

Composition of Colton marble.

	Per cent.
Carbonate of calcium, $CaCO_3$	92.9
Carbonate of magnesium, $MgCO_3$	4.5
Black minerals	2.6
Total	100.0

The black minerals consist of biotite and pyrolusite. The minerals coloring the marble are very refractory to the action of the air and will produce no spotting under ordinary conditions. The stone is therefore a very durable one under any conditions in which marble is likely to be placed, whether in rough ashlar work or with polished face.

Prof. Frank Soule, of the University of California, found the crushing strength to be 9,350 pounds to the square inch.

Sandstone.—The following analysis, specific gravity, and absorption tests upon the sandstone quarried by the Colusa Stone Company at their quarries at Colusa, Colusa County, were made by Messrs. Thomas Price & Son, analytical chemists, of San Francisco, in May, 1896:

Analysis of Colusa sandstone.

	Per cent.
Silica, SiO_2	85.99
Aluminum oxide, Al_2O_3	4.82
Iron oxide, Fe_2O_3	4.49
Calcium carbonate, $CaCO_3$	1.87
Magnesium oxide and alkalies	.76
Moisture	.69
Water of combination, organic matter, and loss	1.38
	100.00

Specific gravity 2.558
Water absorbed in 24 hours .... per cent.. 3.025

When heated to a red heat and plunged into water, the stone neither splinters nor cracks. It resists, without fusion, the temperature of a full white heat, not even the sharp edges of the stone being blunted. Plunged into water, after being subjected to a full white heat, the stone assumes a light-brown color.

We regard this as a very superior building stone.

The grains are small and uniform in size, thus forming a very compact rock, and one exceptionally well adapted for general use as a building material.

Three 1-inch cubes of the same stone were tested as to crushing strength by Mr. P. Noble, of the Pacific Rolling Mill Company, with the following results:

Crushing strength tests of Colusa sandstone.

	Pounds.
No. 1 broke at	8,940
No. 2 broke at	8,440
No. 3 broke at	8,880

COLORADO.

Marble.—Mr. Henry Wood, analytical chemist, found the following results in an analysis of the marble from the quarries of the Denver Onyx and Marble Company, Beulah, Pueblo County, Colorado:

Analysis of marble from Beulah, Pueblo County.

	Per cent.
Carbonate of lime, $CaCO_3$	98.00
Magnesia, MgO	.05
Iron (probably Fe_2O_3)	.04
Silica, SiO_2	.06
Total	98.15

CONNECTICUT.

Granite.—The following tests of crushing strength were made by Mr. Ira H. Woolson, M. E., of Columbia University, New York City, upon the granite quarried by the Columbia Granite Company from a quarry recently developed near the narrows of the Connecticut River, 4 miles southeast of Middletown, Middlesex County.

Crushing tests of granite from Middletown, Middlesex County; coarse-grained variety.

[Pounds per square inch.]

NINE SAMPLES FROM NORTHWEST END OF LEDGE.

Bed	23,000	Bed	22,525	Bed	23,542
Edge	21,450	Bed	22,475		
Edge	21,019	Bed	23,525	Average	23,029
Edge	24,278	Edge	25,450		

SEVEN SAMPLES FROM MIDDLE OF LEDGE.

Bed	21,460	Bed	21,921	Edge	20,470
Bed	22,058	Edge	22,797		
Bed	24,753	Edge	21,831	Average	22,184

Final average, 22,600 pounds per square inch.

Crushing tests of granite from Middletown, Middlesex County; fine-grained gray variety.

[Pounds per square inch.]

Bed	32,525	Bed	32,500	Bed	34,075
Bed	31,019	Bed	32,562	Edge	32,050
Bed	32,700	Bed	30,000	Edge	30,888
Edge	30,050	Bed	29,400	Bed	32,150

The following tabular statement shows the details involved in making the tests. The pieces used were all cubes:

Tests of granite from Middletown, Middlesex County.

COARSE-GRAINED GRANITE.

[Mark: "N. W. end of ledge."]

Test No.	How tested.	Length or height.	Diameter or breadth.	Thickness.	Area.	First crack.	Stress in pounds compression; maximum.	
							On specimen.	Per square inch.
		Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
1045	Bed	2.004	2.00	2.00	4.00	91,600	92,000	23,000
1046	Edge	2.002	2.00	2.00	4.00	84,000	85,800	21,450
1047	Edge	1.994	2.01	2.00	4.02	83,800	84,500	21,019
1048	Edge	2.005	2.01	2.00	4.02	97,500	97,600	24,278
1049	Bed	2.002	2.00	2.00	4.00	....	90,100	22,525
1050	Bed	2.001	2.00	2.00	4.00	....	94,100	23,525
1051	Bed	2.001	2.00	2.00	4.00	89,000	89,900	22,475
1052	Edge	2.001	2.00	2.00	4.00	101,000	101,800	25,450
1053	Bed	2.010	1.99	2.00	3.98	85,000	93,700	23,542

Tests of granite from Middletown, Middlesex County—Continued.

FINE-GRAINED GRAY GRANITE.

[Mark: "South end B."]

Test No.	How tested.	Length or height.	Diameter or breadth.	Thickness.	Area.	First crack.	Stress in pounds compression; maximum.	
							On specimen.	Per square inch.
		Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
1054	Bed...	2.007	2.00	2.00	4.00	126,500	130,100	32,525
1055	Bed...	2.002	2.00	2.01	4.02	95,500	124,700	31,019
1056	Bed...	2.007	2.00	2.00	4.00	129,000	130,800	32,700
1057	Edge..	2.001	2.00	2.00	4.00	119,000	120,200	30,050
1058	Bed...	2.000	2.00	2.00	4.00	....	130,000	32,500
1059	Bed...	2.002	1.99	2.00	3.98	128,900	129,600	32,562
1060	Bed...	2.007	2.01	2.00	4.02	110,000	120,600	30,000
1061	Bed...	2.001	2.00	2.00	4.00	....	117,600	29,400
1062	Bed...	1.998	2.00	2.00	4.00	135,000	136,300	34,075
1063	Edge..	2.001	2.00	2.00	4.00	127,800	128,200	32,050
1064	Edge..	1.999	1.99	1.99	3.94	....	121,700	30,888
1065	Bed...	2.004	2.00	2.00	4.00	128,000	128,600	32,150

COARSE-GRAINED GRANITE.

[Mark: "Middle ledge B."]

1066	Bed...	2.026	2.01	2.01	4.04	85,000	86,700	21,460
1067	Bed...	2.025	2.02	2.02	4.08	89,000	90,000	22,058
1068	Bed...	2.007	2.01	2.02	4.06	100,000	100,500	24,753
1069	Bed...	2.011	2.01	2.02	4.06	....	89,000	21,921
1070	Edge..	2.013	2.00	2.02	4.04	91,000	92,100	22,797
1071	Edge..	2.027	2.01	2.01	4.04	76,000	88,200	21,831
1072	Edge..	2.016	2.01	2.01	4.04	81,000	82,700	20,470

The following tests of crushing strength of granite quarried by the Booth Brothers and Hurricane Isle Granite Company at its quarries at Waterford, New London County, were made by Mr. Ira H. Woolson, M. E., of Columbia University, New York City:

Crushing strength of granite from Waterford, New London County.

[Two-inch cubes tested.]

No.	Size.	Area.	First crack.	Crushed at.	Maximum per square inch.
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
1575	2.1 high by 2.00 by 1.98....	3.96	65,000	93,100	23,510
1576	2.008 high by 2.03 by 2.01..	4.08	92,000	97,600	23,921

The following analysis of the same granite was made by Messrs. Ricketts and Banks, of New York City:

Analysis of granite from Waterford, New London County.

	Per cent.
Silica, SiO_2	68.11
Alumina, Al_2O_3	14.28
Ferrous oxide, FeO	2.63
Lime, CaO	1.86
Magnesia, MgO	.68
Sulphur	.34
Oxide of potassium, K_2O	5.46
Oxide of sodium, Na_2O	6.57
Total	99.93

The following gives the results of investigation of a trap rock at Meriden, New Haven County. The stone is used chiefly for road making and was quarried by the Byxbee De Peyster Trap Rock Company, of Meriden. The mechanical test was made with testing machine at Watertown Arsenal, Massachusetts, by Maj. J. W. Reilly.

Crushing test of trap rock quarried at Meriden, New Haven County.

Test No.	Sectional area.	First crack.	Ultimate strength.	Per square inch.
	Sq. inches.	*Pounds.*	*Pounds.*	*Pounds.*
8175	9.61	163,000	335,600	34,920

The following analysis was made at the mineralogical laboratory of Yale University, at New Haven, Connecticut, by Mr. J. H. Pratt, chemist.

Analysis of sample of trap rock quarried at Meriden, New Haven County.

	Per cent.
Silica, SiO_2	52.37
Aluminum oxide, Al_2O_3	15.06
Ferric oxide, Fe_2O_3	2.34
Ferrous oxide, FeO	9.82
Titanium oxide, TiO_2	.21
Manganous oxide, MnO	.32
Magnesium oxide, MgO	5.38
Calcium oxide, CaO	7.33
Potassium oxide, K_2O	.92
Sodium oxide, Na_2O	4.04
Water, H_2O	2.24
Total	100.03

Specific gravity = 2.965.

The following analysis of trap rock quarried by the Cooke Trap Rock Company at their quarry at Plainville, Hartford County, was made by Mr. Henry Souther, analyst, of Hartford:

Analysis of trap rock quarried at Plainville, Hartford County.

	Per cent.
Silica, SiO_2	50.26
Ferric oxide, Fe_2O_3	13.70
Aluminum oxide, Al_2O_3	15.16
Manganese oxide, MnO_2	.48
Calcium oxide, CaO	10.68
Magnesium oxide, MgO	5.49
Water, H_2O	4.23
Total	100.00

Sandstone.—The following analysis of sandstone quarried by the New England Brown Stone Company at their quarry at Cromwell, Middlesex County, was made by Mr. F. W. Taylor:

Analysis of sandstone quarried at Cromwell, Middlesex County.

	Per cent.
Silica, SiO_2	70.84
Alumina, Al_2O_3	13.15
Ferric oxide, Fe_2O_3	2.48
Calcium oxide, CaO	3.09
Magnesium oxide, MgO	Trace.
Manganese oxide	.70
Potassium oxide, K_2O	3.30
Sodium oxide, Na_2O	5.43
Carbon dioxide and loss	1.01
Total	100.00

The following table gives the results of a number of tests of Con-

Physical tests of sandstone

Name of firm quarrying stone.	Location of quarry.		Name and address of expert conducting tests.
	Town.	County.	
Brainerd, Shaler & Hall Quarry Co.	Portland	Middlesex	Prof. Ira H. Woolson, School of Mines, Columbia University, New York City.
Do	do	do	do
Do	do	do	do
Do	do	do	do
Do *a*	do	do	Maj. J. W. Reilly, Watertown Arsenal.
Do *a*	do	do	do
Do *b*	do	do	do
Do *c*	do	do	do
Do *d*	do	do	do
Do *d*	do	do	do
Middlesex Quarry Co	do	do	Prof. Ira H. Woolson, School of Mines, Columbia University, New York City.
Do	do	do	do
Do	do	do	do
Do	do	do	do
New England Brown Stone Co.	do	do	do
Do	do	do	do
Do	do	do	do
Do	do	do	do
Portland Quarries	do	do	Watertown Arsenal
Do	Middletown	do	General Gillmore, Chief of Engineers, report, 1875.
New England Brown Stone Co.	Cromwell	do	Watertown Arsenal

a First quality. *b* Second quality.

necticut sandstones:

quarried in Connecticut.

Compression tests.									
No. of test.	How tested.	Grain.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
			Height.	Compressed surface.				Total.	Per square inch.
			Inches.	*Inches.*	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	*Pounds.*
1657	Bed.....	Moderately coarse.	3.017	3.004	3.007	9.033	107,600	110,400	12,221
1658	....do ...	Fine......	2.977	3.000	3.011	9.033	98,200	98,200	10,871
1659	....do ...	.....do	3.007	3.022	3.003	9.075	112,400	112,400	12,385
1660	....do ...	Very coarse	3.011	3.014	3.005	9.057	102,300	102,400	11,306
7330	....	....	2.50	2.50	2.45	6.13	84,800	85,700	13,980
7331	....	....	2.50	2.48	2.47	6.13	81,700	81,700	13,330
7332	....	....	2.98	3.00	2.95	8.85	123,200	123,200	13,920
7333	....	....	2.95	2.98	2.97	8.85	122,000	132,950	15,020
7334	....	....	2.51	2.55	2.53	6.45	63,850	63,850	9,900
7335	....	....	2.48	2.48	2.52	6.25	58,340	58,340	9,330
1653	Bed.....	Fine......	3.017	3.017	3.019	9.108	100,000	105,700	11,605
1654	....do ...	.....do	2.982	3.005	2.989	8.981	94,000	94,000	10,466
1655	....do ...	.....do	3.000	3.010	3.019	9.087	75,200	87,500	9,629
1656	....do ..	.....do	3.006	2.983	3.015	8.993	111,000	112,400	12,498
1649	....do ...	.....do	3.019	3.020	2.995	9.044	111,800	117,100	12,947
1650	....do ...	.....do	3.037	3.010	3.035	9.135	110,000	110,000	12,041
1651	....do ...	.....do	3.021	3.043	3.034	9.232	117,100	117,100	12,947
1652	....do ...	.....do	3.026	3.035	3.048	9.250	92,400	98,000	10,594
....	....	....	....	....	....	....	....	....	12,580
....	....	....	....	....	....	....	....	....	6,250
....	....	....	....	....	....	....	....	....	16,890

c Third quality. *d* Bridge quality.

Physical tests of sandstone quarried

Name of firm quarrying stone.	Location of quarry.		Name and address of expert conducting tests.
	Town.	County.	
Brainerd, Shaler & Hall Quarry Co.	Portland	Middlesex	Prof. Ira H. Woolson, School of Mines, Columbia University, New York City.
Do	do	do	do
Do	do	do	do
Do	do	do	do
Middlesex Quarry Co	do	do	do
Do	do	do	do
Do	do	do	do
Do	do	do	do
New England Brown Stone Co.	do	do	do
Do	do	do	do
Portland Quarries	do	do	Watertown Arsenal
Do	Middletown	do	General Gillmore, Chief of Engineers, report, 1875.
New England Brown Stone Co.	Cromwell	do	Watertown Arsenal

in Connecticut—Continued.

Transverse tests.						Number of specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.
No. of test.	Distance between supports.	Dimensions.		Ultimate strength.					
		Breadth.	Depth.	Total.	Modulus of rupture.				
	Inches.	*Inches.*	*Inches.*	*Pounds.*				*Pounds.*	
1665	19	4.02	6.01	9,500	1,864				
1666	19	3.99	5.98	9,300	1,857				
1667	19	4.01	6.00	10,500	2,073				
1668	19	4.00	6.01	9,800	1,933				
1669	19	3.99	6.00	11,500	2,282				
1670	19	4.00	6.00	9,400	1,860				
1671	19	4.00	5.99	10,200	2,025				
1672	19	3.98	6.00	10,900	2,168				
1673	19	4.01	5.99	9,900	1,961				
1674	19	4.11	6.04	10,400	1,977				
						6	2.35	146.9	1–40
						2	2.63 2.36	148.5	1–40
						2	2.68 2.50	156.0	1–40

Limestone.—The following analyses of limestone quarried by the Canaan Lime Company at their quarries at Canaan, Litchfield County, and of the lime made from it were made by Mr. J. S. Adam, chemist:

Analysis of limestone quarried at Canaan, Litchfield County.

	Per cent.
Calcium carbonate, $CaCO_3$	54.40
Magnesium carbonate, $MgCO_3$	45.12
Oxides of iron and aluminum	.25
Silica, SiO_2	.08
Total	99.85

Analysis of lime from limestone quarried at Canaan, Litchfield County.

	Per cent.
Lime, CaO	56.57
Magnesia, MgO	42.56
Silica and alumina, SiO_2 and Al_2O_3	.42
Carbon dioxide and water	.10
Total	99.65

The following is an analysis of limestone quarried by Messrs. Canfield Brothers at their quarries at East Canaan, Litchfield County, made at the Connecticut Agricultural Experiment Station:

Analysis of limestone quarried at East Canaan, Litchfield County.

	Per cent.
Matter insoluble in acid	0.48
Oxides of iron and aluminum	.20
Lime, CaO	31.31
Magnesia, MgO	21.03
Carbon dioxide, CO_2	46.98
Total	100.00

DELAWARE.

Granite.—The following tests and analysis were made by Messrs. Booth, Garrett, and Blair, of Philadelphia, on the gneiss quarried by the Brandywine Granite Company, of Wilmington, Delaware, at their quarries at Rockford, Newcastle County.

Analysis and tests of granite from Rockford, Newcastle County.

	Per cent.
Loss on ignition, i. e., organic matter and moisture	0.30
Silica, SiO_2	67.98
Alumina, Al_2O_3	16.14
Ferrous oxide, FeO	4.39
Lime, CaO	5.89
Magnesia, MgO	53
Oxide of sodium, Na_2O	4.32
Oxide of potassium, K_2O	.45
Total	100.00

Specific gravity = 2.77.

Crushing test: On natural bed No. 1, 2 by 2 inches equals 4 square inches, at 100,300 pounds, equals 25,075 pounds per square inch. Across natural bed No. 2, 2 by 2 inches equals 4 square inches, at 99,000 pounds, equals 24,750 pounds per square inch.

Average: 24,913 pounds per square inch.

Absorption of water: Weight after drying twenty-four hours at 212° F., 1.20 pounds. Weight after immersing twenty-four hours in distilled water, 1.20 pounds. Water absorbed, 0.0 pounds or 0.0 per cent.

GEORGIA.

Granite.—The following results of crushing strength test were obtained by Maj. J. W. Reilly at the Watertown Arsenal upon granite, quarried by Venable Brothers at their quarries at Stone Mountain and Lithonia, Dekalb County:

Tests of granite quarried at Stone Mountain, Dekalb County.

No.	Pounds per square inch.	Position.
1	25,630	On bed.
2	28,130	On bed.

Tests of granite quarried at Lithonia, Dekalb County.

No.	Pounds per square inch.	Position.
1	30,320	On bed.
2	28,290	On bed.
3	28,250	On bed.

Marble.—The following tests, taken from Bulletin No. 1 of the Geological Survey of Georgia, 1894, were made at the University of Tennessee on a Tinius Olsen testing machine, capacity 20,000 pounds, upon inch cubes placed between pieces of dense cardboard one-sixteenth inch in thickness. The specimens were furnished by the Georgia Marble Company and the Southern Marble Company from their various quarries near Tate, Pickens County. The absorption tests were also made at the University of Tennessee.

Crushing tests of Georgia marble.[1]

Name of quarry.	Name of firm quarrying stone.	Compressed surface.	Position.	Actual crushing load.	Compressive strength per square inch.	Reduced to correspond to pressure per square inch on 2-inch cubes.*a*	Specific gravity.	Weight per cubic foot.
		Inches.		*Pounds.*	*Pounds.*	*Lbs. per sq. in.*		
Kennesaw, No. 1	Georgia Marble Co.	0.99 by 0.99	Bed.	10,000	*b*10,204	12,244		
Kennesaw, No. 2	do	1.00 by 1.00	Bed.	11,400	*c*11,400	13,680	2.717	169.8
Kennesaw, No. 3	do	1.00 by 1.00	Bed.	10,672	*d*10,672	12,806		
Creole, No. 1	do	1.00 by 1.00	Bed.	13,900	*d*13,900	16,680		
Creole, No. 2	do	1.00 by 1.00	Bed.	13,100	*d*13,100	15,700	2.763	172.6
Creole, No. 3	do	1.00 by 1.00	Bed.	13,200	13,200	15,840		
Etowah, No. 1	do	1.00 by 1.00	Bed.	13,200	13,200	15,840		
Etowah, No. 2	do	.99 by .99	Bed.	12,000	12,244	14,692	2.707	169.1
Etowah, No. 3	do	.99 by .98	Bed.	12,300	12,540	15,048		
Southern, No. 1	Southern Marble Co.	.99 by 1.00	Bed.	11,300	11,414	13,696		
Southern, No. 2	do	.99 by 1.00	Bed.	10,900	11,010	13,212	2,734	171.8
Southern, No. 3	do	.98 by 1.00	Bed.	10,800	11,020	13,224		

a Gen. Q. A. Gillmore, in his report on the compressive strength of building stones of the United States, Appendix II, Annual Report of the Chief of Engineers for 1875, determined a general formula for converting the crushing strength of different cubes into each other. In applying this formula for 1 and 2 inch cubes, it is found that the crushing weight of the smaller cube should be increased by approximately one-fifth of itself, in order to compare correctly the strength of the two cubes.

b Cracked on edge before bursting.

c Burst suddenly.

d Burst with explosion.

[1] The Survey is under obligations to Prof. Charles Ferris, of the engineering department of the University of Tennessee, for valuable aid rendered in making the crushing and absorption tests.

Absorption tests of Georgia marble.

Name of firm, quarrying stone.	Name of quarry.	Weight, after drying for 24 hours at 212° F.	Weight, after remaining in water for 72 hours at about 60° F.	Approximate percentage of absorption.
		Grams.	*Grams.*	*Per cent.*
Georgia Marble Co	Kennesaw	45.160	45.200	0.008
Do	Creole	44.320	44.335	.004
Do	Etowah	42.215	42.240	.005
Southern Marble Co	No. 1	46.170	46.200	.006
Do	No. 2	44.440	44.475	.008

The following artificial weathering tests taken from Bulletin No. 1 of the Geological Survey of Georgia, 1894, were made by W. H. Emerson, Ph. D., upon specimens furnished by the Georgia Marble Company from their quarries near Tate, Pickens County. The specimens were suspended for several days in an atmosphere of hydrochloric, sulphurous and carbonic acids.

Weathering tests of marble from Pickens County.

No.		Original weight.	Final weight.	Loss.
		Grams.	*Grams.*	*Grams.*
1	Polished	45.0868	44.9337	.1531
1	Unpolished	45.9492	45.7793	.1699
3	Do	44.2569	44.1240	.1329
6	Do	42.1369	41.9943	.1426

It is noticeable that the unpolished cube of No. 1 was dissolved with considerable more readiness than the polished.

The following chemical analyses were also made by Dr. Emerson. The samples were taken from various localities in Georgia, as indicated by the explanatory notes appended.

Chemical analyses of Georgia marbles.

No.	Calcium oxide.	Magnesium oxide.	Ferric oxide and alumina.	Insoluble siliceous matter.	Loss on ignition.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	54.06	0.90	0.10	2.12	42.86	100.04
2	32.73	19.37	.35	0.73	46.58	99.76
3	55.00	1.12	.15	.35	44.16	100.76
4	31.53	21.30	.24	.10	47.26	100.43
5	31.61	21.06	.78	1.01	46.49	100.95
6	54.41	.75	.32	1.62	43.13	100.23
7	54.67	1.01	.42	.76	43.49	100.35
8	52.77	.82	3.28	1.43	41.85	100.15
9	24.07	17.24	.43	21.76	37.08	100.58
10	30.42	19.86	.91	4.23	(*a*)	----------
11	31.89	19.64	.74	1.73	(*a*)	----------

a Undetermined.

1. A coarsely crystalline, white marble, from the Cherokee quarry (Georgia Marble Company), Pickens County.
2. A white, fine-grained marble, from Mr. J. P. Harrison's quarry, 2 miles east of Jasper.
3. A coarse-grained, black-and-white mottled marble, "Creole," of the Georgia quarries.
4. A fine-grained, gray marble, from the Dickey property.
5. A fine-grained, bluish-gray marble, from the Holt property.
6. A coarse-grained flesh-colored marble, "Etowah," of the Georgia quarries.
7. A coarse-grained, gray marble, from the Eslinger farm.
8. A coarse-grained, brown marble, from the Haskins farm.
9. A fine-grained, light-gray marble, from the White property.
10. A fine-grained, black marble from Six Mile Station.
11. A fine-grained, white marble, from Fannin County.

The following analysis of marble quarried by the Southern Marble Company at their quarries at Marblehill, Pickens County, was made by L. P. Kinnicutt, Ph. D., of the Institute of Technology, Worcester, Massachusetts:

Analysis of marble from Marblehill, Pickens County.

	Per cent.
Carbonate of calcium, $CaCo_3$	98.96
Aluminum and iron oxides, Al_2O_3 and Fe_2O_3	.22
Insoluble residue	.61
Loss and undetermined	.08
Total	99.87

The following is an analysis of Pickens County marble, quarried by the Georgia Marble Company at their quarries near Tate, Pickens County, made by Mr. John C. Jackson, of Chicago:

Analysis of Pickens County marble.

	Per cent.
Calcium carbonate, $CaCO_3$	97.32
Magnesium carbonate, $MgCO_3$	1.60
Silica, SiO_2	.62
Iron protoxide, FeO	.26
Alumina, Al_2O_3	.25
Total	100.05

The following tests, by compression, of the strength of three cubes of Georgia marble, quarried by the Georgia Marble Company at their quarries near Tate, Pickens County, made in 1886 by Capt. Marcus W. Lyon, United States Army, with the testing machine at Watertown Arsenal, Massachusetts, serve to indicate the crushing strength of this marble:

Mechanical tests of Georgia marble.

Test No.	Marks.	Dimensions.		Sectional area.	Ultimate strength.	
		Height.	Compressed surface.		Total pounds.	Pounds per square inch.
		Inches.	*Inches.*	*Sq. Inch.*		
4337	Cherokee	6.04	6.01 by 6.00	36.06	395,800	10,976
4338	Creole	6.03	6.00 by 5.99	36.94	434,100	12,078
4339	Etowah	6.03	6.03 by 6.01	36.12	384,400	10,642

Limestone.—The following analyses of lime and limestone, quarried by the A. C. Ladd Lime Works at their quarries at Bartow, Jefferson County, were made by Mr. N. P. Pratt, formerly State mineralogist:

Analysis of lime from Bartow, Jefferson County.

	Per cent.
Lime, CaO	34.070
Magnesia, MgO	55.736
Alumina and iron oxide	1.236
Silica, SiO_2	7.252
Moisture	1.622
Total	99.916

Analysis of limestone from Bartow, Jefferson County.

	Per cent.
Calcium carbonate, $CaCO_3$	56.02
Magnesium carbonate, $MgCO_3$	38.43
Alumina and iron oxide	1.50
Silica, SiO_2	1.94
Moisture	0.00
Total	97.89

Slate.—The following analysis of slate, quarried by the Georgia Slate Company at their quarries at Rockmart, Polk County, was made by Messrs. J. W. Slocum and H. H. Van Deventer, chemists, of Knoxville, Tennessee:

Analysis of Rockmart slate.

	Per cent.
Silica, SiO_2	58.20
Alumina, Al_2O_3	18.83
Protoxide of iron, FeO	5.78
Lime, CaO	4.35
Magnesia, MgO	3.51
Potassium oxide, K_2O	2.51
Sodium oxide, Na_2O	.69
Carbon, C	.82
Carbonic acid, CO_2	.60
Sulphur, S	.49
Water, H_2O	4.07
Titanic acid, TiO_2	.10
Lithia, Li_2O	.02
Oxide of manganese	Trace.
Total	99.97

ILLINOIS.

Limestone.—The following is a table of analyses of limestone quarried in Illinois:

Analyses of limestone quarried in Illinois.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst	Substances determined.							
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Silica, SiO_2.	Insoluble matter.	Water and loss.	Moisture, organic matter, and alkalies.	Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Chicago Union Lime Works Co.	Chicago	Cook	J. Blodget Britton, Ironmasters' Laboratory, Warrenton, Va.	52.76	45.04	1.48		0.21	0.51		100.00
Marble Head Lime Co.	Marble Head	Adams	N. Gray Bartlett, 94 22d st., Chicago, Ill.	95.62	.82	2.18	0.47			0.91	100.00
F. W. Menke Stone and Lime Co.	Quincy	do	C. G. Hopkins, University of Illinois.	92.77	6.75	.27		.37			100.16
Stearns Stone and Lime Co.	Chicago	Cook	T. C. Hopkins, State College, Pa.	52.75	44.28	.55		.60			98.18
Artesian Stone and Lime Co.:											
Average of quarry	do	do	do	53.70	42.34	1.04		1.28			98.36
Lumpy layer	do	do	do	52.07	42.18	1.78		4.00			100.03
Union Lime Co.	do	do	do	54.99	44.04	.58		.87			100.48
Blue Island quarry	do	do	do	23.39	19.40	2.04	.34	54.15			99.32
Insoluble portion of Blue Island quarry stone.	do	do	do			15.70	75.35			*a* 9.58	
Stony Island avenue quarry	do	do	do	52.08	37.54						89.62

a Includes 1.03 per cent of magnesia, MgO.

The following analysis was made by Prof. S. E. Swartz, Shurtleff College, Upper Alton, Illinois, of lime made from limestone quarried by Mr. John Armstrong at his quarries at Alton, Madison County:

Analysis of lime from limestone quarried at Alton, Madison County.

	Per cent.
Calcium oxide, CaO	97.72
Ferrous oxide, FeO	.20
Alumina, Al_2O_3	1.10
Silica, SiO_2	1.01
Magnesia, MgO	None.
Total	100.03

The following is a partial analysis of the stone quarried by the Kankakee Stone and Lime Company at their quarries at Kankakee, Kankakee County, made by Mr. C. S. Robinson, chemist of Illinois Steel Company:

Analysis of limestone from Kankakee, Kankakee County.

	Per cent.
Silica, SiO_2	3.00
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	2.50
Calcium oxide, CaO	30.45
Magnesium oxide, MgO	20.50
Phosphorus	.006

The following data in regard to the same stone were secured by Prof. C. W. Rolfe, of the Illinois State University, at Champaign:

Weight per cubic foot, 165.75 pounds; specific gravity, 2.65; crushing strength, 13,544 pounds to the square inch.

INDIANA.

Sandstone.—The following results of crushing strength test and chemical analysis of sandstone quarried by Messrs. Guyer and Burchby at Riverside, Fountain County, were obtained by Prof. W. S. Blatchley, State geologist:

Crushing tests of Riverside sandstone.

No.	Sample.	Pounds per square inch.
1	Gray	6,000
2	Blue	6,090

Analysis of Riverside sandstone.

	Per cent.
Insoluble residue, SiO_2	93.16
Alumina, Al_2O_3	1.60
Ferric oxide, Fe_2O_3	2.69
Lime, CaO	.13
Total	97.58

Analyses of sandstone quarried in Indiana.

Name of firm quarrying stone.	Location of quarry.		Name of analyst.	Substances determined.						
	Town.	County.		Silica, SiO_2.	Alumina, Al_2O_3.	Ferric oxide, Fe_2O_3.	Calcium oxide, CaO.	Carbon dioxide, CO_2.		Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
	Portland *a*	Jay		91.18	2.14	1.12	*e*0.86		MgO 1.41 H_2O 3.29	100.00
	Mansfield	Parke	W. A. Noyes, Rose Polytechnic.	92.16		6.29	.05		Alkalies 0.09	98.59
J. B. Lynne & Sons *b*	St. Anthony	Dubois	do	*c*88.41	.63	8.40	.13	0.10		97.67
	Bloomfield	Greene	do	*c*85.29	.19	11.83	.06	.05		97.42
	Greenhill	Warren	do	*c*98.73	.28	.36	.03	.02		99.42
	Hillsboro	Fountain	do	*c*91.65	.56	6.60	.12	.10		99.03
	Judson	Parke	do	*d*93.21	.51	4.91	.12	.10		98.85
	Fountain	Fountain	do	*d*91.66	.60	6.44	.05	.04		98.79
Williamsport Stone Co.	Williamsport	Warren	do	*d*98.57	.05	.65	.02	.02		99.31
F. S. Pauline & Co	Cannelton	Perry	do	*d*96.18	.54	1.56	.15			98.43

a Professor Kramer, of Cincinnati, Ohio, gives crushing strength of this stone as 6,825 pounds per square inch.
b Crushing strength given as 3,000 pounds per square inch and ratio of absorption 1-13.
c Includes silica and insoluble silicates.
d Insoluble in hydrochloric acid.
e Calcium carbonate.

Limestone.—The following table gives the results of a number of analyses of limestone quarried in Indiana:

Analyses of limestone quarried in Indiana.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.												
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Silica, SiO_2.	Ferric oxide, Fe_2O_3.	Alumina, Al_2O_3.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Water and loss at 212° F.	Carbon dioxide, CO_2.	Loss and undetermined.	Sulphuric anhydride, SO_3.	Total.
				Per ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per ct.*	*P. ct.*	*P. ct.*	*Per ct.*	*P. ct.*	*P. ct.*	*Per cent.*
Acme Bedford Stone Co.	Clear Creek.	Monroe	W. S. Blatchley, State geologist, Rose Polytechnic Institute.	97.39	0.78	0.13	*a*0.84			*c*0.10						99.24
Bedford Quarries Co.	Bedford	Lawrence	F. W. Clarke, chief chemist U. S. Geological Survey.	97.26			1.69	0.49			0.37	0.19				100.00
Bedford Portland Cement Co.:																
No. 1	do	do	Prof. A. W. Smith, Case School of Applied Science, Cleveland, Ohio.				.89	*b*.25	0.38	54.48	.36		43.40			99.76
No. 2	do	do	do				.87	.13	.34	54.68	.32		43.44			99.78
Bedford Indiana Stone Co.	do	do	do	98.27	.84	.15	*a*.64									99.90
Hunter Valley Quarry			do	98.11	.92	.16	*a*.86									100.05
Romona Quarry	Romona	Owen	do	97.90	.65	.18	*a*1.26									99.99
Twin Creek Quarry	Salem	Washington	do	98.16	.97	.15	*a*.76									100.04
Hoosier Quarry (buff)			do	98.20	.39		*a*.63	.39								99.61
Salem Quarry			do	96.04	.72	1.06	*a*1.13			*d*0.15		.10				
Mauckport Quarry	Mauckport	Harrison	do	98.09			*a*.31	.18	.14	*d*0.40		.12				
Big Creek Quarry			do	93.80	4.01		*a*.15	.64				1.09				99.69

a Insoluble in acid. *b* Including 0.13 of ferrous oxide. *c* Sodium oxide. *d* Potassium and sodium oxides.

Analyses of limestone quarried in Indiana—Continued.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.												
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Silica, SiO_2.	Ferric oxide, Fe_2O_3.	Alumina, Al_2O_3.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Water and loss at 212° F.	Carbon dioxide, CO_2.	Loss and undetermined.	Sulphuric anhydride, SO_3.	Total.
				Per ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per ct.*	*P. ct.*	*P. ct.*	*Per ct.*	*P. ct.*	*P. ct.*	*Per cent.*
Defenbaugh & Smith:																
No. 1	Kokomo	Howard	Grasselli Chemical Co	98.66			.24	Trace	.43		Trace					99.33
No. 2	do	do	do	97.05			1.62	.16	.60		.36				Trace	99.79
Baltes Land, Stone, and Oil Co.:																
Top rock	Montpelier	Blackford	S. S. Gorby, State geologist			4.70	2.75			42.92	3.88	.95	41.20	2.81	0.79	100.00
Intermediate rock	do	do	do			5.25	2.68			42.55	4.40	1.25	39.10	3.68	1.09	100.00
Bottom rock	do	do	do			5.17	2.43			43.01	4.18	1.00	41.55	1.78	.88	100.00
Huntington White Lime Co.	Huntington	Huntington	G. M. Levette, Indianapolis, Ind.			4.70	2.75			42.92	4.41	.95	41.20	1.82	1.25	100.00
Indiana Macadam and Construction Co.	Rensselaer	White	W. E. Stone, professor of chemistry, Purdue University.	56.28	43.26	.14	*a* .33									100.01
J. A. Derbyshire	Laurel	Franklin	Prof. W. A. Noyes, Rose Polytechnic Institute, Terre Haute, Ind.	43.67	20.60	11.01	21.51			*b* 1.55		1.39				99.73
Romona Oolitic Stone Co.	Romona	Owen	do			.18	*c* 1.26			54.82	.31		43.49			100.06
Peru Stone and Lime Co.	Peru	Miami	J. N. Hurtz, Indianapolis, Ind.	52.90	38.94		4.05	1.20	1.25			2.63				100.97
Casparis Stone Co	Kenneth	Cass	S. S. Gorby, State geologist.	93.48		2.07	1.33				1.16	1.57		.39		100.00
Twin Creek Stone and Land Co.	Salem	Washington	Prof. W. A. Noyes, Rose Polytechnic Institute.			.15	*c* .76			54.97	.46		43.68			100.02

a Includes 0.25 per cent insoluble in acids.

b Potassium and sodium oxides.

c Insoluble in acid.

The following table gives the physical characteristics of the Bedford oölitic limestone:

Physical characteristics of Bedford oölitic limestone.

Operators.	Locality.	County.	Crushing strength per square inch.	Number of specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Authority.
			Pounds.			*Pounds.*		
G. K. Perry	Ellettsville	Monroe	10,000	4			1-31	Rose Polytechnic Institute.
Matthews Bros.	do	do	13,500			142.2	1-28	General Gillmore.
Indiana Steam Stone Works.	Stinesville	do	5,600	3			1-17	Rose Polytechnic Institute.
Hunter Valley Stone Co.	Bloomington.	do	4,100	3			1-14	Do.
Hunter Brothers Stone Co.	do	do	5,700	3	2.46	153.7	1-19	Do.
Crescent Stone Co.	do	do	5,700	3			1-15	Do.
Romona Oölitic Stone Co.	Romona	Owen	9,100	4	2.48	155	1-39	Do.
Bedford, Ind., Stone Co.	Bedford	Lawrence	5,600	3	2.47	154.4	1-23	Do.
The Chicago and Bedford Stone Co.	do	do	8,600	3			1-31	Do.
Bedford Quarries Co.	do	do	4,450	4			1-15	Do.
Dark Hollow Stone Co.	Bedford	Washington.	6,625			142.9	1-19	General Gillmore.
Twin Creek Stone Co.	Salem	do	9,900	3	2.51	156.9	1-31	Rose Polytechnic Institute.

IOWA.

Limestone.—The following analysis of limestone quarried by Messrs. L. B. Stuart & Co. at their quarry at Monmouth, Jackson County, was made by Prof. Samuel Calvin, State geologist.

Analysis of limestone quarried at Monmouth, Jackson County.

	Per cent.
Insoluble silicates (sand)	0.42
Ferric oxide, Fe_2O_3	.53
Calcium carbonate, $CaCo_3$	57.54
Magnesium carbonate, $MgCo_3$	41.51
Total	100.00

The following physical data were obtained by Messrs. R. H. Hollembeak and W. M. Jones, of Iowa State Agricultural College, upon limestone from the quarries of the Le Grande Quarry Company, of Le Grande, Marshall County.

Physical tests of Le Grande limestone.

Quarry.	Crushing tests.				Absorption in 180 hours.			
	No.	Strength per square inch.	No.	Strength per square inch.	No.	Per cent.	No.	Per cent.
		Pounds.		*Pounds.*				
North quarry	11	(*a*)	12	(*a*)	3	1.79	2	0.77
Do					7	1.32		
South quarry	15	(*a*)	26	15,940				
West quarry	28	9,773	31	15,940	30	1.83	29	1.70
North quarry	1	9,390			25	6.54		
South quarry	36	10,375	35	10,400	13	5.10		
Do	37	10,930						
West quarry	16	15,360			19	3.92	17	3.63
Do					18	4.70		
North quarry	*a*10	10,825	9	11,055	8	4.53	49	5.55
South quarry	39	(*a*)	42	(*a*)	41	1.50	40	2.69
North quarry	27	(*b*)	24	(*b*)	*b*10	2.03		
Timber Creek quarry	33	8,712	34	8,383	32	3.20	45	5.35
North quarry	4	13,450	5	14,970	20	2.75	21	4.05
Do	6	10,260						
South quarry	22	12,740	23	14,250	38	2.62	44	2.21
Do	43	13,250			46	2.66		

No.	Locality.	Kind of stone.	Crushing strength per square inch.		Percentage of absorption in 192 hours.	Percentage of loss in weight, freezing 20 times.	Sp. gr.
			Before freezing.	After freezing 20 times.			
			Pounds.	*Pounds.*	*Per ct.*	*Per ct.*	
6J	Le Grande	Buff fossiliferous limestone.	6,640	5,670	5.96	0.03	2.288
5J	do	"Iowa marble," buff limestone, veined.	12,100	12,625	3.61	.07	2.454
3J	do	"Caen stone," buff magnesian limestone.	6,600	(*a*)	6.26	4.65	2.304
4J	do	Hard blue limestone	23,985	26,200	.83	.06	2.451
2J	do	Gray oölitic limestone	7,440	6,380	4.21	.03	2.396
1A	Stone City	Warm, gray dolomitic limestone.	3,375	4,185	9.77	.18	2.029
2A	do	do	3,500	5,000	10.06	.10	2.073
3A	do	do	9,040	6,360	6.86	.02	2.158

a Not broken because so badly disintegrated. *b* (?).

Sandstone.—The following tests were made by Messrs. R. H. Hollembeak and W. M. Jones, of Iowa State Agricultural College, upon blue-gray calcareous sandstone quarried at La Grande:

Crushing strength. Before freezing.	Crushing strength. After freezing 20 times.	Percentage of absorption in 192 hours.	Percentage of loss after freezing 20 times.	Specific gravity.
Lbs. per sq. in.		*Per cent.*	*Per cent.*	
6,805	Too badly disintegrated..	4.66	1.85	2.029

KANSAS.

Sandstone.—The following table gives the results of a number of analyses of sandstone quarried in Kansas:

Tests and analyses of sandstone quarried in Kansas.

Name of firm quarrying stone.	Location of quarry. Town.	Location of quarry. County.	Name and address of analyst.	Crushing strength per square inch.	Weight per cubic foot.	Specific gravity.	Ratio of absorption.
				Pounds.	*Pounds.*		*Per cent.*
James McGinty .	Valley Falls.	Jefferson.	Dr. S. W. Williston, Lawrence, Kans.	1,612	152.3	2.44	0.12
Ezekiel Marsh *a*.	....	....do ...	.....do............	8,057	153.2	2.45	.01

Name of firm quarrying stone.	Location of quarry. Town.	Location of quarry. County.	Name and address of analyst.	Analyses. Insoluble matter.	Oxides of iron and aluminum.	Calcium carbonate $CaCO_3$.	Magnesium carbonate $MgCO_3$.	Sulphate.	Total.
				Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
James McGinty .	Valley Falls.	Jefferson.	Dr. S. W. Williston, Lawrence, Kans.	94.35	2.35	1.14	1.01	0.42	99.27
Ezekiel Marsh *a*.	....	....do ...	.....do.........	97.71	1.31	.21	.54	.23	100.00

a Average of 5 blocks.

Limestone.—The following table gives the results of a number of analyses of limestone quarried in Kansas:

Tests and analyses of limestone quarried in Kansas.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Crushing strength.	Weight per cubic foot.	Specific gravity.	Ratio of absorption.	Substances determined by analyses.					
	Town.	County.						Insoluble matter.	Oxides of iron and aluminum.	Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Sulphates.	Total.
				Pounds.	*Pounds*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*
H. Heddeman	Cambridge	Cowley	Dr. S. W. Williston, Lawrence, Kans.	12,567	164.5	2.63	0.01	3.34	1.69	93.98	0.94	....	99.95
I. Kuhn & Co.	Marion	Marion	....do	12,364	168.2	2.69	.03	5.51	1.24	91.50	1.62	....	98.87
Do	....do	....do	....do	13,711	170.7	2.73	.04	6.75	1.59	51.05	40.51	....	99.90
Do	....do	....do	....do	8,136	167.6	2.68	.05	13.51	1.65	61.64	22.72	....	99.52
Ulrich Bros	Monterey	Riley	....do	3,272	159.1	2.55	.07	....	....	....	....	....	....
Bittiger Bros	Cottonwood Falls.	Chase	....do	6,800	161.6	2.59	.04	8.57	3.62	84.72	1.75	0.90	99.56
Frey Bros	Horton	Brown	....do	4,721	164.5	2.63	.06	11.83	5.53	81.91	1.56	.05	100.88
A. Zechser	Alma	Wabaunsee	....do	7,646	161.3	2.58	.05	9.12	.70	88.55	1.25	....	99.62
A. W. Charles	....	Jackson	....do	11,005	163.5	2.62	.02	10.93	2.02	83.99	2.66	.14	99.74

KENTUCKY.

Sandstone.—The following is an analysis of blue sandstone quarried by the Rockcastle Stone Company, at their quarries at Langford, Rockcastle County, by Mr. W. M. Mew:

Analysis of sandstone quarried at Langford, Rockcastle County.

	Per cent.
Silica, SiO_2	91.075
Oxide of iron and alumina, Fe_2O_3 and Al_2O_3	4.920
Lime, CaO	1.187
Water	2.361
Total	99.543

The stone absorbs 3 per cent of water.

The same stone was tested at the Watertown Arsenal, by Capt. Ira MacNutt, with the following results:

Tests of sandstone quarried at Langford, Rockcastle County.

Test No.	Marks.	How tested.	Dimensions.			Sectional area.	Ultimate strength.	
			Height.	Compressed surface.			Total.	Per sq. in.
			Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*
5485	Upper ledge.	On bed	2.01	2.00	2.02	4.04	61,250	15,160
5486	......do	On edge	2.03	2.00	2.02	4.04	49,320	12,208
5487	Lower ledge.	On bed	2.03	2.01	2.01	4.04	61,050	15,111
5488	......do	On edge	2.03	2.00	2.00	4.00	49,900	12,475

Crack appeared in No. 5486 at 47,500 pounds.
Crack appeared in No. 5488 at 43,000 pounds.
Fractures all pyramidal.

Limestone.—The following analysis of limestone quarried by the Caden Stone Company at their quarries in Warren County was made by Prof. W. E. Stone, of Purdue University:

Analysis of limestone quarried in Warren County.

	Per cent.
Moisture	0.38
Organic—Combustible	3.31
Oxide of iron, Fe_2O_3	.22
Silica, SiO_2	.76
Lime, CaO	54.80
Oxides of potassium and sodium	6.48
Carbon dioxide, CO_2	33.00
Magnesium oxide, MgO	Trace not determined.
Sulphuric anhydride, SO_3	
Phosphoric anhydride, P_2O_5	
Total	98.95

The following compression tests of the same stone were made February 13, 1890, at the Watertown Arsenal under the direction of Lieut. Col. D. W. Flagler:

[Compressed surfaces faced with plaster of paris to secure even bearings in the testing machine.]

Compression tests of limestone from Warren County.

Test No.	Marks.	How tested.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
			Height.	Compressed surface.				Total.	Pounds per square inch.
			Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	
6443	1	On bed..	4.98	5.07	4.96	25.15	170,900	170,900	6,795
6444	1	On edge.	5.07	4.98	4.93	24.55	179,800	179,800	7,324
6445	2	On bed..	4.94	5.05	5.05	25.30	187,850	187,850	7,425
6446	2	On edge.	5.03	4.87	4.87	24.45	138,300	138,300	5,656
6447	3	On bed..	5.02	5.05	5.05	25.50	172,700	172,700	6,773
6448	3	On edge.	5.03	5.00	5.00	25.05	154,800	154,800	6,180

Pyramidal fractures.

MAINE.

Granite.—The following statements by Mr. F. L. Bartlett, of the Maine State assay office, have been made relative to the granite quarried by Mr. E. B. Mallet, jr., at his quarry at Freeport, Cumberland County:

Analysis of granite quarried at Freeport, Cumberland County.

	Per cent.
Specific gravity	2.627
Hardness	Medium.
Iron in form of pyrite	None.
Iron in form of oxide in combination	1.872
Per cent insoluble in strong acids	95.200
Per cent soluble in dilute acids	None.
Absorption in water	None appreciable.

The following tests of granite quarried by Messrs S. L. Treat & Son at their quarries at Millbridge, Washington County, were made at the Watertown Arsenal under the direction of Maj. J. W. Reilly:

Tests of granite from Millbridge, Washington County.

COMPRESSIVE ELASTIC PROPERTIES.

[Sectional area, 4."12 × 6."09 = 25.09 square inches. Gaged length, 20".]

Applied loads.		In gaged length.		Remarks.
Total.	Per square inch.	Compression.	Set.	
Pounds.	*Pounds.*	*Inch.*	*Inch.*	
2,509	100	0	0	Initial load.
25,090	1,000	.0023		
50,180	2,000	.0047		
75,270	3,000	.0069		
100,360	4,000	.0089		Modulus of elasticity E = 9,800,000.
125,450	5,000	.0108		
100,360	4,000	.0089		
75,270	3,000	.0069		
50,180	2,000	.0050		
25,090	1,000	.0030		
2,509	100		.0008	
25,090	1,000	.0027		
50,180	2,000	.0045		
75,270	3,000	.0067		
100,360	4,000	.0088		
125,450	5,000	.0108		
100,360	4,000	.0089		
75,270	3,000	.0069		
50,180	2,000	.0049		
25,090	1,000	.0030		
2,509	100		.0008	

Tests of granite from Millbridge, Washington County—Continued.

LATERAL EXPANSION.

[Gaged length, 5.5″.]

Applied loads.		In gaged length.		Remarks.
Total.	Per square inch.	Compression.	Set.	
Pounds.	*Pounds.*	*Inch.*	*Inch.*	
2,509	100	0	0	Initial load.
125,450	5,000	.0005	....	
2,509	100	....	.0001	Ratio of lateral expansion to longitudinal compression, 1 to 6.8.
125,450	5,000	.0005	....	
2,509	100	....	.0001	

This specimen used in transverse test No. 391.

SHEARING TEST.

[Light-colored stone.]

No. of test.	Shearing dimensions.	Shearing area.	Transverse fracture developed on tension side.	Shearing strength.		Surfaces sheared.
				Total.	Per square inch.	
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*	
309	4.02 by 5.99 by 2	48.16	43,800	135,800	2,820	One.

TRANSVERSE TESTS.

[Ends supported 20″ apart; loaded over length of 1″ at middle.]

No. of test.	Dimensions.		Ultimate strength.		Remarks.
	Breadth.	Depth.	Total.	Modulus of rupture R.	
	Inches.	*Inches.*	*Pounds.*	*Pounds.*	
391	4.12	6.09	10,540	2,069	
424	4.13	6.08	10,320	2,027	Had been previously exposed to hot and cold water baths during observations made on the coefficient of expansion by heat.

Coefficient of expansion 0.00000400 between 32° and 212° F.

The following tests of granite quarried by the Booth Bros. and Hurricane Isle Granite Company at their quarries at Hurricane Island, Jonesboro, and Waldoboro, were made by Prof. Ira H. Woolson, School of Mines, Columbia College:

Compression tests of granite quarried in Maine.

Name of quarry.	Location of quarry.	County.	No. of test.	Dimensions.		
				Height.	Breadth.	Thickness.
				Inches.	*Inches.*	*Inches.*
Hurricane Isle.	Hurricane Island.	Knox	1709	2.017	2.018	2.022
Jonesboro Red.	Jonesboro	Washington.	1711	2.01	2.016	2.013
Maine White	Waldoboro	Lincoln	1714	2.01	2.013	2.012

Name of quarry.	Location of quarry.	County.	Sectional area.	First crack.	Ultimate strength.	
					Total.	Per square inch.
			Inches.	*Pounds.*	*Pounds.*	*Pounds.*
Hurricane Isle.	Hurricane Island.	Knox	4.08	72,000	79,900	19,583
Jonesboro Red.	Jonesboro	Washington.	4.06	84,900	100,500	24,507
Maine White	Waldoboro	Lincoln	4.05	....	93,600	23,111

The following analysis of granite quarried by the Booth Bros. and Hurricane Isle Granite Company at their quarry at Waldoboro, Lincoln County, was made by Messrs. Ricketts & Banks, of New York City:

Analysis of granite quarried at Waldoboro, Lincoln County.

	Per cent.
Silica, SiO_2	73.48
Alumina, Al_2O_3	15.26
Ferrous oxide, FeO	1.42
Calcium oxide, CaO	.88
Magnesia, MgO	.09
Manganous oxide, MnO	.10
Soda, Na_2O	3.12
Potash, K_2O	5.66
Sulphur, S (total)	Trace.
Carbonic acid, CO_2	None.
Total	100.01

The following compression tests were made at the Watertown Arsenal, under the direction of Maj. F. W. Parker, upon granite quarried by the Maine and New Hampshire Granite Company, at their quarries at North Jay, Franklin County:[1]

Compression tests of granite quarried at North Jay, Franklin County.

Color of stone.	Height.	Dimensions compressed surface.		Sectional area.	First crack.	Ultimate strength.		Remarks.
						Total.	Per square inch.	
	Inches.	*In.*	*In.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*	
Red	3.02	3.00	3.00	9.00	196,800	201,300	22,367	Pyramidal fracture.
White	....	6.18	6.00	37.08	583,000	604,800	16,310	Do.

The following analysis of the white granite has been made by Mr. E. T. Rogers:

Analysis of granite quarried at North Jay, Franklin County.

	Per cent.
Silica, SiO_2	71.54
Titanic oxide, TiO_2, and iron peroxide, Fe_2O_3	.84
Alumina, Al_2O_3	14.24
Ferric oxide, Fe_2O_3	.74
Ferrous oxide, FeO	1.18
Lime, CaO	.98
Magnesia, MgO	.34
Soda, Na_2O	3.39
Potash, K_2O	4.73
Water (at red heat)	.61
Sulphur, S	Trace.
Carbon dioxide, CO_2	Trace.
Total	98.59

[1] For further detailed information see U. S. Geological Survey Report on Stone for 1897.

The following analysis of granite quarried by the Chase Granite Company, at their quarries at Blue Hill, Hancock County, was made by Messrs. Ricketts & Banks, of New York City:

Analysis of granite quarried at Blue Hill, Hancock County.

	Per cent.
Silica, SiO_2	73.02
Ferrous oxide, FeO	2.59
Alumina, Al_2O_3	16.22
Manganous oxide, MnO	Trace.
Lime, CaO	.94
Magnesia, MgO	Trace.
Potassium oxide, K_2O	3.42
Sodium oxide, Na_2O	3.60
Sulphur, S	None.
Loss and undetermined	.21
Total	100.00

The following analysis of the granite, quarried by the Blue Hill Granite Company, at their quarries at Blue Hill, Hancock County, Maine, was made by Mr Henry J. Williams, chemist, of Boston, Massachusetts:

Analysis of granite from Blue Hill, Hancock County.

	Per cent.
Water, H_2O	0.27
Silica, SiO_2	74.64
Ferric oxide, F_2O_3	1.56
Alumina, Al_2O_3	14.90
Lime, CaO	.39
Magnesia, MgO	Trace.
Potassium oxide, K_2O	6.88
Sodium oxide, Na_2O	.41
Total	99.05

Slate.—The following analysis of Monson, Piscataquis County, slate was made at the Watertown Arsenal, and published in Tests of Metals, etc., for 1892:

Analysis of slate from Monson, Piscataquis County.

	Per cent.
Silica, SiO_2	54.24
Ferric oxide, Fe_2O_3	8.39
Alumina, Al_2O_3	24.71
Calcium oxide, CaO	5.23
Magnesium oxide, MgO	2.59
Sodium oxide, Na_2O	1.43
Potassium oxide, K_2O	.72
Sulphuric anhydride, SO_3	2.03
Phosphoric anhydride, P_2O_5	None.
Manganous oxide, MnO	.50
Loss	.16
Total	100.00

The following analysis of slate, quarried by the Monson Slate Company, at their quarries at Monson, Piscataquis County, was made by Mr. L. M. Norton, of the Massachusetts Institute of Technology, at Boston, Massachusetts:

Analysis of slate quarried at Monson, Piscataquis County.

	Per cent.
Loss on ignition, including organic matter	3.88
Silica, SiO_2	56.42
Alumina, Al_2O_3	24.14
Ferrous oxide, FeO	4.46
Lime, CaO	.52
Magnesia, MgO	2.28
Oxide of potassium, K_2O	5.53
Oxide of sodium, Na_2O	3.15
Total	100.38

The following tests of Monson slate were made at the Watertown Arsenal:

Transverse test of Monson slate.

Length	inches..	24
Breadth	do....	4.02
Depth	do....	6.08
Distance between supports	do....	19
Total ultimate strength	pounds..	40,000
Maximum fiber stress per square inch	do....	7,671

Shearing test of Monson slate.

Shearing dimensions	inches..	4.00 by 6.10
Shearing area	square inches..	48.8
First crack	pounds..	91,800
Total shearing strength	do....	107,000
Shearing strength per square inch	do....	2,192
Irregular tensile fractures		Stone did not shear

Compression test of Monson slate.

Height	inches..	12.00
Compressed surface	do....	6.06 by 4.05
Sectional area	square inches..	24.5
First crack	pounds..	160,000
Total ultimate strength	do....	478,000
Ultimate strength per square inch	do....	19,510

Coefficient of expansion of Monson slate.

Original gaged length in air	inches..	19.9954
Temperature of bath:		F.
Hot		194°
Cold		34°
Difference		160°
Gaged length in bath:		
Hot	inches..	20.0108
Cold	do....	19.9950
Difference	do....	.0158
Coefficient of expansion		.000005

The following tests of slate quarried by the East Brownville Slate Company at their quarries at Brownville, Piscataquis County, were made by Prof. W. O. Crosby, of the Massachusetts Institute of Technology, at Boston, Massachusetts:

Compression tests of slate quarried at Brownville, Piscataquis County.

Size of cube.	How applied.	Ultimate strength per square inch.
		Pounds.
1-inch cube	On bed	29,420
Do	do	29,120
Do	On edge	16,750

Transverse tests of slate quarried at Brownville, Piscataquis County.

Width.	Thickness.	Distance between supports.	Broke at—	Remarks.
Inches.	*Inches.*	*Inches.*	*Pounds.*	
6.00	1.00	11.00	2,540	Imperfect in structure.
6.00	1.00	11.00	3,550	

The following tests of slate quarried by the Monson-Burmah Slate Company, at their quarries at Monson, Piscataquis County, were made by Prof. Walter Flint, M. E., of the University of Maine:

Transverse tests of slate quarried at Monson, Piscataquis County.

[Load applied perpendicular to grain.]

No.	Size.	Span.	Load.	Modulus.
	Inches.	*Feet.*	*Pounds.*	*Pounds.*
1..	1 by 1 by 15	1	730	13,140
2..	1 by 1 by 15	1	800	14,400
3..	1 by 1 by 15	1	770	13,860
4..	1 by 1 by 15	1	730	13,140
5..	1 by 1 by 15	1	780	14,040
6..	1 by 1 by 15	1	760	13,680
7..	1 by 1 by 15	1	730	13,140
8..	1 by 1 by 15	1	770	13,860
9..	1 by 1 by 15	1	820	14,760
10..	1 by 1 by 15	1	780	14,040

Average per square inch, 13,778 pounds.

Transverse tests of slate quarried at Monson, Piscataquis County.

[Load applied parallel to grain.]

No.	Size.	Span.	Load.	Modulus.
	Inches.	*Feet.*	*Pounds.*	*Pounds.*
1...	1 by 1 by 15	1	700	12,600
2...	1 by 1 by 15	1	770	13,860
3...	1 by 1 by 15	1	740	13,320
4...	1 by 1 by 15	1	830	14,940

Average per square inch, 13,430 pounds.

Compression tests.

No.	Size.	Load.
		Pounds.
1..	1-inch cube	24,460
2..	.....do	24,950
3..	.....do	26,080
4..	.....do	22,700
5..	.....do	24,440
6..	.....do	25,600
7..	.....do	22,560
8..	.....do	26,770
9..	.....do	23,830
10..	.....do	24,630

Average, 24,602 pounds.

Limestone.—The following table gives the results of a number of analyses of limestone quarried in Maine:

Analyses of limestone quarried in Maine.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.										
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Silica, SiO_2.	Ferrous oxide, FeO.	Aluminum oxide, Al_2O_3.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Carbon dioxide, CO_2.	Moisture.	Organic matter.	Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Jas. H. McNamara.	Rockland.	Knox.	F. C. Robinson, Bowdoin College..	....	....	1.08	0.08	0.07	54.97	0.04	43.25	....	0.28	99.77
Geo. W. Bachelder.	Union	...do ..	.....do	95.20	1.00	1.00	Trace.	....	....	....	....	2.70	....	99.90
McLoon and Stover Lime Co.	Warren...	...do ..	S. P. Sharpless, Boston, Mass	53.52	45.13	.95	....	....	....	....	....	.40	....	100.00

MARYLAND.

Granite.—The following analysis of granite, quarried by the McClenahan & Bro. Granite Company at their quarries at Port Deposit, Cecil County, was made by Dr. H. N. Morse, professor of analytical chemistry in Johns Hopkins University:

Analysis of granite quarried at Port Deposit, Cecil County.

	Per cent.
Silica, SiO_2	73.690
Alumina, Al_2O_3	12.891
Ferric oxide, Fe_2O_3	1.023
Ferrous oxide, FeO	2.585
Lime, CaO	3.737
Magnesia, MgO	.498
Potash, K_2O	1.481
Soda, Na_2O	2.811
Water, H_2O	1.060
Total	99.776

Marble.—In a compression test of marble, quarried by the Beaver Dam Quarry Company at their quarries, Cockeysville, Baltimore County, Lieut. Col. Q. A. Gillmore found the crushing strength to be 22,500 pounds per square inch. The weight per cubic foot was 178 pounds.

Slate.—The following analysis of slate, quarried in the Peach Bottom slate region of York County, Pennsylvania, and Harford County, Maryland, was made by Messrs. Booth, Garrett and Blair, of Philadelphia, Pennsylvania:

Analysis of the Peach Bottom slate.

	Per cent.
Silica, SiO_2	58.370
Protoxide of iron, FeO	10.661
Alumina, Al_2O_3	21.985
Lime, CaO	.300
Magnesia, MgO	1.203
Alkalies	1.933
Sulphur, S	.107
Carbonic acid, CO_2	.390
Carbon, C	.930
Water, H_2O	4.030
Titanic acid, TiO_2	Trace.
Oxide of manganese	Trace.
Total	99.909

Sandstone.—The following analysis of sandstone, quarried by Mr. B. S. Randolph at his quarry, Frostburg, Allegany County, was made by the chemist of the Maryland Geological Survey:[1]

Analysis of sandstone from Frostburg, Allegany County.

	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Silica, SiO_2	99.25	99.56	99.40	97.55
Alumina, Al_2O_3	.61	.34	.47	2.44
Calcium oxide, CaO	.11	.81	.10	.01
Manganese oxide	Trace.	Trace.	Trace.	Trace.
Ferric oxide, Fe_2O_3	....	....	.27	Trace.
Ferrous oxide, FeO	.25	.20	....	....
Total	100.22	100.91	100.24	100.00

[1] For further detailed information, see Vol. II, pp. 209, 210, of the Maryland Geological Survey.

Limestone.—The following table gives the results of a number of analyses of limestone quarried in Maryland:

Analyses of limestone quarried in Maryland.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.								
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Silica, SiO_2.	Calcium oxide, CaO.	Loss on ignition.	Alumina, Al_2O_3.	Ferric oxide, Fe_2O_3.	Oxides of aluminum and iron.	Total.
J. W. Stimmel:				*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
No. 1	Walkersville	Frederick	Prof. H. J. Patterson, College Park, Md.	93.57	0.30	4.73					1.40	100.00
No. 2	do	do	do	81.97	13.00	4.31					.90	100.18
M. J. Grove Lime Co.:												
Dark stone	Frederick	do	Julian O. Hargrove, 3310 N street, N.W., Washington, D.C.	97.32	2.03	.22			0.29	0.25		100.11
Light stone	do	do	do	96.79	2.86	.10			.16	Trace.		99.91
P. G. Zouck & Co	Cavetown	Washington	Lehman & Glaser, Baltimore, Md			.47	55.51	44.02				100.00

MASSACHUSETTS.

Granite.—The following tests and analysis of granite quarried by the Rockport Granite Company at their quarries at Cape Ann, Essex County, were made at the Watertown Arsenal:[1]

Analysis of granite quarried at Cape Ann, Essex County.

	Per cent.
Silica, SiO_2	81.05
Ferric oxide, Fe_2O_3	2.71
Alumina, Al_2O_3	14.70
Calcium oxide, CaO	1.10
Magnesium oxide, MgO	Trace.
Sulphuric anhydride, SO_3	None.
Phosphoric anhydride, P_2O_5	None.
Loss	.44
Total	100.00

Compression test of granite quarried at Cape Ann, Essex County.

Height	inches	11.93
Compressed surface	do	6.00 by 4.00
Sectional area	square inches	24.00
First crack	pounds	173,000
Total ultimate strength	do	487,100
Ultimate strength per square inch	do	20,296

Shearing test.

Shearing dimensions	inches	4.10 by 6.08
Shearing area	square inches	49.8
First crack	pounds	37,800
Total shearing strength	do	122,950
Shearing strength per square inch	do	2,469

Transverse test of granite quarried at Cape Ann, Essex County.

Length	inches	24
Breadth	do	4.03
Depth	do	6.08
Distance between supports	do	19
Ultimate resistance	pounds	12,500
Maximum stress	do	2,392

Coefficient of expansion of granite quarried at Cape Ann, Essex County.

Original length in air ... inches	19.9303
Temperature of bath:	F.
Hot	181°
Cold	33.5°
Difference	147.5°

[1] For further detailed information see "Tests of Metals, etc.," for 1890, 1891, and 1892.

Gaged length in bath:		
Hot	inches..	19.9401
Cold	do....	19.9310
Difference	do....	0.0091
Coefficient of expansion		.00000311

The following test of granite quarried by the Shea Pink Granite Company at their quarries at Milford, Worcester County, was made at the Watertown Arsenal under the direction of Maj. J. W. Reilly:

Compression test of granite quarried at Milford, Worcester County.

Number of test		10,892
Height	inches..	4.06
Compressed surface	inches..	4.00 by 4.08
Sectional area	square inches..	16.32
First crack	pounds..	258,000
Total ultimate strength	do....	504,100
Ultimate strength per square inch	do....	30,888
Pyramidal fracture.		

An analysis of the same stone by Prof. H. P. Talbott, of the Massachusetts Institute of Technology, Boston, Massachusetts, is as follows:

Analysis of granite quarried at Milford, Worcester County.

	Per cent.
Silica, SiO_2	76.95
Alumina, Al_2O_3	11.15
Ferric oxide, Fe_2O_3	.25
Ferrous oxide, FeO	.55
Sodium oxide, Na_2O	5.60
Potassium oxide, K_2O	5.03
Moisture	.20
Manganous oxide, MnO	Trace.
Calcium oxide, CaO	Trace.
Magnesium oxide, MgO	Trace.
Total	99.73

The following test of crushing strength was made at the Watertown Arsenal under the direction of Maj. F. H. Parker. The stone tested was Milford pink granite, quarried by Messrs. Norcross Brothers from their quarries at Milford, Worcester County:

Test by compression of one 6-inch cube of Milford granite.

[Compressed surfaces faced with plaster of paris to secure even bearings.]

Test number.	Dimensions.			Sectional area.	Ultimate strength.	
	Length.	Compressed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*
2596	5.98	5.83	5.96	34.75	725,700	20,883

Snapping sounds and pieces flew off at 546,000 pounds. Slight explosive sound at 674,500 pounds. Burst into small fragments and sand at the maximum load, accompanied by a loud report. One principal fragment was pyramidal shaped, with sharp apex.

The following analysis of the same stone was made at the School of Mines, Columbia University, New York City, by Prof. C. F. Chandler:

Analysis of Milford pink granite.

	Per cent.
Silica, SiO_2	76.07
Alumina, Al_2O_3	12.67
Ferric oxide, Fe_2O_3	2.00
Oxide of manganese	.03
Lime, CaO	.85
Magnesia, MgO	.10
Potash, K_2O	4.71
Soda, Na_2O	3.37
Total	99.80

The W. N. Flint Granite Company report the following facts relative to trap rock quarried by them at their quarries at Monson, Hampden County. The highway commissioner of Massachusetts determined what is known as the "coefficient of wear" to be 22.13. The following analysis of the same stone is credited to the Watertown Arsenal:

Analysis of trap rock quarried at Monson, Hampden County.

	Per cent.
Silica, SiO_2	52.59
Ferric oxide, Fe_2O_3	14.55
Alumina, Al_2O_3	23.42
Lime, CaO	9.05
Magnesia, MgO	.28
Manganous oxide, MnO	.09
Total	99.98

Marble.—The following analysis and tests of marble quarried by Mr. W. H. Gross at his quarries at Lee, Berkshire County, were made at the Watertown Arsenal:[1]

Analysis of marble quarried at Lee, Berkshire County.

	Per cent.
Silica, SiO_2	1.00
Ferric oxide, Fe_2O_3 Alumina, Al_2O_3	0.20
Calcium oxide, CaO	23.00
Magnesium oxide, MgO	27.98
Sulphuric anhydride, SO_3	.64
Phosphoric anhydride, P_2O_5	None.
Carbon dioxide, CO_2	46.64
Loss	.54
Total	100.00

Compression test of marble quarried at Lee, Berkshire County.

Height	inches	11.99
Compressed surface	inches	5.88 by 3.98
Sectional area	square inches	23.4
First crack	pounds	422,300
Total ultimate strength	do	422,300
Ultimate strength per square inch	do	18,047

[1] For further detailed information see Tests of Metals, etc., for 1890, 1891, and 1892.

Transverse tests of marble quarried at Lee, Berkshire County.

Length.	Breadth.	Depth.	Distance between supports.	Ultimate strength.	
				Total.	Maximum fiber stress per square inch.
Inches.	*Inches.*	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*
24.0	4.01	5.98	19	7,980	1,586
23.97	3.97	6.00	19	7,940	1,584

Shearing test of marble quarried at Lee, Berkshire County.

Shearing dimensions .... inches..	4.00 by 6.01
Shearing area .... square inches..	48.1
First crack .... pounds..	83,200
Total shearing strength .... do....	98,700
Shearing strength per square inch .... do....	2,052

Cracked at middle of length. Sheared ends.

Coefficient of expansion of marble quarried at Lee, Berkshire County.

Original length in air .... inches..	20.0061
Temperature of bath:	F.
Hot	189.5°
Cold	33.5°
Difference	156°
Gauged length in bath:	
Hot .... inches..	20.0236
Cold .... do....	20.0061
Difference .... do....	0.0175
Coefficient of expansion	.00000562

The following analysis of marble quarried by the North Adams Marble and Milling Company at their quarries at North Adams, Berkshire County, was made by Prof. Wm. P. Mason of the Rensselaer Polytechnic Institute:

Analysis of marble quarried at North Adams, Berkshire County.

	Per cent.
Silica, SiO_2	0.688
Phosphoric anhydride, P_2O_5	.053
Oxides of iron and aluminum	.061
Magnesium carbonate, $MgCO_3$	5.338
Calcium carbonate, $CaCO_3$	93.860
Total	100.000

The following is an analysis made by Prof. Arthur A. Noyes, of the Massachusetts Institute of Technology, of a serpentine marble from Westfield, Hampden County, and owned by the Westfield Marble and Sandstone Company:

Analysis of serpentine marble quarried at Westfield, Hampden County.

	Per cent.
Water, H_2O	0.00
Silica and silicate	.20
Ferrous oxide, FeO	.41
Calcium oxide, CaO	32.77
Magnesium oxide, MgO	19.68
Carbon dioxide, CO_2	46.91
Total	99.97

Maj. J. W. Reilly, Watertown Arsenal, made the following compression tests of the same stone:

Compressive strength tests of Westfield serpentine marble.

No. of test.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
	Height.	Compressed surface.				Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
8779	4.05	3.73	5.60	20.89	412,000	455,800	21,820
8780	9.75	3.57	3.24	11.57	139,900	139,900	12,090

Sandstone.—The following table gives the results of a number of analyses of sandstone quarried in Massachusetts:

Analyses of sandstone quarried in Massachusetts.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances found.								
	Town.	County.		Silica, SiO_2.	Ferric oxide, Fe_2O_3.	Alumina, Al_2O_3.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Oxides of potassium and sodium.	Water, carbon dioride, and loss.	Manganese oxide.	Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Norcross Bros. (Worcester quarry).	East Long Meadow.	Hampden.	Dr. L. P. Kinnicutt, Worcester Polytechnic Institute.	88.89	1.79	5.95	0.27	....	0.86	1.83	0.41	100.00
Norcross Bros. (Maynard quarry).	.... do	.....do	.....do	79.38	2.43	8.75	2.57	....	4.08	2.79	....	100.00
Norcross Bros. (Kibbe quarry).	.....do	.....do	Prof. C. F. Chandler, School of Mines, Columbia University, New York City.	81.38	3.54	9.44	.76	0.28	....	4.49	.11	100.00

The following table gives the results of a number of physical tests of sandstone quarried in Massachusetts:

Physical tests of sandstone quarried in Massachusetts.

Name of firm quarrying stone.	Location of quarry.		Name and address of expert.	Compression tests.							Remarks.
	Town.	County.		No. of specimen.	Dimensions.			Sectional area.	Ultimate strength.		
					Height.	Compressed surface.			Total.	Per square inch.	
					Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	
Norcross Bros. (Worcester quarry)	East Long Meadow.	Hampden	Lieut. Col. F. H. Parker, Watertown Arsenal.	4096	6.16	6.03	6.02	36.30	420,900	11,595	The specimens were tested between flat steel platforms. Their bed surfaces were faced with a thin (0 02 inch) coating of plaster of paris to secure even bearings in the testing machine. Single pyramidal fracture.
Do	do	do	do	4097	6.13	6.02	6.01	36.18	371,800	10,276	
Norcross Bros. (Kibbe quarry).	do	do	do	3337	6.00	5.97	6.00	35.82	452,000	12,619	Tested in same way as stone from Worcester quarry. No. 3337 cracked under 451,000 pounds pressure. Single pyramid. No. 3338 cracked under 435,000 pounds pressure. Double pyramid.
Do	do	do	do	3338	6.02	5.97	5.98	35.70	459,600	12,874	
Norcross Bros. (Maynard quarry).	do	do	do		6.16	6.03	6.02	36.30	371,100	10,223	Tested same as above. Single pyramid.
James & Marra (Kibbe red stone).	do	do	Maj. J. W. Reilly, Watertown Arsenal.		4.97	4.95	4.98	24.65	301,100	12,210	Weight per cubic foot, 154.5 pounds; first crack at 299,000 pounds; specific gravity, 2.49; ratio of absorption, 1-23.
James & Marra (Kibbe brownstone).	do	do	do		4.89	5.03	4.92	24.75	305,150	12,330	Weight per cubic foot, 154.5 pounds; first crack at 304,800 pounds; specific gravity, 2.48.

Limestone.—The following analysis of limestone quarried by the Adams Marble Company, at their quarries at Renfrew, Berkshire County, was made by Prof. E. E. Olcott:

Analysis of limestone quarried at Renfrew, Berkshire County.

	Per cent.
Calcium carbonate, $CaCO_3$	99.60
Magnesium carbonate, $MgCO_3$	.49
Oxide of iron and alumina, Fe_2O_3 and Al_2O_3	.55
Silica, SiO_2	.63
Total	101.27

The following analysis of limestone quarried by the Cheshire Manufacturing Company, at their quarries at Cheshire, Berkshire County, was made by Messrs. Davenport and Williams:

Analysis of limestone quarried at Cheshire, Berkshire County.

	Per cent.
Silica, SiO_2	0.31
Oxide of iron and alumina, Fe_2O_3 and Al_2O_3	.23
Calcium carbonate, $CaCO_3$	98.80
Magnesium carbonate, $MgCO_3$	.37
Organic matter	.35
Total	100.06

The following are two analyses, No. 1 by Mr. P. S. Burns, No. 2 by Mr. H. P. Eddy, of lime made from limestone quarried by Messrs. J. Follet & Son, at their quarries at Renfrew, Berkshire County:

Analyses of lime from Renfrew, Berkshire County.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Lime, CaO	98.13	96.63
Magnesia, MgO	.42	.88
Silica, SiO_2	.36	.81
Alumina, Al_2O_3	.15	.47 (Alumina and ferric oxide together)
Ferric oxide, Fe_2O_3	....	
Carbon dioxide, CO_2	.60	.12 (Carbon dioxide and water together)
Water, H_2O	.20	
Total	99.86	98.91

The following analysis of lime made from limestone quarried by Messrs. Hutchinson Brothers, at their quarry at New Lenox, Berkshire County, was made by Mr. W. M. Habirshaw, chemist, New York State Agricultural Society:

Analysis of lime from New Lenox, Berkshire County.

	Per cent.
Lime, CaO	95.66
Magnesia, MgO	.76
Oxides of iron and aluminum	.17
Silica, SiO_2	1.14
Loss on ignition	3.00
Total	100.73

The following analysis of limestone quarried by Mr. C. H. Hastings, at his quarry at West Stockbridge, Berkshire County, was made by Mr. J. Blodget Britton, of Warrenton, Virginia:

Analysis of limestone quarried at West Stockbridge, Berkshire County

	Per cent.
Calcium carbonate, $CaCO_3$	99.029
Magnesium carbonate, $MgCO_3$	.266
Total	99.295

MICHIGAN.

Sandstone.—The following compression tests of sandstone quarried by the Kerber-Jacobs Redstone Company, at their quarries at Red Rock, Houghton County, were made under the direction of Maj. J. W. Reilly at the Watertown Arsenal:

Compression tests of sandstone from Red Rock, Houghton County.

Test No.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
	Height.	Compressed surface.				Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
7823	2.00	2.03	2.03	4.12	24,800	24,800	6,019
7824	2.00	2.04	2.02	4.12	21,700	21,820	5,296
7825	2.00	2.01	2.02	4.06	27,510	27,510	6,776
7826	2.00	2.01	2.00	4.02	27,440	27,440	6,826
7827	1.99	2.03	2.02	4.10	24,550	24,550	5,988
7828	2.00	2.02	2.02	4.08	24,980	24,980	6,123

Pyramidal fractures.

Limestone.—The following analyses of limestone quarried by the Sibley Quarry Company at their quarry at Trenton, Wayne County, were made by Mr. H. Harrison:

Analyses of limestone from Trenton, Wayne County.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Calcium carbonate, $CaCO_3$	98.53	97.50
Magnesium carbonate, $MgCO_3$	.53	1.26
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	.06	.08
Silica, SiO_2	.60	.40
Total	99.72	99.24

The following is a partial analysis of limestone quarried by Mr. H. O. Rose, at his quarry at Petoskey, Emmet County, made by Messrs. Strong and Dunham, of Marquette:

Partial analysis of limestone from Petoskey, Emmet County.

	Per cent.
Calcium carbonate, $CaCO_3$	87.65
Magnesium carbonate, $MgCO_3$	11.22

The following analysis of limestone quarried by Mr. R. Collins at his quarry at Alpena, Alpena County, was made by the chemist of the Lake Superior Carbide Works, of Sault Ste. Marie, Michigan:

Analysis of limestone from Alpena, Alpena County.

	Per cent.
Calcium carbonate, $CaCO_3$	98.54
Magnesium carbonate, $MgCO_3$	1.24
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	Trace.
Total	99.78

The following are two analyses of lime made from the same stone and analyzed by the same chemist:

Analyses of lime made from limestone quarried in Alpena, Alpena County.

	No. 3.	No. 5.
	Per cent.	*Per cent.*
Silica, SiO_2	1.96	3.42
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	.94	1.21
Calcium oxide, CaO	95.60	94.26
Magnesium oxide, MgO	.14	.32
Carbon dioxide and water	1.36	.79
Total	100.00	100.00

The following analyses by Mr. E. J. Schneider are of lime made from limestone quarried by the Petoskey Lime Company at their quarry at Bay Shore, Charlevoix County:

Analyses of lime made from limestone quarried at Bay Shore, Charlevoix County.

	For commercial uses.	For chemical uses.
	Per cent.	*Per cent.*
Silica, SiO_2	1.09	0.70
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	1.74	.66
Calcium oxide, CaO	81.83	96.80
Magnesium oxide, MgO	13.42	.67
Carbon dioxide and water	1.92	1.17
Total	100.00	100.00

MINNESOTA.

Sandstone.—The following is an analysis of the sandstone known as Kettle River sandstone, quarried by the Minnesota Sandstone Company at their quarries at Sandstone, Pine County, by Prof. N. H. Winchell:

Analysis of sandstone from Sandstone, Pine County.

	Per cent.
Water	0.00
Silica, SiO_2	98.69
Alumina, Al_2O_3	1.06
Iron oxide	Slight trace.
Calcium oxide, CaO	.42
Magnesium oxide, MgO	.01
Sodium oxide, Na_2O	.17
Total	100.35

Limestone.—The following facts were obtained by Prof. N. H. Winchell, of Minnesota State University, relative to the limestone quarried by Mr. Philip Biesanz at his quarry at Winona, Winona County:

Weight per cubic foot	pounds..	160
Total crushing strength of 1-inch cube on bed or edge	do....	65,000
Crushing strength per square inch	do....	16,250

MISSOURI.

Granite.—The following compression tests of granite quarried by the Syenite Granite Company at their quarries at Graniteville, Iron County, were made by Prof. J. B. Johnson, professor of civil engineering, Washington University, St. Louis, Missouri:

Tests of granite quarried at Graniteville, Iron County.

No. of test.	Size of specimens.	Crushed at—	Crushing strength per square inch.
	Sq. inches.	*Pounds.*	*Pounds.*
1	3.85	93,100	24,181
2	3.78	95,700	25,317

Limestone.—The following is a table of analyses of various Missouri limestones:

Analyses of limestone quarried in Missouri.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.							
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Iron oxide.	Aluminum oxide, Al_2O_3.	Silica, SiO_2.	Magnesium oxide, MgO.	Total.
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Marble Head Lime Co.	Springfield	Greene	R. Chauvenet & Bro., St. Louis, Mo.	99.46			0.21		0.33		100.00
Do.	Sarcoxie	Jasper	Chemist of St. Louis Sampling and Testing Works, St. Louis, Mo.	98.34	Trace.		.05	0.88	*a*.42		99.69
Hannibal Lime Co	Hannibal	Marion	do	98.80		0.40			.08	0.02	99.30
Star Lime Co	do	Ralls	do	99.64	0.21				*a*.15		100.00
Glencoe Lime and Cement Co.	Glencoe	St. Louis	do	98.36		.68			*a*.70	.26	100.00
Ashgrove White Lime Association.	Ashgrove	Greene	Chas. W. Eoff	99.82			.01	.05	.12	Trace.	*b* 100.00

a Insoluble in acids. *b* Contains traces of manganese and sulphur, but no phosphorus.

The following facts relative to the limestone quarried by the Thompson & Gray Quarry Company, at their quarry at Jungs, St. Charles County, were obtained by Mr. A. S. Ferguson under the direction of Hon. M. L. Holman, water commissioner, city of St. Louis:

	Per cent.
Absorption (48 hours)	0.40
Specific gravity	2.68

MONTANA.

Limestone.—The following analysis of limestone quarried by the Persell Limestone Company at their quarry at Helena, Lewis and Clarke County, was made by Mr. E. Starz:

Analysis of limestone quarried at Helena, Lewis and Clarke County.

	Per cent.
Calcium carbonate, $CaCO_3$	88.25
Magnesium carbonate, $MgCO_3$	5.70
Ferric oxide, Fe_2O_3	.76
Alumina, Al_2O_3	.16
Silica, SiO_2	1.45
Gold, silver, and zinc	Trace.
Total	96.32

NEVADA.

Granite.—The following analysis of granite quarried by Mr. John Barrett at his quarry at Reno, Washoe County, was made by Prof. J. W. Phillips:

Analysis of granite quarried at Reno, Washoe County.

	Per cent.
Silica, SiO_2	58.67
Alumina, Al_2O_3	14.89
Manganese dioxide, MnO_2	1.00
Ferric oxide, Fe_2O_3	7.56
Lime, CaO	5.68
Magnesia, MgO	1.79
Soda, Na_2O	7.69
Potash, K_2O	2.69
Loss by ignition	.57
Total	100.54

NEW HAMPSHIRE.

Granite.—Mr. Franklin C. Robinson, Maine State assayer, Brunswick, Maine, reports the following facts relative to the red and green granites quarried by the Maine and New Hampshire Granite Company at their quarries at Redstone, Carroll County:

Analyses and specific gravities of red and green granites quarried at Redstone, Carroll County.

	Red.	Green.
	Per cent.	*Per cent.*
Silica, SiO_2	71.44	70.42
Alumina, Al_2O_3	14.72	14.64
Ferrous oxide, FeO	.46	2.34
Ferric oxide, Fe_2O_3	2.39	1.54
Sodium oxide, Na_2O	7.66	7.80
Potassium oxide, K_2O	.89	.71
Magnesia, MgO	.96	1.20
Rare elements (mostly oxides of titanium and thorium, TiO_2 and ThO_2)	.78	.48
Loss at red heat (mostly water)	.61	.61
Manganese, sulphur, calcium, phosphates	Traces.	Traces.
Total	99.91	99.74
Specific gravity	2.635	2.634

The following compression test of granite quarried by the Troy Granite Company at their quarries at Troy, Cheshire County, was made at the Watertown Arsenal, under the direction of Lieut. Col. D. W. Flagler:

Compression test of granite quarried at Troy, Cheshire County.

Test number	No.	7419
Length	inches.	5.95
Compressed surface	do.	5.84 by 5.90
Sectional area	square inches.	35.01
First crack	pounds.	525,000
Total ultimate strength	do.	630,100
Ultimate strength per square inch	do.	17,950

Pyramidal fracture.

The following analysis of the same stone was made by Dr. Leonard P. Kinnicutt, of the Worcester Polytechnic Institute:

Analysis of granite quarried at Troy, Cheshire County.

	Per cent.
Silica, SiO_2	73.15
Oxides of iron and aluminum	17.04
Calcium oxide, CaO	.81
Magnesium oxide, MgO	.30
Potassium oxide, K_2O	5.74
Sodium oxide, Na_2O	2.05
Loss and undetermined	.91
Total	100.00

Professor Ricketts, of Rensselaer Polytechnic Institute, reports that the granite quarried by Messrs. Young & Sons at their quarry at Milford, Hillsboro County, has a crushing strength of 24,950 pounds to the square inch.

The following analysis of granite quarried by the Mason-New Hampshire Granite Company, at their quarry at Mason, Hillsboro County, was made by Messrs. Ricketts & Banks, 1045 John street, New York City:

Analysis of granite quarried at Mason, Hillsboro County.

	Per cent.
Silica, SiO_2	72.47
Ferrous oxide, FeO	.41
Alumina, Al_2O_3	16.17
Calcium oxide, CaO	1.65
Magnesium oxide, MgO	.14
Manganous oxide, MnO	.39
Potassium oxide, K_2O	4.83
Sodium oxide, Na_2O	3.43
Sulphur, S	.02
Loss and undetermined	.49
Total	100.00

NEW JERSEY.

Granite.—The following table gives a number of analyses of trap rock quarried in New Jersey.

Dr. William C. Day, Swarthmore College, Pennsylvania, recently tested the trap rock quarried by Messrs. Hatfield & Chamberlain at their quarries at Scotch Plains, Union County, and found its crushing strength to be 35,000 pounds to the square inch.

Analyses of trap rock quarried in New Jersey.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.									
	Town.	County.		Silica, SiO_2.	Ferrous oxide, FeO.	Ferric oxide, Fe_2O_3.	Alumina, Al_2O_3.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Sodium oxide, Na_2O.	Potassium oxide, K_2O.	Water.	Total.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Francisco Bros	Little Falls	Passaic	Dr. William C. Day, Swarthmore College, Pa.	50.81	....	14.66	13.25	10.96	6.97	0.76	1.71	0.88	100.00
Morris County Crushed Stone Co.: *a*													
No. 1	Millington	Morris	Prof. T. B. Stillman, Stevens Institute Hoboken, N. J.	49.20	....	17.01	14.50	7.50	6.30	1.69		3.80	100.00
No. 2	do	do	do	50.03	....	16.81	18.20	11.10	1.02	1.03		1.81	100.00
No. 3	do	do	do	51.20	....	11.12	20.88	12.50	2.17	1.03		1.10	100.00
Freeman & McCollum	Mine Brook	Somerset	do	50.61	13.91	....	18.34	7.01	6.73	1.60	1.08	1.72	100.00

a Samples taken from different veins. The Massachusetts Highway Commission made the coefficient of wear to be 19.64.

Sandstone.—The following analysis of sandstone quarried by the Passaic Quarry Company, at their quarry at Avondale, Essex County, was made by Prof. T. B. Stillman, Stevens Institute of Technology:

Analysis of sandstone quarried at Avondale, Essex County.

	Per cent.
Silica, SiO_2	82.05
Alumina, Al_2O_3	5.27
Ferric oxide, Fe_2O_3	2.71
Calcium oxide, CaO	3.35
Magnesium oxide, MgO	.76
Sodium oxide, Na_2O	.20
Potassium oxide, K_2O	.60
Sulphuric anhydride, SO_3	Trace.
Carbon dioxide, CO_2	4.40
Water, H_2O	.71
Manganous oxide, MnO	None.
Total	100.05

Limestone.—The following analysis of limestone quarried at Vernoy, Hunterdon County, by the estate of E. Weise, was made by Mr. H. B. Weaver:

Analysis of limestone quarried at Vernoy, Hunterdon County.

	Per cent.
Calcium carbonate, $CaCO_3$	52.450
Magnesium carbonate, $MgCO_3$	43.250
Iron oxide	1.340
Alumina, Al_2O_3	.545
Phosphorus, P	.035
Silica, SiO_2	2.280
Total	99.900

NEW YORK.

Granite.—The following analysis of granite quarried by Mr. Daniel E. Donovan at his quarry at Stony Point, in Rockland County, was made by Mr. Jos. F. Geiste, Harrison and Hudson streets, New York City.

Analysis of granite quarried at Stony Point, Rockland County.

	Per cent.
Silica, SiO_2	63.190
Ferric oxide, Fe_2O_3	10.967
Alumina, Al_2O_3	10.504
Ferrous oxide, FeO	1.508
Calcium oxide, CaO	6.120
Magnesium oxide, MgO	1.437
Potassium oxide, K_2O	4.016
Sodium oxide, Na_2O	1.916
Loss on ignition	.185
Undetermined	.157
Total	100.000

The following compression tests of granite quarried by the Pochuck Quarry Company at their quarries near Goshen, Orange County, were made by Prof. J. P. Carlin, of Cornell University:

Compression tests of granite quarried near Goshen, Orange County.

No.	Size.	Sectional area.	First crack.	Ultimate strength.	
				Total.	Per square inch.
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
1	2.02 by 1.98 by 2.0	4	66,500	94,000	23,500
2	2 by 2.1 by 2	4.2	74,000	96,000	22,900

Marble.—The following analysis and tests of marble quarried by the South Dover Marble Company at their quarries at South Dover, Dutchess County, were made by Messrs. Ricketts and Banks, of New York City:

Analysis of marble quarried at South Dover, Dutchess County.

	Per cent.
Silica, SiO_2	0.70
Ferric oxide, Fe_2O_3	.25
Alumina, Al_2O_3	.37
Calcium oxide, CaO	30.63
Magnesium oxide, MgO	20.25
Sodium oxide, Na_2O	.12
Potassium oxide, K_2O	.46
Undetermined and loss	.56
Carbon dioxide, CO_2	46.66
Total	100.00

Tests of marble quarried at South Dover, Dutchess County.

Specific gravity 2.86
Porosity:
Weight of sample .... grams.. 143.173
Volume of sample .... cubic centimeters.. 50.05
Absorption of water after soaking 24 hours .... grams.. .267

The following tests of the same marble were made by Prof. Ira H. Woolson, engineering department of the school of mines, Columbia University, New York City:

Tests of marble quarried at South Dover, Dutchess County.

Test No.	How tested.	Shape of test piece.	Dimensions. Length or height.	Dimensions. Diameter or breadth.	Original. Thickness.	Original. Area.	Elastic limit.	First crack.	Stress, maximum.	Compression, maximum per square inch.
			Inches.	*Inches.*	*Inches.*	*Sq. in.*		*Pounds.*	*Pounds.*	*Pounds.*
1355	Bed...	Cube.	1.995	2.01	2.01	4.04	Slightly.	67,800	76,100	18,836
1356	Bed...	Cube.	1.985	2.02	2.00	4.04	....	48,800	70,300	17,401
1357	Bed...	Cube.	1.986	2.04	2.00	4.08	....	77,400	85,200	20,882

Average, 10,039 pounds to the square inch.

The following analysis of marble quarried by the Snowflake Marble Company at their quarries at Pleasantville, Westchester County, New York, was made by Prof. C. F. Chandler, of Columbia University, New York:

Analysis of marble quarried at Pleasantville, Westchester County.

	Per cent.
Calcium carbonate, $CaCO_3$	54.12
Magnesium carbonate, $MgCO_3$	45.04
Ferric oxide, Fe_2O_3	.11
Alumina, Al_2O_3	.07
Silica, SiO_2	.10
Total	99.44

The following compression test of marble quarried by the St. Lawrence Marble Company at their quarry at Gouverneur, St. Lawrence County, was made at the Watertown Arsenal under the direction of Maj. F. H. Parker:

Compression test of marble quarried at Gouverneur, St. Lawrence County.

Compressed surface	inches..	6.11 by 6.28
Sectional area	square inches..	38.37
Total ultimate strength	pounds..	487,000
Ultimate strength per square inch	do..	12,692

The compressed surfaces were faced with a thin coating of plaster of paris to secure even bearings. Double pyramidal fracture, the bases of the pyramids forming the compressed surfaces of the stone, their apexes overlapping. Snapping sounds were heard immediately preceding the fracture.

Slate.—The following analysis and tests of slate quarried by the Hamburg Slate and Mining Company at their quarry at Hamburg, Erie County, were made by Dr. John A. Miller, chemist, 203 Ellicott street, Buffalo, New York:

Analysis of slate quarried at Hamburg, Erie County.

	Per cent.
Silica, SiO_2	67.70
Iron oxide	2.75
Alumina, Al_2O_3	13.49
Calcium oxide, CaO	.81
Magnesia, MgO	1.29
Alkalies by difference, K_2O and Na_2O	4.91
Moisture	.71
Loss on ignition	8.34
Total	100.00

A sample placed in water for twenty-four hours shows an absorption of water equal to 0.27 per cent.

Upon heating a small slab to red heat for one hour and allowing it to cool, the edges showed slight flaking.

Bluestone.—The following analysis of bluestone quarried by the F. G. Clarke Bluestone Company at their quarry at Oxford, Chenango County, was made by Mr. W. E. Gifford, 54 Pine street, New York City:

Analysis of bluestone quarried at Oxford, Chenango County.

	Per cent.
Silica, SiO_2	77.56
Alumina, Al_2O_3	10.65
Oxide of iron, Fe_2O_3	4.59
Oxide of manganese	.09
Lime, CaO	.34
Magnesia, MgO	1.22
Potassa, K_2O	2.15
Soda, Na_2O	.90
Water, H_2O	1.93
Undetermined matter and loss	.57
Total	100.00

The following tests of the same stone were made by the assistant engineer employed in testing material for the pedestal of the statue of "Liberty Enlightening the World" in New York Harbor:

Compression tests of bluestone quarried at Oxford, Chenango County.

No.	Dimensions.	Sectional area.	Ultimate strength.	
			Total.	Per sq. inch.
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*
1	3.0 by 2.936 by 2.786	8.180	103,700	12,677
2	3.0 by 2.770 by 2.776	7.699	103,600	13,472
3	3.0 by 2.888 by 2.802	8.092	98,340	12,152

The following analysis of bluestone quarried by the Warsaw Bluestone Company at their quarries at Rock Glen, Wyoming County, was made by Dr. E. P. Harris, of Amherst College, Massachusetts:

Analysis of bluestone quarried at Rock Glen, Wyoming County.

	Per cent.
Silica, SiO_2	76.50
Alumina, Al_2O_3	14.75
Oxide of iron	6.35
Water	2.00
Total	99.60

The following tests of bluestone quarried by the Warsaw Bluestone Company at their quarries at Warsaw, Wyoming County, were made by Lieut. Col. D. W. Flagler at the Watertown Arsenal:

Tests of bluestone from Warsaw, Wyoming County.

[Stones tested on bed.]

Test No.	Weight.		Dimensions.			Sectional area.	First crack.	Ultimate strength.	
	Total.	Per cubic foot.	Height.	Compressed surface.				Total.	Per square inch.
	Lbs. oz.	*Pounds.*	*Inches.*	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
6648	11 7½	158.2	5.01	5.00	5.00	25.00	499,200	499,200	19,968
6649	11 6	157.3	5.00	5.00	5.00	25.00	476,900	476,900	19,076
6650	11 7½	157.3	5.01	5.02	5.01	25.15	478,400	478,400	19,022

Pyramidal fractures; stones burst into fragments when the maximum load was reached.

The following analysis of bluestone quarried by the Hudson River Stone and Supply Company at their quarry at Stoneco, Dutchess County, was made by Dr. Charles F. McKenna, 221 Pearl street, New York City:

Analysis of bluestone quarried at Stoneco, Dutchess County.

	Per cent.
Silica, SiO_2	63.24
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	19.52
Calcium oxide, CaO	3.80
Magnesium oxide, MgO	1.29
Carbon dioxide, CO_2	2.72
Alkalies, etc	9.43
Total	100.00

Limestone.—The following tables give the results of a number of analyses of limestone and lime made from limestone quarried in New York:

Analyses of limestone quarried in New York.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.										
	Town.	County.		Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Carbon dioxide, CO_2.	Alumina, Al_2O_3.	Ferric oxide, Fe_2O_3.	Silica, SiO_2.		Total.
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*	*Per cent.*
D. C. Hewitt:														
Upper stratum	Amsterdam	Montgomery	J. M. Sherrerd, chemist of Troy Steel and Iron Co.	......	......	3.00	52.78	None.	*a*42.97	......	......	1.25	......	100.00
Intermediate stratum.	do	do	do	......	......	1.08	52.46	None.	*a*42.64	......	......	3.82	......	100.00
Lower stratum	do	do	do	......	......	2.76	52.12	None.	*a*39.44	......	......	5.68	......	100.00
D. R. and H. Fogelsonger.	Williamsville	Erie	Hugo Carlson, chemist, Johnson County, Johnstown, Pa.	96.54	1.00	.64	......	......	......	......	......	1.17	S 0.10; P .01	99.46
Halderman Lime and Cement Co.	Howecave	Schoharie	Prof. Chas. A. Schaeffer, president Iowa State University.	97.24	1.39	.73	......	......	......	......	......	1.27	SO_3 Trace.; P_2O_5 None.	100.63
Ossining Lime Co.	Ossining	Westchester	Ledoux Chemical Laboratory	......	......	.23	30.04	22.28	47.14	......	......	*b*.20	......	99.89
Cobbleskill Quarry Co.	Cobbleskill	Schoharie	Dr. C. F. McKenna, 221 Pearl street, New York City.	......	......	.97	51.05	1.65	41.90	......	......	4.31	S .29	100.17
F. W. Jones	Hudson	Columbia	Professor Egleston	......	......	......	51.40	2.23	41.19	0.63	1.82	1.84	P .15; H_2O .27	*c*99.68
Do	do	do	Chemist of Burden Iron Works.	91.70	3.51	......	......	......	......	1.01	.55	1.89	P .02; SO_3 .05	98.73
Keenan Lime Co.	Smiths Basin	Washington	Chemist of Albany and Rensselaer Iron and Steel Co., Troy, N. Y.	......	......	......	54.15	.39	42.95	.08	.02	.97	P_2O_5 .01; H_2O 1.47	*d*100.10

a Carbon dioxide, CO_2, loss and undetermined. *b* Insoluble in acids. *c* Includes 0.15 per cent SO_3. *d* Includes 0.06 per cent organic matter.

Analyses of lime made from limestone quarried in New York.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.							
	Town.	County.		Calcium oxide, CaO.	Magnesium oxide, MgO.	Oxides of iron and aluminum.	Alumina, Al_2O_3.	Ferric oxide, Fe_2O_3.	Silica, SiO_2		Total.
				Per ct.	*Per ct.*	*Per cent.*	*Per cent.*	*Per ct.*	*Per cent.*	*Per cent.*	*Per cent.*
Robinson & Ferris	Mechanicsville	Washington	M. L. Griffin, Mechanicsville, N. Y.	97.64	0.80	....	1.04	0.25	0.23	....	99.66
E. B. Alvord & Co.	Jamesville	Onondaga	F. E. Englehardt, Ph. D., Syracuse, N. Y.	91.93	3.06	2.03	....	....	*a* 1.88	SO_3 0.73	99.63
Chazy Marble Lime Co	Chazy	Clinton	Enrique Tonceda, Troy, N. Y	97.08	1.40	....	.14	.12	.79	....	99.53
Brown Cement Co	Manlius	Onondaga	Dr. Wm. M. Smith, Syracuse, N. Y.	47.48	18.55	13.67	....	....	20.30	....	100.00
Keenan Lime Co	Smiths Basin	Washington	Prof. J. H. Appleton	95.50	Trace.	.58	....	....	*a* 1.06	{ CO_2 , H_2O } 2.08	99.22
Do	do	do	Chemist of Albany and Rensselaer Iron and Steel Co., Troy, N. Y.	94.07	.79	....	.20	.07	1.93	{ P_2O_5 .01 ; CO_2 3.04 }	100.11

a Insoluble in acid.

NORTH CAROLINA.

Sandstone.—The following analysis of sandstone quarried by Mr. A. H. McNeall at his quarry at Carthage, Moore County, was made by Dr. Charles Cresson, of Philadelphia, Pennsylvania.

Analysis of sandstone quarried at Carthage, Moore County.

	Per cent.
Silica, SiO_2	79.63
Oxide of iron	4.16
Alumina, Al_2O_3	7.16
Calcium oxide, CaO	.92
Manganese oxide	.34
Magnesium oxide, MgO	2.63
Sulphuric anhydride, SO_3	.50
Oxides of potassium and sodium, water and loss.	4.66
Total	100.00

The following compression test of the same stone was made by Messrs. Tinius Olsen & Co., of Philadelphia, Pennsylvania:

Compression test of sandstone quarried at Carthage, Moore County.

Height	inches	2.229
Compressed surface	do	2.187 by 2.33
Sectional area	square inches	4.883
Total ultimate strength	pounds	62,240
Ultimate strength per square inch	do	12,750

Weight per cubic foot, 159 pounds.

OHIO.

Sandstone.—The following analysis of sandstone quarried by the Chippewa Sand and Stone Company at their quarry at Massillon, Wayne County, was made by Mr. E. B. Baltzley:

Analysis of sandstone quarried at Massillon, Wayne County.

	Per cent.
Silica, SiO_2	97.36
Alumina, Al_2O_3	2.28
Calcium oxide, CaO	.05
Magnesium oxide	.08
Iron	Trace.
Total	99.77

The following analyses of sandstone quarried by Mr. F. C. Neeb at his quarries at Lancaster, Fairfield County, was made by Mr. Hugo Blanck, of Pittsburg, Pennsylvania:

Analyses of sandstone quarried at Lancaster, Fairfield County.

	Yellow (No. I).	Pale (No. II).
	Per cent.	*Per cent.*
Silica, SiO_2	96.822	97.762
Alumina, Al_2O_3	.505	.731
Oxide of iron	.670	.510
Lime, CaO	.040	.122
Magnesia, MgO	.005	.003
Water, H_2O	1.281	.511
Total	99.323	99.639

The following compression tests of the same stone were made by Mr. M. J. Becker, chief engineer of the Pittsburg, Cincinnati, Chicago and St. Louis Railroad:

Compression tests of sandstone quarried at Lancaster, Fairfield County.

No. of test.	Dimensions.			Sectional area.	Ultimate strength.	
	Height.	Compressed surface.			Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*
1	5.9	6.00	5.90	35.40	210,600	5,950
2	5.8	5.85	5.85	34.22	231,400	6,762

The following is the statement of an analysis of the sandstone quarried by Messrs. Reynolds Brothers at their quarries at Freeport, Harrison County, Ohio, by Mr. Charles D. Rawling, chemist, of Wheeling, West Virginia:

Analysis of Freeport, Harrison County, sandstone.

	Per cent.
Dried at 100° C.	
Silica, SiO_2	95.17
Alumina, Al_2O_3	.73
Ferric oxide, Fe_2O_3	2.53
Lime, CaO	.36
Magnesia, MgO	Trace.
Loss on ignition	1.17
Total	99.96
Water absorbed	6.08

The following facts relating to the sandstone quarried by the Rarden Stone Company at their quarries at Rarden, Scioto County, were obtained by Prof. Edward Orton, jr., Ohio State University:

Dried sample at 250° F.
Soaked sample 24 hours in water.
Percentage of absorption, 2.25.
Exposed sample 12 hours while wet to a temperature of 20° F., then thawed. Re-soaked for a short time and froze again. On thawing, practically no change in the stone was noticeable.

Limestone.—The following tables give the results of a number of analyses of limestone and lime made from limestone quarried in Ohio:

Analyses of limestone quarried in Ohio.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.					
	Town.	County.		Calcium carbonate, $CaCO_3$	Magnesium carbonate, $MgCO_3$	Oxides of iron and aluminum.	Siliceous matter insoluble in acids.		Totals.
				Per cent.	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*
Snowflake Lime Co	Bowling Green	Wood	Prof. Edward Orton, State geologist.	53.88	44.91	0.40	0.30		99.49
M. Daum & Son	Carey	Wyandot	do	56.40	41.99	.31	.48		99.18
T. J. Price & Co	Columbus	Franklin	do	94.80	1.21	.80	3.20		100.01
D. P. Lloyd & Co	Fostoria	Wood	do	52.00	45.26	2.70	Trace.		99.96
N. E. Gregg & Co	Genoa	Ottawa	do	54.30	45.14	.16	.23		99.83
Olemacher Lime Co	Sandusky	Erie	do	89.08	8.34	.35	1.51		99.28
J. Kingham	Rockyridge	Ottawa	do	54.10	44.27	.29	.87		99.53
Sugar Ridge Lime and Stone Co.	Sugarridge	Wood	do	55.23	43.12	.69	.84		99.88
O. D. Brown	Rex	Miami	do	95.60	3.93	.40	.07		100.00
Casparis Stone Co	Cold Springs	Clark	Ellis Lovejoy, Columbus, Ohio	54.05	44.94	.23	.49		99.71
Do	Columbus	Franklin	Chemist of Cleveland Rolling Mills.	93.21	4.70	1.74			99.65
Norris & Christian Lime and Stone Co.	Marion	Marion	do	86.22	9.27	2.30	2.86	P 0.11	100.76
N. B. Eddy	Luckey	Wood	G. A. Kirchmaier, Toledo, Ohio	54.10	44.90	.36	*a* .45		99.81
Duncan & Bussard	Williston	Ottawa	do	53.90	44.82	.21	*a* .21	P_2O_5 .001	99.141
J. W. Ruhl	Covington	Miami	J. D. Lisle	53.00	37.11		*a* 3.77	Al_2O_3 .33 Fe_2O_3 .67	*b* 96.34
W. E. Marsh	Eifort	Scioto	Chemist of Burgess Steel and Iron Works, Portsmouth, Ohio.	97.32	.45	1.40	*a* .60		99.77
Doherty & Co	Toledo	Wood	Hugo Blanck, Pittsburg, Pa	57.30	36.70		*a* 4.95	H_2O .21 Al_2O_3 .02	*c* 99.50

Analysis of lime made from limestone quarried in Ohio.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Substances determined.						
	Town.	County.		Alumina, Al_2O_3	Ferric oxide, Fe_2O_3	Silica, SiO_2	Calcium oxide, CaO	Magnesium oxide, MgO	Water.	Totals.
				Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
L. McCollum & Co.........	Tiffin	Seneca........	Prof. Otto Wulte, Pittsburg, Pa..	0.10	0.07	1.61	57.44	40.36	0.41	99.99

a Given as silica, SiO_2. *b* Includes also organic matter, 0.73 per cent, and manganese oxide, 0.73 per cent. *c* Includes also 0.32 per cent organic matter.

OREGON.

Sandstone.—The following is a statement of the results of analysis and physical test of sandstone quarried by the Victor Sandstone Company at their quarries at Chitwood, Lincoln County, by Maj. J. W. Reilly at the Watertown Arsenal:

Analysis of sandstone quarried at Chitwood, Lincoln County.

	Per cent.
Silica, SiO_2	72.45
Oxide of iron	10.80
Alumina, Al_2O_3	12.60
Lime, CaO	4.10
Magnesia, MgO	Trace.
Total	99.95

Compression test.

Sectional area, 4.03 by 4.20 by 6.07=24.46 square inches.
First crack at 145,000 pounds.
Ultimate strength, 153,700=6,284 pounds per square inch; pyramidal fracture.

The following analysis of sandstone, quarried by the Forest Grove Stone Company at their quarries at Forestgrove, Washington County, was made by Mr. A. R. Sweetser, instructor in chemistry at T. A. & P. U., Forestgrove, Oregon:

Analysis of sandstone quarried at Forestgrove, Washington County.

	Per cent.
Silica, SiO_2	55.21
Ferric Oxide, Fe_2O_3	14.75
Alumina, Al_2O_3	17.87
Calcium oxide, CaO	2.10
Alkalies	4.98
Loss on ignition	5.09
Total	100.00

Specific gravity, 2.35.

PENNSYLVANIA.

Granite.—The following analysis of trap rock, quarried by the John T. Dyer Company at their quarry at Birdsboro, Berks County, was made by Dr. Hermann Fleck, of the University of Pennsylvania:[1]

Analysis of trap rock quarried at Birdsboro, Berks County.

	Per cent.
Silica, SiO_2	46.87
Alumina, Al_2O_3	13.36
Ferrous oxide, FeO	2.71
Ferric oxide, Fe_2O_3	9.79
Calcium oxide, CaO	14.70
Magnesium oxide, MgO	4.35
Sodium oxide, Na_2O	4.64
Potassium oxide, K_2O	2.01
Titanium oxide, TiO_2	1.98
Total	100.41

Marble.—The following analysis of marble, quarried by Mr. J. H. Black at his quarries in Dauphin County, near Annville, was made by Prof. G. G. Pond of the chemical department at State College, Pennsylvania:

Analysis of marble quarried in Dauphin County, near Annville.

	Per cent.
Carbonate of calcium, $CaCO_3$	95.10
Carbonate of magnesium, $MgCO_3$	3.96
Silica, SiO_2	1.07
Oxide of iron	.23
Alumina, Al_2O_3	.14
Phosphorus, P	.00
Organic matter	Slight tr.
Total	100.50
Specific gravity	2.67
Crushing strength, pounds per square inch	12,210

[1] For further detailed information see United States Geological Survey Report on Stone for 1897.

Slate.—The following analysis of "Peach Bottom" slate quarried by Messrs. J. Humphreys & Co. at their quarry at Delta, York County, was made by Dr. A. S. McCreath:

Analysis of slate quarried at Delta, York County.

	Per cent.
Silica, SiO_2	55.880
Titanium oxide, TiO_2	1.270
Alumina, Al_2O_3	21.849
Ferrous oxide, FeO	9.033
Manganous oxide, MnO	.586
Cobaltous oxide, CoO	Trace.
Calcium oxide, CaO	.155
Magnesia, MgO	1.495
Potassium oxide, K_2O	3.640
Sodium oxide, Na_2O	.460
Water, H_2O	3.385
Pyrite, FeS_2	.051
Sulphuric anhydride, SO_3	.022
Carbon, C	1.794
Total	99.620

The following analysis of slate, quarried by the East Bangor Consolidated Slate Company at their quarries at East Bangor, Northampton County, was made by Mr. Henry Leffman, of Philadelphia:

Analysis of slate quarried at East Bangor, Northampton County.

	Per cent.
Silica, SiO_2	68.620
Iron oxide	4.200
Alumina, Al_2O_3	12.680
Calcium carbonate, $CaCO_3$	2.337
Magnesium	3.759
Alkalies	3.730
Moisture and combustible matter	4.470
Total	99.796
Summary:	
Silicates	89.160
Carbonates	6.096
Moisture and combustible matter	4.470

Sandstone.—The following table gives the results of a number of specific-gravity determinations and analyses of sandstone quarried in Pennsylvania:

The following tables give the results of a number of physical tests and analyses of sandstone quarried in Pennsylvania:

Crushing strength, specific gravity, and ratio of absorption of sandstone quarried in Pennsylvania.

Name of firm quarrying stone.	Location of quarry.		Name and address of authority.	Crushing strength per square inch.	Number of specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.
	Town.	County.						
				Pounds.			*Pounds.*	
Hummelstown Brown Stone Co.	Hummelstown	Dauphin	Riehlé Brothers, Philadelphia, Pa.	13,097	3			
Do	do	do	Merrill, stones for building and decorating	12,810				
Hummelstown Brown Stone Co., No. 3	do	do	Riehlé Brothers, Philadelphia, Pa.	14,630	4			
Hummelstown Brown Stone Co., No. 4	do	do	do	10,933	4			
Hummelstown Brown Stone Co., No. 3	do	do	Rose Polytechnic Institute	14,000	3	2.66	146.0	1-27
Do	do	do	Watertown Arsenal	14,753	3			1-37
George Brook	Birdsboro	Berks	do	11,448	3			
Lumberville Granite Co	Lumberville	Bucks	Fairbanks's Laboratory, New York	19,895	4			1-93
Do	do	do	Booth, Garrett & Blair, Philadelphia, Pa.	24,625	2	2.60	162.5	1-88
Do	do	do	Garrison & Olsen, Philadelphia, Pa.	22,025	8			
Paul A. Oliver	Laurel Run	Luzerne	School of Mines, Columbia College	22,250		2.66	166.1	
Do	do	do	Cornell University	17,600	12	2.66	166.1	1-900
Pennsylvania Quarry Co	White Haven	do	Watertown Arsenal	29,252	3			
Do	do	do	do	32,397	7			

Analyses of sandstone quarried in Pennsylvania.

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.	Specific gravity.	Substances determined.										
	Town.	County.			Silica, SiO_2.	Alumina, Al_2O_3.	Ferric oxide, Fe_2O_3.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Potassium oxide, K_2O.	Sodium oxide, Na_2O.	Ferrous oxide, FeO.	Manganese dioxide, MnO_2.	Water, H_2O.	Total.
Hummelstown Brown Stone Co.—					*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*P. ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Blue	Hummelstown	Dauphin	From chemical laboratory of State College, Pa.	2.657	90.34	4.35	1.09	0.95	0.17	1.30	0.19	0.74	......	0.61	99.74
Brown	do	do	do	2.669	88.96	4.74	2.19	.86	.44	1.31	.24	......	......	.87	99.61
Swatara Brown Stone Co.	Swatara	Schuylkill	do	......	91.52	3.80	2.02	.50	.22	*a* 1.20	......	......	......	.74	100.00
Mount Gretna	Gretna	Washington	do	2.695	91.07	2.68	3.29	.23	.33	1.12	.24	......	......	.73	99.69
John Westley	Mohnsville	Berks	do	2.73	84.96	7.78	3.71	.10	.38	1.11	.43	......	0.18	1.40	100.05
Moody & Edwards	Grenoble	Bucks	do	2.66	79.08	12.42	2.50	......	......	2.02	3.01	......	.09	.55	99.67
Henry Mitchell	Newtown	do	do	2.66	82.34	11.46	1.07	.27	.19	.17	3.76	......	.07	.80	100.13
—— Yardley	Yardley	do	do	2.675	82.72	10.29	1.92	.17	.36	.10	2.92	......	.16	1.20	99.84
Laurel Run Red Stone Co.	Laurel Run	Luzerne	A. A. Breneman, New York City.	2.666	*b* 94.00	Trace.	1.98	1.10	1.00	......	......	......	Trace.	*c* 1.92	100.00
Pennsylvania Quarry Co.	White Haven	do	Chemist of Crane Iron Co.	......	90.36	2.17	*d* 1.15	2.00	Trace.	......	......	......	......	......	95.68
Edge Hill Mica Schist Co.	Edge Hill	Montgomery	Chemist of Pennsylvania Steel Co., Steelton, Pa.	......	89.00	6.83	2.21	.07	.16	1.73		......	......	......	100.00
Webster Keasey	Rough Run	Butler	James O. Handy, chemist, Pittsburg, Pa.	......	97.96	1.15	.11	......	......	.24		......	......	*e* .54	100.00

a Includes alkalies and loss.
b Silica and insoluble residue.
c Volatile matter—water and carbonic acid.
d Given as protoxide; evidently a mistake.
e Contains water and organic matter.

Bluestone.—The following analysis of bluestone quarried by Mr. Frank Carlucci at his quarry at Lathrop, Susquehanna County, was made by Mr. D. W. Humphrey, of Scranton, Pennsylvania.

Analysis of bluestone quarried at Lathrop, Susquehanna County.

	Per cent.
Silica, SiO_2	91.40
Alumina, Al_2O_3	6.64
Ferric oxide, Fe_2O_3	.16
Water, H_2O	1.28
Total	99.48

Limestone.—The following tables give the results of a number of analyses

Analyses of limestone

Name of firm quarrying stone.	Location of quarry.		Name and address of analyst.
	Town.	County.	
Carbon Limestone Co	Youngstown	Lawrence	S. W. McKeown
Steacy & Co	Wrightsville	York	A. S. McCreath, Harrisburg, Pa
Do	Hellam	do	do
R. McCoy Lime Co	Bridgeport	Montgomery	Chas. F. Reader
Chickies Iron Co	Chickies	Lancaster	Chickies Iron Co. chemist
James Copeland	Downingtown	Chester	Jas. H. Eastewick, Germantown, Pa.
Abraham K. Stauffer	Esterly	Berks	Chas. T. Davies
Wm. H. Gelbach	Fairfield	Adams	Franklin Menger, Ph. D
Geo. W. Musselman	do	do	do
Geo. W. Bachman	Freemansburg	Northampton	Irwin A. Bachman, Ph. D., Allentown, Pa.
J. King McLanahan, jr	Frankstown	Blair	Chemist of Shoenberger Steel Co.
Wm. B. Rambo:			
Quarry No. 1	Norristown	Montgomery	Booth, Garrett & Blair, Philadelphia, Pa.
Quarry No. 2	do	do	do
Jas. B. Smith:			
No. 1	Reedsville	Mifflin	R. Kent, Burnham, Pa
No. 2	do	do	do
Jno. C. Fisher	Richland Station	Lebanon	A. S. McCreath, Harrisburg, Pa
S. A. Royer	do	do	do
Listie Mining Co	Listie	Somerset	Chemist of W. Dewees Wood Co., McKeesport, Pa.
Winfield Mineral Co	West Winfield	Butler	Chemist of Pennsylvania Salt Mfg. Co., Natrona, Pa.
Jos. E. Thorpp	Everett	Bedford	By company chemist
Israel Stettler	Trexlertown	Lehigh	H. R. Hartzell
W. L. Heisey & Co	Rheems	Lancaster	State chemist, Harrisburg, Pa

Analyses of lime made from lime

Jno. Yeager	Dalmatia	Northumberland.	Dr. Wm. Frear, State chemist
R. McCoy Lime Co	Bridgeport	Montgomery	Chas. I. Reader

of limestone and lime made from limestone quarried in Pennsylvania:

quarried in Pennsylvania.

Calcium carbonate, $CaCO_3$.	Magnesium carbonate, $MgCO_3$.	Oxides of iron and aluminum.	Calcium oxide, CaO.	Magnesium oxide, MgO.	Ferric oxide, Fe_2O_3.	Aluminum oxide, Al_2O_3.	Siliceous matter insoluble in acids.	Silica, SiO_2.	Loss on ignition.	Phosphoric anhydride, P_2O_5.	Potassium oxide, K_2O.	Phosphorous, P.	Sulphur, S.	Total.
P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
96.43	0.40	1.60	......	......	......	......	......	1.50	......	......	......	0.02	0.08	100.03
54.26	44.51	.66	......	......	......	......	......	.56	......	......	......	......	......	99.99
93.14	6.50	.14	......	......	......	......	......	.12	......	......	......	......	......	99.90
55.70	41.97	.72	......	......	......	......	......	1.58	......	......	......	......	......	99.97
51.00	48.49	......	......	......	......	0.31	......	.36	......	......	......	......	......	100.16
54.15	45.20	......	......	......	0.37	......	......	......	......	......	......	......	......	99.72
55.58	39.21	1.22	......	......	......	......	3.89	......	......	......	......	......	......	99.90
85.23	2.78	1.50	......	......	......	......	......	10.30	0.19	......	......	......	......	100.00
86.91	3.11	......	......	......	.60	......	......	8.85	......	0.12	0.38	......	......	99.97
89.09	5.16	......	......	......	.32	1.61	......	2.18	......	......	......	......	......	98.36
......	......	1.00	54.90	None.	......	......	......	1.06	43.80	......	......	......	......	100.76
53.49	45.76	......	......	......	.45	......	.20	......	......	......	......	......	......	99.90
54.04	45.51	......	......	......	.20	......	.25	......	......	......	......	......	......	100.00
95.75	2.03	1.36	......	......	......	......	......	1.69	......	......	......	.002	......	100.832
96.24	2.86	.61	......	......	......	......	......	.33	......	......	......	.002	......	100.042
99.02	.67	.19	......	......	......	......	......	.07	......	......	......	.003	......	99.953
98.36	.91	.24	......	......	......	......	......	.39	......	......	......	.002	......	99.902
92.12	2.35	2.00	......	......	......	......	3.53	......	......	......	......	.02	......	100.02
95.10	1.12	1.00	......	......	......	......	2.78	......	......	......	......	......	......	100.00
......	......	......	30.18	19.48	......	.89	......	4.48	......	......	......	......	......	55.03
86.50	1.21	2.30	......	......	......	......	......	7.22	......	......	......	......	......	97.23
97.95	.98	.11	......	......	......	......	.96	......	......	......	......	......	......	100.00

stone quarried in Pennsylvania.

......	......	6.80	81.38	1.34	......	......	2.43	......	7.05	0.35	0.65	......	......	100.00
......	......	1.35	58.33	37.37	......	......	......	2.95	......	......	......	......	......	100.00

RHODE ISLAND.

Limestone.—The following analysis of limestone quarried by Mr. Herbert Harris at his quarry at Lime Rock, Providence County, was made by Prof. J. H. Appleton, of Brown University:

Analysis of limestone quarried at Lime Rock, Providence County.

	Per cent.
Moisture	0.040
Oxide of iron	.011
Alumina, Al_2O_3	.309
Siliceous matter, insoluble	2.748
Calcium carbonate, $CaCO_3$	88.233
Magnesium carbonate, $MgCO_3$	8.797
Total	100.138

SOUTH CAROLINA.

Granite.—The following compression test of granite quarried by the Georgia-Carolina Granite Company at their quarry at Carlisle, Union County, was made when the quarry was operated by A. J. Salenas & Son, at the Watertown Arsenal:

Compression test of granite quarried at Carlisle, Union County.

Dimensions.	Sectional area.	First crack.	Ultimate strength.	
			Total.	Per square inch.
Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
1.99 by 2.03 by 2.03	4.12	112,000	120,100	29,150

SOUTH DAKOTA.

Sandstone.—The following compression test of sandstone quarried by the Burke Stone Company at their quarry at Hot Springs, Fall River County, was made at the Watertown Arsenal:

Compression test of sandstone quarried at Hot Springs, Fall River County.

Test No.	Height.	Compressed surface.	Sectional area.	First crack.	Ultimate strength.	
					Total.	Per square inch.
	Inches.	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
8721	1.02	2.05 by 2.04	4.18	28,900	28,900	6,914

The following tests of sandstone quarried by the Baker Quarry Company at their quarries at Rapid City, Pennington County, were made by Mr. William F. M. Goss, at Purdue University:

Tests of sandstone quarried at Rapid City, Pennington County.

Kind of stone.	Area.	Total crushing strength.	Strength per square inch.
	Square inches.	*Pounds.*	*Pounds.*
Gray	4.42	50,618	11,452
White	4.40	31,030	7,052
Red	4.14	25,320	6,116
Buff	4.34	39,220	9,037
Variegated	4.14	36,855	8,902
Brown	4.43	25,825	5,829

Limestone.—The following is a partial analysis of limestone quarried by the Deadwood and Delaware Smelting Company at their quarry at Deadwood, Lawrence County, made by Mr. J. V. N. Door:

Partial analysis of limestone quarried at Deadwood, Lawrence County.

	Per cent.
Siliceous matter, insoluble	1.80
Oxides of iron and aluminum	Trace.
Calcium oxide, CaO	33.80
Magnesium oxide, MgO	15.70

TENNESSEE.

Limestone.—The following analysis of lime made from limestone quarried by the Arlington Lime Company at their quarry at Erin, Houston County, was made by Prof. J. C. Wharton, Nashville, Tenn.:

Analysis of lime made from limestone quarried at Erin, Houston County.

	Per cent.
Calcium oxide, CaO	97.82
Calcium carbonate, CaCO	1.27
Magnesium oxide, MgO	.12
Ferric oxide, Fe_2O_3	.23
Aluminum oxide, Al_2O_3	.13
Siliceous matter, insoluble in hydrochloric acid	.43
Total	100.00

The following analysis of lime made from limestone quarried by the Gager Lime and Manufacturing Company at their quarry at Sherwood, Franklin County, was made by the chemist of the Proctor & Gamble Company, Cincinnati, Ohio:

Analysis of lime made from limestone quarried at Sherwood, Franklin County.

	Per cent.
Calcium oxide, CaO	97.89
Calcium carbonate, $CaCO_3$	.27
Magnesium carbonate, $MgCO_3$	1.05
Silica, SiO_2	.56
Oxides of iron and aluminum	.22
Total	99.99

TEXAS.

Limestone.—The following analysis of limestone, quarried by Mr. D. R. Boone at his quarry at Oglesby, Coryell County, Texas, was made by Prof. H. H. Harrington, of the Agricultural and Mechanical College and Experiment Station, of Texas:

Analysis of limestone quarried at Oglesby, Coryell County.

	Per cent.
Siliceous matter	1.09
Organic matter	.52
Iron oxide	.35
Calcium oxide, CaO	54.02
Magnesium oxide, MgO	.12
Sulphur trioxide, SO_3	.17
Carbon dioxide, CO_2	43.96
Total	100.23

The following analyses of lime, made from limestone quarried by the Austin White Lime Company at their quarries at McNeil, Travis County, were made by Prof. James R. Bailey, of the chemical department, University of Texas:

Analyses of lime made from limestone quarried at McNeil, Travis County.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Loss of weight at white heat	1.41	1.02
Residue insoluble in acids	.25	.15
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	.15	.16
Calcium oxide, CaO	97.46	97.82
Undetermined	.73	.85
Total	100.00	100.00

UTAH.

Sandstone.—The following analysis of sandstone, quarried by the Kyune Graystone Company at their quarry at Jennings Spur, Utah County, was made by Mr. Herman Harms, chemist for the Nelden-Judson Drug Company, Salt Lake, Utah:

Analysis of sandstone quarried at Jennings Spur, Utah County.

	Per cent.
Silica, SiO_2	83.64
Iron oxide	1.96
Alumina, Al_2O_3	.46
Calcium carbonate, $CaCO_3$	8.50
Magnesium oxide, MgO	.70
Water and volatile matter	3.22
Loss in analysis	1.62
Total	100.10

Specific gravity (practically), 2.5.

VERMONT.

Granite.—The following report on the "dark" and "medium" granite, quarried by Messrs. Wells, Lamson & Co. at their quarries at Barre, Washington County, was recently made by Dr. Wm. C. Day, of the analytical and testing laboratory of Swarthmore College, Swarthmore, Pennsylvania.[1]

REPORT ON DARK AND MEDIUM GRANITE FROM BARRE, WASHINGTON COUNTY.

Chemical analysis of dark granite.

	Per cent.
Silica, SiO_2	69.56
Ferric oxide, Fe_2O_3	2.65
Alumina, Al_2O_3	15.38
Manganese	Trace.
Lime, CaO	1.76
Magnesia, MgO	Trace.
Sodium oxide, Na_2O	5.38
Potassium oxide, K_2O	4.31
Loss on ignition, CO_2, and moisture	1.02
Total	100.06

[1] For further detailed information see United States Geological Survey Report on Stone for 1897.

Determinations of specific gravity.

DARK GRANITE.

	Grams.
Weight of granite	8.8061
Weight of water displaced	3.2956
Specific gravity found	2.672

Temperature of water, 22° C.

MEDIUM GRANITE.

Weight of granite	32.95745
Weight of water displaced	12.37680
Specific gravity found	2.662

Temperature of water, 20° C.

Determinations of absorption capacity.

DARK GRANITE.

	Grams.
Weight of granite after heating in air at 110° C. for six hours	49.9625
Weight of granite after boiling in water for three hours and wiping dry	50.0230
	.0605
Weight after heating again at 110° C. for six hours	49.9328

Per cent of water absorbed, 0.121.

MEDIUM GRANITE.

Weight of granite after heating in air at 110° C. for six hours	64.1723
Weight of granite after boiling in water for three hours and wiping dry	64.2549
	.0826
Weight after heating again at 110° C. for six hours	64.1534

Per cent of water absorbed, 0.129.

Crushing strength of the same granite, using the standard Tinius Olsen testing machine.

DARK GRANITE.

[Crushing strain applied perpendicular to rift.]

No.	Size.	Area.	Broke at—	Crushing strength per square inch.
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*
1	2 high by 2 by 2.02	4.04	71,870	17,790
2	2 high by 2.03 by 2.07	4.20	70,220	16,719

[Crushing strain applied parallel to rift.]

3	2 high by 2.06 by 2.04	4.20	83,820	19,957

MEDIUM GRANITE.

[Crushing strain applied perpendicular to rift.]

1	2 high by 2 by 2.02	4.04	72,140	17,856
2	2 high by 2.02 by 2.04	4.12	61,670	14,968

[Crushing strain applied parallel to rift.]

3	2 high by 2 by 2.03	4.06	64,170	15,805

Marble.—The following analysis of marble, quarried by the Columbian Marble Company at their quarry at Proctor, Rutland County, was made by Professor Penfield, of Yale University:

Analysis of marble quarried at Proctor, Rutland County.

	Per cent.
Carbonate of lime, $CaCO_3$	98.37
Carbonate of magnesia, $MgCO_3$	.77
Carbonate of iron	.034
Manganese and aluminum oxides	.005
Siliceous matter insoluble in acids	.63
Organic matter	.08
Total	99.889

The coloring matter is pure carbon graphite, which is incapable of decomposition by atmospheric agents.

Slate.—The following table gives analyses of slate quarried in the slate belt of eastern New York and western Vermont:

Analyses of slate quarried in the slate belt

Name of firm quarrying stone.	Location of quarry.		Name of analyst.
	Town.	County and State.	
Rising & Nelson (quarry No. 2).	West Pawlet	Rutland, Vt ..	Dr. W. F. Hillebrand, U. S. Geological Survey.
Griffith & Nathaniel........	South Poultney...	.....do	.....do ....
William H. Hughes (quarry No. 10).	Brownell	.....do	.....do ....
Auld & Conger.............	Wells.............	.....do	.....do ....
Eureka Slate Quarries	Poultney	.....do	.....do ....
Valley Slate Co	.....do	.....do	.....do ....
M. & J. McCarty.	South Poultney..	.....do	.....do ....
Francis & Sons	Castleton	.....do	.....do ....
Eureka Slate Quarries.	Poultney	.....do	.....do ....
H. H. Mathews	Hampton	Washington, N. Y.	.....do ....
Empire Red Slate Co.......	Granville.........	.....do	.....do ....
National Red Slate Co......	.....do	.....do	.....do ....
National Red Slate Co......	.....do	.....do	.....do ....
Empire Red Slate Co.......	.....do	.....do	Mr. George Steiger, U. S. Geological Survey.
Fair Haven Red Slate Co ..	East Whitehall...	.....do	.....do ....
National Red Slate Co......	Granville.........	.....do	Dr. Hillebrand..................
American Black Slate Co...	Benson	Rutland, Vt ..	.....do ....

Name of firm quarrying stone.	Location of quarry.		Name of analyst.
	Town.	County and State.	
Rising & Nelson (quarry No. 2).	West Pawlet	Rutland, Vt ..	Dr. W. F. Hillebrand, U. S. Geological Survey.
Griffith & Nathaniel	South Poultney...	.....do	.....do ....
William H. Hughes (quarry No. 10).	Brownell	.....do	.....do ....
Auld & Conger.............	Wells.............	.....do	.....do ....
Eureka Slate Quarries	Poultney	.....do	.....do ....
Valley Slate Co	.....do	.....do	.....do ....
M. & J. McCarty	South Poultney..	.....do	.....do ....
Francis & Sons.............	Castleton	.....do	.....do ....
Eureka Slate Quarries	Poultney	.....do	.....do ....
H. H. Mathews	Hampton	Washington, N. Y.	.....do ....
Empire Red Slate Co.......	Granville.........	.....do	.....do ....
National Red Slate Co......	.....do	.....do	.....do ....
National Red Slate Co......	.....do	.....do	.....do ....
Empire Red Slate Co.......	.....do	.....do	Mr. George Steiger, U. S. Geological Survey.
Fair Haven Red Slate Co ..	East Whitehall...	.....do	.....do ....
National Red Slate Co......	Granville.........	.....do	Dr. Hillebrand..................
American Black Slate Co...	Benson	Rutland, Vt ..	.....do ....

of eastern New York and western Vermont.

Substances determined.									
Silica, SiO_2.	Titanium dioxide, TiO_2.	Zirconia, ZrO_2.	Alumina, Al_2O_3.	Ferric oxide, Fe_2O_3.	Ferrous oxide, FeO.	Manganous oxide, MnO.	Nickelous oxide, NiO.	Cobaltous oxide, CoO.	Strontia, SrO.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
67.76	0.71	....	14.12	0.81	4.71	0.10	Trace?	Trace?	....
62.37	.74	....	15.43	1.34	5.34	.22	Trace.	Trace.	....
59.84	.74	....	15.02	1.23	4.73	.34	Trace.	Trace.	....
65.29	....	....	....	....	....	....	....	....	....
59.27	.99	....	18.81	1.12	6.58	.13	Trace?	Trace?	....
59.48	1.02	Trace?	18.22	1.24	6.81	.07	Trace.	....	Trace?
61.63	.68	....	16.33	4.10	2.71	.09	Trace?	Trace?	....
60.96	.86	Trace.	16.15	5.16	2.54	.07	Trace.	Trace.	....
60.24	.92	Trace?	18.46	2.56	5.18	.07	Trace.	Trace.	....
67.61	.56	....	13.20	5.36	1.20	.10	Trace.	Trace.	....
67.55	.58	....	12.59	5.61	1.24	.19	Trace.	Trace.	....
56.49	.48	....	11.59	3.48	1.42	.30	Trace.	Trace.	....
63.88	.47	....	9.77	3.86	1.44	.21	Trace.	Trace.	....
....	....	....	....	7.10	1.00	....	....	....	....
....	....	....	....	1.02	1.67	....	....	....	....
67.89	.49	....	11.03	1.47	3.81	.16	Trace.	Trace.	....
59.70	.79	....	16.98	.52	4.88	.16	Trace?	Trace?	....

Substances determined.									
Calcium oxide, CaO.	Baryta, BaO.	Magnesia, MgO.	Potassium oxide, K_2O.	Sodium oxide, Na_2O.	Lithium oxide, Li_2O.	Water below 110° C.	Water above 110° C.	Phosphoric anhydride, P_2O_5.	Carbon dioxide, CO_2.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0.63	0.04	2.38	3.52	1.39	Strong tr.	0.23	2.98	0.07	0.40
.77	.07	3.14	4.20	1.14	Trace.	.34	3.71	.06	.87
2.20	.09	3.41	4.48	1.12	Strong tr.	.41	3.44	.09	2.98
....	....	....	....	....	....	....	....	....	....
.42	.05	2.21	3.75	1.88	Trace.	.32	3.98	.11	.21
.56	.05	2.50	3.81	1.55	Trace.	.17	4.05	.10	.39
.50	.06	2.92	5.54	1.26	Strong tr.	.31	3.24	.16	.41
.71	.04	3.06	5.01	1.50	Trace.	.17	3.08	.23	.68
.33	.03	2.33	4.09	1.57	Strong tr.	.18	3.81	.11	.08
.11	.04	3.20	4.45	.67	Trace.	.45	2.97	.05	None.
.26	.31	3.27	4.13	.61	Trace.	.40	3.03	.10	.11
5.11	.06	6.43	3.77	.52	Strong tr.	.37	2.82	.09	7.42
3.53	.05	5.37	3.45	.20	Strong tr.	.27	2.48	.08	5.08
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....
1.43	.04	4.57	2.82	.77	Trace.	.36	3.21	.10	1.89
1.27	.08	3.23	3.77	1.35	Strong tr.	.30	3.82	.16	1.40

Analyses of slate quarried in the slate belt of eastern

Name of firm quarrying stone.	Location of quarry.		Name of analyst.
	Town.	County and State.	
Rising & Nelson (quarry No. 2).	West Pawlet	Rutland, Vt	Dr. W. F. Hillebrand, U. S. Geological Survey.
Griffith & Nathaniel	South Poultney	do	do
William H. Hughes (quarry No. 10).	Brownell	do	do
Auld & Conger	Wells	do	do
Eureka Slate Quarries	Poultney	do	do
Valley Slate Co	do	do	do
M. & J. McCarty	South Poultney	do	do
Francis & Sons	Castleton	do	do
Eureka Slate Quarries	Poultney	do	do
H. H. Mathews	Hampton	Washington, N. Y.	do
Empire Red Slate Co	Granville	do	do
National Red Slate Co	do	do	do
National Red Slate Co	do	do	do
Empire Red Slate Co	do	do	Mr. George Steiger, U. S. Geological Survey.
Fair Haven Red Slate Co	East Whitehall	do	do
National Red Slate Co	Granville	do	Dr. Hillebrand
American Black Slate Co	Benson	Rutland, Vt	do

New York and western Vermont—Continued.

Substances determined.					Total sulphur included above, S.	Specific gravity.	Remarks.
Pyrite, FeS_2.	Sulphuric anhydride, SO_3.	Carbon, C.	Fluorine, Fl.	Total.			
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		
0.22	Trace.	None.	....	100.07	0.12	....	Sea-green slate.
.06	Trace.	Strong tr.	....	99.80	.032	....	Do.
.05	Trace.	Trace.	0.11	100.28	.024	2.7910	Do.
....	....	....	....	....	....	2.7627	Do.
.15	Trace.	None.	....	99.98	.08	2.795	Unfading-green slate.
.13	....	None.	.08	100.23	.07	....	Do.
.04	Trace.	None.	....	99.98	.02	2.8064	Purple slate.
None.	....	None.	....	100.22	.07	....	Do.
.16	....	None.	....	100.12	.087	2.8053	Variegated slate.
.03	Trace.	None.	....	100.00	.016	....	Red slate.
.04	Trace.	None.	....	100.02	.02	....	Do.
.03	Trace,	None.	....	100.38	.016	2.7839	Do.
Trace.	....	None.	....	100.14	....	....	Do.
....	....	....	....	....	....	2.8085	Do.
....	....	....	....	....	....	....	Do.
.04	Trace.	None.	....	100.08	.022	2.7171	Bright-green speckled slate.
1.18	Trace.	0.46	....	100.05	.63	2.7748	Black slate.

For comparison the following well-authenticated foreign analyses are inserted:

Analyses of foreign slates.

Kind of slate.	Location of quarry.	Name of analyst.	Substances determined. Silica, SiO_2.	Titanium oxide, TiO_2.	Alumina, Al_2O_3.	Ferric oxide, Fe_2O_3.	Ferrous oxide, FeO.	Calcium oxide, CaO.	Magnesia, MgO.	Potassium oxide, K_2O.	Sodium oxide, Na_2O.	Water.	Phosphoric anhydride, P_2O_5.	Carbon dioxide, CO_2.	Total.	Specific gravity.
			Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
Delabole, gray roofing slate (two analyses).	Camelford, Cornwall, England.	J. A. Phillips *a*	58.30	0.23	21.89	7.05	2.57	0.39	1.09	2.45	1.18	4.61	......	......	99.76	2.81
Fumay:																
Purple roofing slate	Ardennes, France	A. Renard *b*	61.57	1.31	19.22	6.63	1.20	.22	2.00	3.63	.93	3.25	......	......	99.96	......
Green roofing slate	do	do	65.63	.94	20.20	2.72	.85	.19	1.54	3.81	.71	3.17	......	......	99.76	......
La Richolle Quarry:																
Blue-gray roofing slate.	Rimogne, Ardennes, France.	Klement *c*	61.43	.73	19.10	4.81	3.12	.31	2.29	3.24	.83	3.52	......	......	99.38	......
Black slate	Westphalia	H. von Dechen *d*	67.56	......	12.23	2.87	6.99	.27	3.03	1.76	1.28	1.00	0.10	*h* 3.11	100.20	......
Do	Frankenberg, Prussia	A. von Groddeck *e*	59.35	1.00	13.56	1.10	4.75	5.20	3.60	1.77	1.48	3.41	.31	4.45	99.98	......
Bluish roofing slate	Near Wigstadl, Mohradorf, Silesia, Austria.	Nikolic *f*	55.06	......	22.55	1.97	5.96	1.30	2.92	3.82	2.17	4.35	......	......	100.10	2.78
Glyn quarries, blue slate.	Llanberis, Wales, England.	Museum of Practical Geology, London. *g*	60.68	.59	21.20	5.68	.46	1.71	.88	3.64	2.09	2.88	.16	*h* .07	100.04	......

a London, Edinburgh, and Dublin Phil. Mag., 4th ser., No. 27, pp. 95-96, Feb., 1871. *b* Recherches sur la composition et la structure des phyllades ardenais, pub. by A. Renard; Bull. Mus. Roy. d'Hist. Nat. de Belgique, Vol. I, p. 239, 1882. *c* Pub. by A. Renard, op. cit. supra, p. 233. *d* Roth. Allgem. und Chem. Geol., II, pp. 586, 587, 1884. *e* Jahrb. pr. Geol. Landesanst., 1885-86; quoted in Roth. Allgem. Chem. Geol., II, pp. 586, 587. *f* Tschermaks Min. Mitth., 1871, p. 207; quoted by Roth. op. cit. supra, pp. 588, 589. *g* Geol. Mag., London, 1868, Vol. V, p. 123. *h* Carbon, C.

Slate.—The following tests of slate quarried by the American Black Slate Company at their quarries at Benson, Rutland County, were made by Dr. William C. Day, of the analytical and testing laboratory of Swarthmore College, Pennsylvania:

Transverse tests of slate quarried at Benson, Rutland County.

No. of specimen.	Distance between supports.	Width of slab.	Thickness of slab.	Broke at—	Modulus of rupture in pounds per square inch.	Remarks.
	Inches.	*Inches.*	*Inches.*	*Pounds.*		
1	19.0	12.00	0.1925	171.25	10,975	
2	19.0	12.00	.1455	110.00	12,340	Deflection, 0.35 inches.
3	10.9	6.12	.1674	102.25	9,726	Deflection, 0.25 inches.

Specific gravity determinations of same slate.

No. 1.

	Grams.
Weight of pycnometer	26.3083
Weight of pycnometer and slate	33.4626
Weight of slate	7.1543
Weight of pycnometer, slate, and water	90.2068
Weight of pycnometer and water	85.6405
Weight of water displaced	2.5880

Temperature, 20.4° C.
Specific gravity found = 2.764.

No. 2.

	Grams.
Weight of slate in air	4.3861
Weight of slate in water	2.8120
Weight of water displaced	1.5741

Temperature, 20° C.
Specific gravity found = 2.786.

Absorptive capacity of same slate.

No. 1.

	Grams.
Weight of 6 pieces of slate in natural state	45.8621
Weight of 6 pieces of slate after drying six hours at 105° C	45.8067
Weight of 6 pieces of slate after drying again six hours at 105° C	45.7991
Weight of 6 pieces of slate after boiling in water six hours and wiping dry	45.9184
Gain in weight from absorbed water	.1193
	.0991

$$\text{Absorptive capacity} = \frac{0.1193}{45.7991} = 00.26 \text{ per cent.}$$

No. 2.

[Same samples as in No. 1, but dried at 55° C. for twenty-four hours, instead of 105° C., and soaked in cold water forty-eight hours.]

	Grams.
Weight of sample after drying at 55° C	45.8003
Weight of sample after soaking in water forty-eight hours and wiping dry, and allowing to stand in air a short time	45.9000

Absorptive capacity $= \frac{0.0997}{45.8003} =$ 00.22 per cent.

Corrodibility test of same slate.

	Grams.
Weight of sample taken	24.3815
Weight of sample after soaking in acid bath (2 per cent solution of equal weights of HCl and H_2SO_4) twenty-four hours, then in water twenty-four hours, and finally drying in air one hour	24.2956
Weight of sample after soaking in fresh acid bath forty-eight hours, then in water twenty-four hours, and drying in air one hour	24.2010

Per cent of loss after twenty-four hours = 0.35.
Per cent of loss after seventy-two hours = 0.74.

The following analysis of the same slate was made by Dr. W. F. Hillebrand, of the chemical laboratory, United States Geological Survey:

Analysis of black slate quarried at Benson, Rutland County.

	Per cent.
Silica, SiO_2	59.70
Titanium dioxide, TiO_2	.79
Alumina, Al_2O_3	16.98
Ferric oxide, Fe_2O_3	.52
Ferrous oxide, FeO	4.88
Manganous oxide, MnO	.16
Nickelous oxide, NiO	Trace?
Cobaltous oxide, CoO	Trace?
Calcium oxide, CaO	1.27
Baryta, BaO	.08
Magnesia, MgO	3.23
Potassium oxide, K_2O	3.77
Sodium oxide, Na_2O	1.35
Lithium oxide, Li_2O	Strong tr.
Water below 110°C	.30
Water above 110° C	3.82
Phosphoric anhydride, P_2O_5	.16
Carbon dioxide, CO_2	1.40
Pyrite, FeS_2	1.18
Sulphuric anhydride, SO_3	Trace.
Carbon, C	.46
Total	100.05
Total sulphur in above, S	.63
Specific gravity	2.7748

Limestone.—The following three analyses show the composition of lime made from limestone quarried by Mr. J. P. Rich at his quarry at Swanton, Franklin County. No. 1 was made by Mr. C. Sharpless, No. 2 by Mr. F. C. Robinson, and No. 3 by Mr. J. R. Chilton:

Analyses of lime made from limestone quarried at Swanton, Franklin County.

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Calcium oxide, CaO	98.47	99.29	98.84
Magnesium oxide, MgO	1.12	.46	.12
Ferric oxide, Fe_2O_3	Trace.		
Ferrous oxide, FeO		.12	
Carbon dioxide, CO_2	.45		1.02
Silica, SiO_2	Trace.	.10	.02
Aluminum and manganese		Trace.	
Total	100.04	99.97	100.00

The following analysis of lime made from limestone quarried by Messrs. Follet Brothers at their quarry at North Pownal, Bennington County, was made by Mr. R. Schuppaus:

Analysis of lime made from limestone quarried at North Pownal, Bennington County.

	Per cent.
Calcium oxide, CaO	98.14
Magnesium oxide, MgO	1.40
Silica, SiO_2	.27
Alumina, Al_2O_3	.11
Ferric oxide, Fe_2O_3	.08
Total	100.00

The following analysis of lime made from limestone quarried by the Brandon Lime and Marble Company at their quarry at Leicester Junction, Addison County, was made by Mr. C. T. Lee:

Analysis of lime made from limestone quarried at Leicester Junction, Addison County.

	Per cent.
Calcium oxide, CaO	98.262
Calcium carbonate, $CaCO_3$	.409
Magnesium oxide, MgO	.299
Silica, SiO_2	.383
Ferric oxide, Fe_2O_3	.647
Total	100.000

The following analysis of lime made from limestone quarried by Mr. W. B. Fonda at his quarry at St. Albans, Franklin County, was made by Prof. F. C. Robinson, of Bowdoin College, Brunswick, Maine:

Analysis of lime made from limestone quarried at St. Albans, Franklin County.

	Per cent.
Calcium oxide, CaO	99.23
Insoluble matter	.14
Alumina, Al_2O_3	Trace.
Iron	Trace.
Magnesium oxide, MgO	.60
Total	99.97

The following analysis was made by Mr. S. P. Sharples, State assayer for Massachusettes, of limestone quarried by Mr. L. H. Felton at his quarry at Highgate Springs, Franklin County, Vermont:

Analysis of limestone quarried at Highgate Springs, Franklin County.

	Per cent.
Calcium oxide, CaO	55.83
Magnesium oxide, MgO	Trace.
Oxides of iron and aluminum	.10
Silica, SiO_2	.40
Carbon dioxide, CO_2	43.65
Total	99.98

VIRGINIA.

Granite.—The following chemical analysis and tests of the granite quarried by the Petersburg Granite Quarrying Company at their quarries at Petersburg, Dinwiddie County, Virginia, were made by Messrs. Hunt and Clapp at their Pittsburg testing laboratory:

Analysis of granite quarried at Petersburg, Dinwiddie County.

	Per cent.
Silica, SiO_2	64.12
Alumina, Al_2O_3	20.91
Oxide of iron, Fe_2O_3	2.96
Lime, CaO	1.98
Magnesia, MgO	.66
Sodium oxide, Na_2O	4.57
Potassium oxide, K_2O	4.82
Total	100.02

Constituent minerals of granite from Petersburg, Dinwiddie County.

	Per cent.
Mica	15.00
Feldspar	60.00
Quartz	25.00
Total	100.00

Test of 2-inch cube of granite from quarries at Petersburg, Dinwiddie County.

Original dimensions, 2 inches square.
Original area, 4 square inches.
Ultimate load, 100,400 pounds.
Crushing strength, 25,100 pounds per square inch.

The following tests of granite quarried by Mr. Peter Copeland at his quarry at Richmond, Henrico County, were made at the Watertown Arsenal:

Compression tests of granite quarried at Richmond, Henrico County.

No. of test.	Height.	Sectional area.	First crack.	Ultimate strength.	
				Total.	Per square inch.
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
1	1.90	4.00	93,000	102,080	25,520
2	1.90	4.00	103,000	114,500	28,625

Slate.—The following is an analysis of slate quarried by Messrs. John R. Williams & Co. at their quarries at Arvonia, Buckingham County, by Dr. Henry Froehling:

Analysis of slate from Arvonia, Buckingham County.

	Per cent.
Silica, SiO_2	60.65
Alumina, Al_2O_3	16.87
Ferric oxide, Fe_2O_3	7.79
Manganese	Trace.
Lime, CaO	1.91
Magnesia, MgO	2.39
Carbon dioxide, CO_2	Trace.
Sulphur, S	.69
Potash, K_2O	3.80
Soda, Na_2O	2.18
Water and organic matter	3.63
Total	99.91

The sample dried at 212° F.

Limestone.—The following analysis of limestone quarried by the Crozer Iron Company at their quarry at Buchanan, Botetourt County, was made by Mr. W. Walley Davis:

Analysis of limestone quarried at Buchanan, Botetourt County.

	Per cent.
Silica, SiO_2	0.104
Oxides of iron and aluminum	.518
Calcium carbonate, $CaCO_3$	61.640
Magnesium carbonate, $MgCO_3$	37.578
Total	99.840

The following analysis was made by Dr. Henry Froehling, Richmond, of limestone quarried by the Moore Lime Company at their quarry at Eagle Rock, Botetourt County:

Analysis of limestone quarried at Eagle Rock, Botetourt County.

	Per cent.
Calcium carbonate, $CaCO_3$	98.71
Magnesium carbonate, $MgCO_3$	.65
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	.31
Silica, SiO_2	.25
Total	99.92

WASHINGTON.

Sandstone.—The following compression tests of sandstone, known as Bellingham Bay stone, and quarried by Mr. Henry Roeder at his quarries at Chuckanut, Whatcom County, were made at the Watertown Arsenal under the direction of Maj. J. W. Reilly:

Tests of sandstone quarried at Chuckanut, Whatcom County.

[Compressed surfaces faced with plaster of paris to secure even bearings in the testing machine.]

Test No.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
	Height.	Compressed surface.				Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
7178	3.99	4.22	4.20	17.72	179,000	182,100	10,276
7179	4.09	4.13	4.20	17.35	183,000	221,900	12,790
7180	4.20	4.21	4.23	17.81	192,000	197,700	10,780

WEST VIRGINIA.

Limestone.—The following analysis of lime, made from limestone quarried by Messrs. G. C. and S. C. Ditto & Co. at their quarries at Marlowe, Berkeley County, was made by Mr. J. A. Ditto, Marlowe, West Virginia:

Analysis of lime made from limestone quarried at Marlowe, Berkeley County.

	Per cent.
Siliceous matter, insoluble	0.18
Calcium oxide, CaO	98.44
Magnesium oxide, MgO	.98
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	.26
Carbon dioxide, CO_2	.32
Total	100.18

The following analysis was made by Mr. J. Blodget Britton, of Warrenton, Virginia, of limestone quarried by Mr. D. Y. Huddleston at his quarry at Snow Flake, Greenbrier County, West Virginia:

Analysis of limestone quarried at Snow Flake, Greenbrier County.

	Per cent.
Calcium carbonate, $CaCO_3$	96.46
Magnesium carbonate, $MgCO_3$	1.11
Organic matter, loss on ignition	Trace.
Insoluble siliceous matter	.97
Sulphur	None.
Aluminum oxide, Al_2O_3	1.46
Phosphorus	None.
Total	100.00

WISCONSIN.

Granite.—The following analysis of granite, quarried by the Milwaukee Monument Company at their quarry in Waushara County, was made by Mr. A. S. Mitchell, chemist, of Milwaukee:

Analysis of granite quarried in Waushara County.

	Per cent.
Silica, SiO_2	76.62
Alumina, Al_2O_3	13.02
Ferric oxide, Fe_2O_3	1.01
Lime, CaO	.51
Magnesia, MgO	.05
Oxide of sodium, Na_2O	2.24
Oxide of potassium, K_2O	6.38
Total	99.83

The following analysis of granite, quarried by Mr. E. J. Nelson at his quarry at Berlin, Green Lake County, was made by Mr. Samuel Weidman, of Madison, Wisconsin:

Analysis of granite quarried at Berlin, Green Lake County.

	Per cent.
Silica, SiO_2	73.65
Alumina, Al_2O_3	11.19
Ferric oxide, Fe_2O_3	1.31
Ferrous oxide, FeO	3.25
Calcium oxide, CaO	2.78
Magnesium oxide, MgO	.51
Potassium oxide, K_2O	1.86
Sodium oxide, Na_2O	3.74
Water, H_2O	.44
Total	98.73

Sandstone.—The following analysis of the sandstone, quarried by the Prentice Brownstone Company at their quarries at Ashland, Ashland County, was made by Prof. C. F. Chandler, of Columbia University, New York City:

Analysis of sandstone quarried at Ashland, Ashland County.

	Per cent.
Silica, SiO_2	91.40
Ferric oxide, Fe_2O_3	2.00
Alumina, Al_2O_3	3.53
Lime, CaO	.25
Magnesia, MgO	None.
Potash, K_2O	2.36
Soda, Na_2O	.14
Sulphur	None.
Carbon dioxide, CO_2	None.
Moisture	.05
Total	99.73

The following is an analysis of quartz quarried by Messrs. Eichert & Werle at their quarry at Wausau, Marathon County. The analysis was made by Mr. Otto Boberg, chemist, of Eau Claire, Wisconsin:

Analysis of quartz quarried at Wausau, Marathon County.

	Per cent.
Silica, SiO_2	97.93
Ferric oxide, Fe_2O_3	.48
Magnesium oxide, MgO	.91
Aluminum oxide, Al_2O_3	.06
Loss on ignition (moisture, etc.)	.62
Total	100.00

Limestone.—The following analysis of limestone, quarried by Messrs. Nast Brothers, at their quarry at Knowles, Dodge County, was made by Prof. W. W. Daniells, of the University of Wisconsin:

Analysis of limestone quarried at Knowles, Dodge County.

	Per cent.
Calcium carbonate, $CaCO_3$	54.30
Magnesium carbonate, $MgCO_3$	45.32
Oxides of iron and aluminum	.24
Siliceous matter, insoluble	.28
Total	100.14

The following analysis was made by Mr. Gustave Bode, Milwaukee, Wisconsin, of limestone quarried by the Ormsby Lime Company at their quarry at Brillion, Calumet County:

Analysis of limestone quarried at Brillion, Calumet County.

	Per cent.
Calcium carbonate, $CaCO_3$	55.09
Magnesium carbonate, $MgCO_3$	43.96
Silica, SiO_2	.59
Aluminum oxide, Al_2O_3	.36
Total	100.00

The following is an analysis of limestone, quarried by the Milwaukee Falls Lime Company at their quarry at Grafton, Ozaukee County:

Analysis of limestone quarried at Grafton, Ozaukee County.

	Per cent.
Calcium carbonate, $CaCO_3$	52.57
Magnesium carbonate, $MgCO_3$	45.34
Silica, SiO_2	.37
Oxides of iron and aluminum, Fe_2O_3 and Al_2O_3	.92
Oxides of potassium and sodium, K_2O and Na_2O	.80
Insoluble	.62
Total	100.62

The following analysis of limestone, quarried by the Hamilton Lime and Stone Company at their quarries at Hamilton, Fond du Lac County, was made by Prof. W. W. Daniells:[1]

Analysis of limestone quarried at Hamilton, Fond du Lac County.

	Per cent.
Calcium carbonate, $CaCO_3$	54.25
Magnesium carbonate, $MgCO_3$	44.48
Ferric oxide, Fe_2O_3	.26
Alumina, Al_2O_3	.10
Siliceous matter, insoluble	.67
Water	.11
Total	99.87

The following analysis was made by Mr. George N. Prentiss, Milwaukee, Wisconsin, of limestone quarried by Messrs. Blair and Larson at their quarries at Lannon, Waukesha County:

Analysis of limestone quarried at Lannon, Waukesha County.

	Per cent.
Calcium carbonate, $CaCO_3$	52.29
Magnesium carbonate, $MgCO_3$	42.27
Oxides of iron and aluminum	1.68
Silica, SiO_2	3.96
Total	100.20

[1] For further detailed information see Vol. II, Geological Survey of Wisconsin, p. 345.

The following analysis of lime made from limestone, quarried by the Sheboygan Lime Works at their quarry at Sheboygan, Sheboygan County, was made by Mr. Gustave Bode, of Milwaukee, Wisconsin:

Analysis of lime made from limestone quarried at Sheboygan, Sheboygan County.

	Per cent.
Calcium oxide, CaO	55.49
Magnesium oxide, MgO	42.31
Carbon dioxide, CO_2	.64
Silica, SiO_2	.46
Oxides of iron and aluminum	1.10
Total	100.00

Prof. N. O. Whitney, College of Mechanics and Engineering, University of Wisconsin, reports that the limestone quarried by the Waukesha Stone and Quarry Company, at their quarries at Waukesha, Waukesha County, has a crushing strength of 8,880 pounds per square inch, and in three tests of transverse strength an average modulus of rupture of 2,379 pounds.

WYOMING.

Sandstone.—The United States Government report of mechanical test gives the sandstone quarried by Mr. James McPherson at his quarry at Rawlins, Carbon County, a crushing strength of 10,833 pounds per square inch.

CLAY PRODUCTS.

By JEFFERSON MIDDLETON.

INTRODUCTION.

The results of the canvass of the clay-working industries of the United States in 1898 by the United States Geological Survey are shown in the following pages—the fifth report of the series. At the beginning of each season for several years the clay workers have had hopes that prosperity would come, only to find at the end of the season that their hopes were vain. In 1898, however, the tide turned, and, in spite of the foreign war in which the country was engaged, the clay-working industries were more prosperous than for several years, as shown by the figures which follow. This is demonstrated by the fact that the number of operating firms reporting in 1898 was about 7 per cent greater than in 1897, while the value of the product increased about 15 per cent. In 1897 there was a slight decline in the product—1 per cent—as compared with 1896. The 1898 product exceeded the 1896 product by $8,486,972, or 13.45 per cent.

ACKNOWLEDGMENTS.

This opportunity is again taken to thank the clay workers of the country for their cooperation in the preparation of this report. The writer is especially indebted to Mr. D. V. Purington, of Chicago, for his interest in the work and for assistance in securing accurate statistics for Cook County, Illinois; to the brick exchanges in the several cities for their cooperation; to Messrs. Campbell and Stover, of Trenton, New Jersey, for their interest in the work and for efforts to secure complete statistics of the pottery industry at Trenton, and to Mr. John N. Taylor, of East Liverpool, Ohio, for assistance rendered in preparing the card of inquiry for the collection of the 1898 pottery statistics.

To the State geological surveys of Iowa and Maryland the thanks of the writer are extended for cooperation in collecting the statistics of

their respective States. To the indefatigable labor of Messrs. Bain and Beyer of the former, and Messrs. Clark and Mathews of the latter, are due the complete statistics of these States in the following pages.

PRODUCTION.

In the following table is given a statement of the total value of the clay products of the United States in 1898, by States:

Value of clay products of the United States in 1898.

State.	Brick and tile.	Pottery.	Total.
Alabama	$440,747	$13,650	$454,397
Arizona	81,509	....	81,509
Arkansas	227,266	17,100	244,366
California	1,004,456	*a* 30,274	1,034,730
Colorado	488,872	*b* 17,350	506,222
Connecticut and Rhode Island	875,580	72,600	948,180
Delaware	90,555	....	90,555
District of Columbia	320,320	(*c*)	320,320
Florida	122,987	(*d*)	122,987
Georgia	834,908	*d* 22,350	857,258
Idaho	27,365	(*b*)	27,365
Illinois	6,067,856	637,537	6,705,393
Indiana	2,944,770	266,742	3,211,512
Indian Territory	35,633	....	35,633
Iowa	2,116,397	34,425	2,150,822
Kansas	440,864	4,111	444,975
Kentucky	898,704	89,686	988,390
Louisiana	513,059	(*e*)	513,059
Maine	588,301	(*f*)	588,301
Maryland	949,907	*c* 303,518	1,253,425
Massachusetts	1,534,505	242,265	1,776,770
Michigan	1,000,412	17,900	1,018,312
Minnesota	794,967	*g* 322,864	1,117,831
Mississippi	289,683	*e* 14,100	303,783
Missouri	2,996,948	58,258	3,055,206
Montana	273,626	(*b*)	273,626
Nebraska	513,565	(*b*)	513,565
New Hampshire	401,989	*f* 31,200	433,189

a Value of pottery products of Oregon and Washington is included with California.
b Value of pottery products of Idaho, Montana, Nebraska, and Utah is included with Colorado.
c Value of pottery products of District of Columbia is included with Maryland.
d Value of pottery products of Florida is included with Georgia.
e Value of pottery products of Louisiana is included with Mississippi.
f Value of pottery products of Maine is included with New Hampshire.
g Value of pottery products of Wisconsin is included with Minnesota.

Value of clay products of the United States in 1898—Continued.

State.	Brick and tile.	Pottery.	Total.
New Jersey	$4,568,925	$4,030,442	$8,599,367
New Mexico	41,940	....	41,940
New York	6,079,645	369,344	6,448,989
North Carolina	401,636	*a* 18,146	419,782
North Dakota	72,900	....	72,900
Ohio	6,652,978	5,759,459	12,412,437
Oklahoma Territory	78,258	....	78,258
Oregon	131,864	(*b*)	131,864
Pennsylvania	8,689,645	952,453	9,642,098
South Carolina	234,232	(*a*)	234,232
South Dakota	30,770	....	30,770
Tennessee	474,424	39,314	513,738
Texas	702,869	55,342	758,211
Utah	180,162	(*c*)	180,162
Vermont	56,974	....	56,974
Virginia	875,857	14,026	889,883
Washington	250,988	(*b*)	250,988
West Virginia	509,357	518,218	1,027,575
Wisconsin	731,706	(*d*)	731,706
Wyoming	3,825	....	3,825
United States	57,644,706	13,952,674	71,597,380
Per cent of total clay products	80.51	19.49	100.00

a Value of pottery products of South Carolina is included with North Carolina.
b Value of pottery products of Oregon and Washington is included with California.
c Value of pottery products of Idaho, Montana, Nebraska, and Utah is included with Colorado.
d Value of pottery products of Wisconsin is included with Minnesota.

In the following table will be found a résumé of the total value of the clay products of the United States in 1897, by States; it is here given for comparative purposes:

Value of clay products of the United States in 1897.

State.	Brick and tile.	Pottery.	Total.
Alabama	$411,028	$32,350	$443,378
Arizona	54,143	....	54,143
Arkansas	167,439	16,660	184,099
California	659,202	*a*44,208	703,410
Colorado	389,354	*b*17,509	406,863
Connecticut and Rhode Island	1,265,170	71,500	1,336,670
Delaware	68,458	....	68,458
District of Columbia	288,981	(*c*)	288,981
Florida	89,435	(*d*)	89,435
Georgia	948,313	*d*14,200	962,513
Idaho	15,914	(*b*)	15,914
Illinois	4,879,674	618,900	5,498,574
Indiana	2,514,584	197,725	2,712,309
Indian Territory	14,135	....	14,135
Iowa	1,782,231	39,016	1,821,247
Kansas	252,418	4,100	256,518
Kentucky	680,938	125,430	806,368
Louisiana	370,910	(*e*)	370,910
Maine	800,739	(*f*)	800,739
Maryland	1,070,265	*c*235,017	1,305,282
Massachusetts	1,950,052	229,344	2,179,396
Michigan	769,570	22,300	791,870
Minnesota	567,394	*g*314,675	882,069
Mississippi	263,100	*e*12,500	275,600
Missouri	2,484,069	52,459	2,536,528
Montana	231,649	(*b*)	231,649
Nebraska	351,385	(*b*)	351,385
New Hampshire	439,672	*f*25,500	465,172
New Jersey	4,195,134	1,985,713	6,180,847
New Mexico	33,270	....	33,270
New York	5,432,239	183,265	5,615,504
North Carolina	355,324	*h*13,870	369,194

a Value of pottery products of Oregon and Washington is included with California.
b Value of pottery products of Idaho, Montana, Nebraska, and Utah is included with Colorado.
c Value of pottery products of District of Columbia is included with Maryland.
d Value of pottery products of Florida is included with Georgia.
e Value of pottery products of Louisiana is included with Mississippi.
f Value of pottery products of Maine is included with New Hampshire.
g Value of pottery products of Wisconsin is included with Minnesota.
h Value of pottery products of South Carolina is included with North Carolina.

Value of clay products of the United States in 1897—Continued.

State.	Brick and tile.	Pottery.	Total.
North Dakota	$62,420	....	$62,420
Ohio	6,347,415	$4,720,269	11,067,684
Oklahoma Territory	30,217	....	30,217
Oregon	115,798	(*a*)	115,798
Pennsylvania	7,171,296	703,399	7,874,695
South Carolina	290,497	(*b*)	290,497
South Dakota	21,800	....	21,800
Tennessee	571,923	40,370	612,293
Texas	1,134,829	62,210	1,197,039
Utah	135,781	(*c*)	135,781
Vermont	53,485	....	53,485
Virginia	804,846	7,200	812,046
Washington	190,720	(*a*)	190,720
West Virginia	595,734	519,520	1,115,254
Wisconsin	724,282	(*d*)	724,282
Wyoming	3,550	....	3,550
United States	52,050,782	10,309,209	62,359,991
Per cent of total clay products	83.47	16.53	100.00

a Value of pottery products of Oregon and Washington is included with California.
b Value of pottery products of South Carolina is included with North Carolina.
c Value of pottery products of Idaho, Montana, Nebraska, and Utah is included with Colorado.
d Value of pottery products of Wisconsin is included with Minnesota.

From these tables it will be seen that the value of the clay products in 1898 was $71,597,380, as compared with $62,359,991 in 1897, an increase of $9,237,389, or nearly 15 per cent. This remarkable increase is due to a large output in both branches of the industry—brick and tile, and pottery—though the percentage of increase in the pottery products is much greater than that of the brick and tile products, the former gaining 35.34 per cent and the latter 10.75 per cent over 1897. By reason of this larger proportionate increase in the pottery products in 1898, they composed 19.49 per cent of the total, while in 1897 they were but 16.53 per cent of the total. In 1898 and 1897 the brick and tile products were 80.51 and 83.47 per cent, respectively, of the total.

In the following table is given a statement of the total value of the clay products of the United States from 1894 to 1898, by States:

Value of clay products of the United States, 1894 to 1898. (a)

State.	1894.	1895.	1896.	1897.	1898.
Alabama	$266, 045	$301, 341	$372, 185	$443, 378	$454, 397
Arizona	18, 081	6, 855	55, 663	54, 143	81, 509
Arkansas	212, 096	243, 959	216, 332	184, 099	244, 366
California	841, 495	1, 421, 154	680, 207	703, 410	1, 034, 730
Colorado	478, 077	553, 383	328, 680	406, 863	506, 222
Connecticut and Rhode Island	1, 011, 600	1, 128, 925	1, 448, 598	1, 336, 670	948, 180
Delaware	46, 028	58, 615	61, 003	68, 458	90, 555
District of Columbia	390, 672	373, 304	353, 565	288, 981	320, 320
Florida	83, 587	114, 015	122, 144	89, 435	122, 987
Georgia	699, 887	867, 355	905, 813	962, 513	857, 258
Idaho	30, 268	18, 890	16, 000	15, 914	27, 365
Illinois	8, 474, 360	7, 619, 884	5, 938, 247	5, 498, 574	6, 705, 393
Indiana	3, 135, 569	3, 117, 520	2, 674, 325	2, 712, 309	3, 211, 512
Indian Territory	(b)	(b)	(b)	14, 135	35, 633
Iowa	2, 379, 506	1, 870, 292	1, 694, 402	1, 821, 247	2, 150, 822
Kansas	218, 575	246, 647	260, 087	256, 518	444, 975
Kentucky	759, 675	839, 198	829, 684	806, 368	988, 390
Louisiana	517, 262	415, 718	402, 412	370, 910	513, 059
Maine	831, 782	737, 104	994, 731	800, 739	588, 301
Maryland	1, 344, 865	1, 066, 987	1, 450, 055	1, 305, 282	1, 253, 425
Massachusetts	2, 339, 934	2, 221, 590	2, 264, 974	2, 179, 396	1, 776, 770
Michigan	2, 254, 329	1, 129, 195	1, 005, 405	791, 870	1, 018, 312
Minnesota	920, 510	1, 100, 135	696, 701	882, 069	1, 117, 831
Mississippi	142, 700	194, 750	224, 809	275, 600	303, 783
Missouri	2, 695, 578	2, 889, 218	2, 810, 245	2, 536, 528	3, 055, 206
Montana	154, 429	204, 193	276, 311	231, 649	273, 626
Nebraska	519, 784	214, 541	144, 373	351, 385	513, 565
New Hampshire	503, 505	521, 567	598, 169	465, 172	433, 189
New Jersey	3, 976, 555	4, 899, 120	4, 728, 003	6, 180, 847	8, 599, 367
New Mexico	(b)	(b)	(b)	33, 270	41, 940
New York	5, 164, 022	5, 889, 496	6, 414, 206	5, 615, 504	6, 448, 989
North Carolina	286, 680	400, 983	420, 899	369, 194	419, 782

a In 1897 and 1898 the figures for California include the pottery products of Oregon and Washington; Colorado, those of Idaho, Montana, Nebraska, and Utah; Maryland, those of the District of Columbia; Georgia, those of Florida; Mississippi, those of Louisiana; New Hampshire, those of Maine; Minnesota, those of Wisconsin; and North Carolina, those of South Carolina. This is done in order that the operations of individual establishments may not be disclosed.

b The figures for Indian Territory and New Mexico in 1894, 1895, and 1896 are included with Oklahoma Territory.

Value of clay products of the United States, 1894 to 1898. (*a*)—Continued.

State.	1894.	1895.	1896.	1897.	1898.
North Dakota	$52, 400	$48, 000	$59, 625	$62, 420	$72, 900
Ohio	10, 668, 498	10, 649, 382	10, 609, 571	11, 067, 684	12, 412, 437
Oklahoma Territory	*b* 56, 663	*b* 45, 307	*b* 38, 444	30, 217	78, 258
Oregon	161, 988	138, 543	126, 345	115, 798	131, 864
Pennsylvania	7, 428, 048	8, 807, 161	9, 063, 829	7, 874, 695	9, 642, 098
South Carolina	236, 697	276, 918	354, 275	290, 497	234, 232
South Dakota	27, 002	10, 740	53, 004	21, 800	30, 770
Tennessee	634, 344	522, 534	537, 325	612, 293	513, 738
Texas	1, 028, 853	1, 030, 446	915, 753	1, 197, 039	758, 211
Utah	176, 900	112, 586	137, 573	135, 781	180, 162
Vermont	98, 052	132, 544	83, 274	53, 485	56, 974
Virginia	937, 593	855, 768	883, 536	812, 046	889, 883
Washington	515, 659	265, 445	161, 528	190, 720	250, 988
West Virginia	673, 006	895, 777	899, 444	1, 115, 254	1, 027, 575
Wisconsin	1, 255, 376	944, 196	788, 995	724, 282	731, 706
Wyoming	6, 850	8, 525	9, 659	3, 550	3, 825
United States	64, 655, 385	65, 409, 806	63, 110, 408	62, 359, 991	71, 597, 380
Operating firms reporting	....	....	5, 293	5, 424	5, 800

a In 1897 and 1898 the figures for California include the pottery products of Oregon and Washington; Colorado, those of Idaho Montana, Nebraska, and Utah; Maryland, those of the District of Columbia; Georgia, those of Florida; Mississippi, those of Louisiana; New Hampshire, those of Maine; Minnesota, those of Wisconsin; and North Carolina, those of South Carolina. This is done in order that the operations of individual establishments may not be disclosed.

b The figures for Indian Territory and New Mexico in 1894, 1895, and 1896 are included with Oklahoma Territory.

The following table gives a comparison of the clay industry in 1897 and 1898, showing the increase or decrease of the several varieties of clay products in 1898:

Value of clay products in the United States in 1897 and 1898, with increase or decrease.

Product.	1897.	1898.	Increase in 1898.	Decrease in 1898.
Common brick	$26,430,207	$29,961,992	$3,531,785	....
Pressed brick	3,855,033	3,495,697	....	$359,336
Vitrified paving brick	3,582,037	3,922,642	340,605	....
Fancy or ornamental brick	685,048	632,165	....	52,883
Fire brick	4,094,704	5,579,761	1,485,057	....
Drain tile	2,623,305	3,026,213	402,908	....
Sewer pipe	4,069,534	3,651,206	....	418,328
Ornamental terra cotta	1,841,422	1,979,825	138,403	....
Fireproofing	1,979,259	1,846,092	....	133,167
Tile (not drain)	1,476,638	1,731,024	254,386	....
Miscellaneous	1,413,595	1,818,089	404,494	....
Total brick and tile	52,050,782	57,644,706	6,557,638	963,714
Increase in brick and tile in 1898	....	....	5,593,924	....
Total pottery	10,309,209	13,952,674	3,643,465	....
Total	62,359,991	71,597,380	*a* 9,237,389	....

a Net increase.

A study of this table shows that, with the exception of the pressed (front) brick and the sewer-pipe industries, all of the important branches of the clay-working industries show an increase in 1898 over 1897, which, indeed, is not surprising, since the improved condition in trade was sensibly felt in 1898, though not to the extent that it has been in 1899, when an increase in the product along all the lines of the clay industry may be looked for confidently. The common-brick output, which unexpectedly and unaccountably fell off in 1897, recovered in 1898, reaching a value of $29,961,992, which exceeded the product of 1897 by $3,531,785. In 1896 the value of common brick was $29,664,043. As already noted, the pressed-brick product declined slightly from $3,855,033 in 1897 to $3,495,697, or $359,336, nearly 10 per cent.

The vitrified paving brick product continued to show a gain, which should be still further increased in the future, since there is an increasing demand for this class of product not only for paving but for use in the erection of buildings and for other purposes. The fancy or ornamental brick showed a decline, though not so great as in 1897. Next to common brick, fire brick shows the greatest gain, and this is but natural considering the increased activity in the iron and coke industries in the latter part of 1898. The drain-tile product also showed a considerable gain over 1897, while the sewer-pipe industry showed a decline of $418,328. Ornamental terra cotta in 1898 increased somewhat over 1897, or from $1,841,422 to $1,979,825, but fell short of the 1895 product of $2,512,193, which was its maximum. Fireproofing suffered a decline of $133,167. Nevertheless, the total increase in the brick and tile products in 1898 over 1897 was $5,593,924, or 10.75 per cent.

The pottery products also showed a great increase in value, from $10,309,209 in 1897 to $13,952,674 in 1898—a gain of $3,643,465, or over 35 per cent, as compared with a gain of 15 per cent in the brick and tile products. As explained elsewhere, the gain noted in the pottery product is, in part at least, due to the statistics being more complete; but notwithstanding this fact it is undoubtedly true that the pottery industry was in a more prosperous condition in 1898 than in 1897.

RANK OF STATES.

The following tables show the rank of States, total value of clay products, and the percentage of the total product made by each State in 1898 and 1897:

Rank of States and output of clay products in 1897 and 1898.

1898.

Rank.	State.	Number of operating firms reporting.	Value.	Per cent of total product.
1	Ohio	866	$12, 412, 437	17. 34
2	Pennsylvania	473	9, 642, 098	13. 47
3	New Jersey	133	8, 599, 367	12. 01
4	Illinois	616	6, 705, 393	9. 37
5	New York	265	6, 448, 989	9. 01
6	Indiana	592	3, 211, 512	4. 49
7	Missouri	228	3, 055, 206	4. 27
8	Iowa	357	2, 150, 822	3. 00
9	Massachusetts	104	1, 776, 770	2. 48
10	Maryland	69	1, 253, 425	1. 75
11	Minnesota	112	1, 117, 831	1. 56
12	California	77	1, 034, 730	1. 44
13	West Virginia	45	1, 027, 575	1. 44
14	Michigan	172	1, 018, 312	1. 42
15	Kentucky	90	988, 390	1. 38
16	Connecticut and Rhode Island	47	948, 180	1. 32
17	Virginia	92	889, 883	1. 24

Rank of States and output of clay products in 1897 and 1898—Continued.

1898—Continued.

Rank.	State.	Number of operating firms reporting.	Value.	Per cent of total product.
18	Georgia	57	$857,258	1.20
19	Texas	145	758,211	1.06
20	Wisconsin	145	731,706	1.02
21	Maine	75	588,301	.82
22	Tennessee	88	513,738	.72
23	Nebraska	88	513,565	.72
24	Louisiana	50	513,059	.72
25	Colorado	56	506,222	.71
26	Alabama	65	454,397	.63
27	Kansas	54	444,975	.62
28	New Hampshire	54	433,189	.60
29	North Carolina	117	419,782	.59
30	District of Columbia	15	320,320	.45
31	Mississippi	45	303,783	.42
32	Montana	23	273,626	.38
33	Washington	27	250,988	.35
34	Arkansas	50	244,366	.34
35	South Carolina	52	234,232	.33
36	Utah	44	180,162	.25
37	Oregon	55	131,864	.18
38	Florida	22	122,987	.17
39	Delaware	23	90,555	.13
40	Arizona	24	81,509	.11
41	Oklahoma Territory	23	78,258	.11
42	North Dakota	4	72,900	.10
43	Vermont	14	56,974	.08
44	New Mexico	9	41,940	.06
45	Indian Territory	10	35,633	.05
46	South Dakota	5	30,770	.04
47	Idaho	19	27,365	.04
48	Wyoming	4	3,825	.01
	United States	5,800	71,597,380	100.00

Rank of States and output of clay products in 1897 and 1898—Continued.

1897.

Rank.	State.	Number of operating firms reporting.	Value.	Per cent of total product.
1	Ohio	843	$11,067,684	17.75
2	Pennsylvania	435	7,874,695	12.63
3	New Jersey	124	6,180,847	9.91
4	New York	231	5,615,504	9.01
5	Illinois	570	5,498,574	8.82
6	Indiana	580	2,712,309	4.35
7	Missouri	203	2,536,528	4.07
8	Massachusetts	109	2,179,396	3.50
9	Iowa	330	1,821,247	2.92
10	Connecticut and Rhode Island	48	1,336,670	2.13
11	Maryland	98	1,305,282	2.09
12	Texas	149	1,197,039	1.92
13	West Virginia	49	1,115,254	1.79
14	Georgia	51	962,513	1.54
15	Minnesota	87	882,069	1.41
16	Virginia	75	812,046	1.30
17	Kentucky	82	806,368	1.29
18	Maine	64	800,739	1.28
19	Michigan	149	791,870	1.27
20	Wisconsin	127	724,282	1.16
21	California	58	703,410	1.13
22	Tennessee	90	612,293	.98
23	New Hampshire	48	465,172	.75
24	Alabama	62	443,378	.71
25	Colorado	58	406,863	.65
26	Louisiana	46	370,910	.59
27	North Carolina	124	369,194	.59
28	Nebraska	68	351,385	.56
29	South Carolina	51	290,497	.47
30	District of Columbia	14	288,981	.46
31	Mississippi	37	275,600	.44
32	Kansas	42	256,518	.41
33	Montana	21	231,649	.37
34	Washington	25	190,720	.31
35	Arkansas	46	184,099	.30
36	Utah	43	135,781	.22
37	Oregon	54	115,798	.19
38	Florida	19	89,435	.14
39	Delaware	25	68,458	.11

Rank of States and output of clay products in 1897 and 1898—Continued.

1897—Continued.

Rank.	State.	Number of operating firms reporting.	Value.	Per cent of total product.
40	North Dakota	8	$62,420	.10
41	Arizona	21	54,143	.09
42	Vermont	13	53,485	.09
43	New Mexico	11	33,270	.05
44	Oklahoma Territory	13	30,217	.05
45	South Dakota	5	21,800	.04
46	Idaho	11	15,914	.03
47	Indian Territory	4	14,135	.02
48	Wyoming	3	3,550	.01
	United States	5,424	62,359,991	100.00

As in previous years, every State and Territory except Nevada and Alaska participated in this total. Ohio still holds the place of honor in value of product, her output in 1898 being valued at $12,412,437, or 17.34 per cent of the total, as compared with $11,067,684, in 1897, which is a gain of $1,344,753, or 12.15 per cent. This gain in Ohio comes principally from the increase in the pottery products, though the brick and the tile products also show large gains, the relative proportion of gain being, pottery about 77 per cent, brick and tile 23 per cent, or $1,039,190 and $305,563, respectively. As for the last four years, Pennsylvania is second, with a product of $9,642,098, or 13.47 per cent of the total, in 1898, as compared with $7,874,695, or 12.63 per cent of the product, in 1897, being a gain of $1,767,403, or 22.44 per cent. In this State the pottery products also increased more proportionately than those of brick and tile, though in actual gain the latter products far outstripped the former, being, brick and tile, $1,518,349, or 21.17 per cent; pottery, $249,054, or 35.41 per cent. As stated elsewhere, Pennsylvania, in the production of brick and tile, leads the country.

New Jersey is again third in rank, with a total value of $8,599,367, or 12.01 per cent of the aggregate for the country, as compared with $6,180,847, or 9.91 per cent of the total, in 1897, a gain of $2,418,520. New Jersey also owes her high position in rank of clay-working States partially to her pottery, which amounted in 1898 to $4,030,442.

Illinois, which occupied fifth place in 1897, with a product valued at $5,498,574, or 8.82 per cent of the total, has displaced New York, which was fourth in 1897, with a product valued at $5,615,504, or 9.01 per cent of the total. The value of the products in 1898 were: Illinois, $6,705,393, or 9.37 per cent of the total, a gain of $1,206,819, or 21.95

per cent; New York, $6,448,989, or 9.01 per cent of the total, a gain of $833,485, or 14.84 per cent.

Indiana and Missouri retain their positions of sixth and seventh, there being, however, but $156,306 difference between them. Indiana's product was valued at $3,211,512 in 1898, or 4.49 per cent of the grand total, as compared with $2,712,309 in 1897, or 4.35 per cent of the total. This is a gain of $499,203, or 18.41 per cent. Missouri's product increased from $2,536,528, or 4.07 per cent of the total in 1897, to $3,055,206 in 1898, or 4.27 per cent of the total, which is a gain of $518,678 or 20.45 per cent.

Iowa and Massachusetts changed positions, with products valued in 1898 at $2,150,822, or 3 per cent of the total, and $1,776,770, or 2.48 per cent of the total, respectively. In 1897 Iowa's product was valued at $1,821,247, or 2.92 per cent of the total, and Massachusetts' at $2,179,396, or 3.50 per cent of the total, thus practically reversing the figures for these States, making a gain of $329,575 in Iowa, or 18.10 per cent, and a loss of $402,626 in Massachusetts, or 18.47 per cent.

Connecticut and Rhode Island fell from tenth place in 1897, with products valued at $1,336,670, or 2.13 per cent of the total, to sixteenth place in 1898, with a product of $948,180, or 1.32 per cent of the total—a loss of $388,490, or 29.06 per cent.

Maryland gained one point, rising from eleventh position in 1897 to tenth in 1898, while Texas fell from twelfth place in 1897 to nineteenth in 1898. Minnesota rose from fifteenth place in 1897 to eleventh in 1898. California, which occupied twenty-first place in 1897, jumped to twelfth in 1898. Kentucky, which was seventeenth in 1897, was fifteenth in 1898. Kansas has also improved its rank by going from thirty-second, hich it has occupied for several years, to twenty-seventh in 1898. Michigan, too, has come up the scale from nineteenth in 1897 to fourteenth in 1898. Nebraska and New Hampshire have exchanged places, the former in 1898 being twenty-third and the latter twenty-eighth; and South Carolina has gone from twenty-ninth in 1897 to thirty-fifth in 1898.

The first nine States, including the great clay-working region between the Ohio and Missouri rivers, together with Pennsylvania, New Jersey, New York, and Massachusetts, produced clay wares in 1898 valued at $54,002,594, or 75.43 per cent of the total; in 1897 they produced $45,486,784, or 72.94 per cent. In 1898 the States of Ohio Indiana, Illinois, Iowa, and Missouri produced clay goods valued at $27,535,370, or 38.46 per cent of the product; in 1897 they produced $23,636,342, or 37.90 per cent of the total.

In the following table is shown the rank of the several States and Territories in the value of clay products from 1894 to 1898, inclusive:

Rank of clay-producing States, in value of production, from 1894 to 1898.

State.	1894.	1895.	1896.	1897.	1898.
Alabama	31	28	26	24	26
Arizona	46	47	43	41	40
Arkansas	34	33	34	35	34
California	16	10	21	21	12
Colorado	27	22	29	25	25
Connecticut *a*	20	20	11	10	16
Delaware	43	41	41	39	39
District of Columbia	28	27	28	30	30
Florida	40	39	39	38	38
Georgia	18	15	15	14	18
Idaho	44	44	46	46	47
Illinois	2	3	4	5	4
Indiana	6	6	7	6	6
Indian Territory	(*b*)	(*b*)	(*b*)	47	45
Iowa	8	9	9	9	8
Kansas	33	32	32	32	27
Kentucky	19	19	18	17	15
Louisiana	24	25	25	26	24
Maine	17	21	13	18	21
Maryland	11	13	10	11	10
Massachusetts	9	8	8	8	9
Michigan	10	11	12	19	14
Minnesota	15	12	20	15	11
Mississippi	38	36	33	31	31
Missouri	7	7	6	7	7
Montana	37	35	31	33	32
Nebraska	23	34	36	28	23
New Hampshire	26	23	22	23	28
New Jersey	5	5	5	3	3
New Mexico	(*b*)	(*b*)	(*b*)	43	44
New York	4	4	3	4	5
North Carolina	30	26	24	27	29
North Dakota	42	42	42	40	42
Ohio	1	1	1	1	1
Oklahoma Territory	*b* 41	*b* 43	*b* 45	44	41
Oregon	36	37	38	37	37

a Including Rhode Island in 1897 and 1898.
b In 1894, 1895, and 1896 Indian Territory and New Mexico were included with Oklahoma Territory.

Rank of clay-producing States, in value of production, from 1894 to 1898—Continued.

State.	1894.	1895.	1896.	1897.	1898.
Pennsylvania	3	2	2	2	2
Rhode Island	29	29	30	(*a*)	(*a*)
South Carolina	32	30	27	29	35
South Dakota	45	45	44	45	46
Tennessee	22	24	23	22	22
Texas	13	14	14	12	19
Utah	35	40	37	36	36
Vermont	39	38	40	42	43
Virginia	14	18	17	16	17
Washington	25	31	35	34	33
West Virginia	21	17	16	13	13
Wisconsin	12	16	19	20	20
Wyoming	47	46	47	48	48

a Included with Connecticut in 1897 and 1898.

This table is principally interesting in showing the slight changes in the relative rank of the clay-working States in the value of their products, the most notable changes in 1898 having been noted in connection with the tables showing the rank of States and output of clay products in 1897 and 1898.

In the following table is given a statement of the output of clay products in the United States from 1894 to 1898 by varieties of product, together with the total for each year and the number of operating firms reporting:

Clay products of the United States from 1894 to 1898, by varieties.

Year.	Number of operating firms reporting.	Common brick.			Pressed brick.			Vitrified paving brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*			*Thousands.*		
1894	....	6,152,420	$35,062,538	$5.70	(*b*)	(*b*)	....	457,021	$3,711,073	$8.12
1895	....	6,017,965	31,569,126	5.25	339,204	$4,399,367	$12.97	381,591	3,130,472	8.20
1896	5,293	5,703,279	29,664,043	5.20	270,335	3,390,941	12.54	320,407	2,794,585	8.72
1897	5,424	5,292,532	26,430,207	4.99	310,918	3,855,033	12.40	435,851	3,582,037	8.22
1898	5,800	5,669,360	29,961,992	5.28	288,765	3,495,697	12.11	462,499	3,922,642	8.48

Year.	Fancy or ornamental brick (value).	Enameled brick (value).	Fire brick (value).	Drain tile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value).	Tile, not drain (value).	Pottery.	Miscellaneous. (*a*)	Total.
1894	$1,128,608	(*c*)	$4,762,820	$5,803,168	$5,989,923	$1,476,185	$514,637	$1,688,724	(*d*)	$4,517,709	$64,655,385
1895	652,519	(*c*)	5,279,004	3,450,961	4,482,577	2,512,193	741,626	2,572,628	(*d*)	6,619,333	65,409,806
1896	763,140	(*c*)	4,944,723	2,613,513	4,588,503	2,359,983	1,706,504	1,618,127	$7,455,627	1,210,719	63,110,408
1897	685,048	(*c*)	4,094,704	2,623,305	4,069,534	1,841,422	1,979,259	1,476,638	10,309,209	1,413,595	62,359,991
1898	353,172	$278,993	5,579,761	3,026,213	3,651,206	1,979,825	1,846,092	1,731,024	13,952,674	1,818,089	71,597,380

a Including miscellaneous pottery products in 1894 and 1895.
b Common and pressed brick not separately classified in 1894.
c Enameled brick not separately classified prior to 1898.
d Pottery not separately classified in 1894 and 1895.

The following table shows the number of operating firms reporting in 1896, 1897, and 1898. In the 1898 card a statement of sales of product was asked for instead of the production. This makes it impossible to determine whether a plant was idle or not, since a plant may have been idle though reporting sales of products made prior to 1898:

Number of operating clay-working plants reporting in 1896, 1897, and 1898.

State.	1898.	1897.	1896.
Alabama	65	62	51
Arizona	24	21	16
Arkansas	50	46	48
California	77	58	60
Colorado	56	58	49
Connecticut and Rhode Island	47	48	42
Delaware	23	25	23
District of Columbia	15	14	12
Florida	22	19	19
Georgia	57	51	55
Idaho	19	11	10
Illinois	616	570	566
Indiana	592	580	556
Indian Territory	10	4	(*a*)
Iowa	357	330	339
Kansas	54	42	34
Kentucky	90	82	80
Louisiana	50	46	44
Maine	75	64	72
Maryland	69	98	96
Massachusetts	104	109	99
Michigan	172	149	156
Minnesota	112	87	88
Mississippi	45	37	37
Missouri	228	203	207
Montana	23	21	19
Nebraska	88	68	52
New Hampshire	54	48	52
New Jersey	133	124	103
New Mexico	9	11	(*a*)
New York	265	231	262
North Carolina	117	124	112
North Dakota	4	8	6
Ohio	866	843	816
Oklahoma Territory	23	13	*a* 11

a In 1896 Indian Territory and New Mexico were included with Oklahoma Territory.

Number of operating clay-working plants reporting in 1896, 1897, and 1898—Continued.

State.	1898.	1897.	1896.
Oregon	55	54	52
Pennsylvania	473	435	457
South Carolina	52	51	46
South Dakota	5	5	9
Tennessee	88	90	82
Texas	145	149	125
Utah	44	43	37
Vermont	14	13	12
Virginia	92	75	86
Washington	27	25	22
West Virginia	45	49	39
Wisconsin	145	127	130
Wyoming	4	3	4
Total	5,800	5,424	5,293

An inspection of this table shows that the number of operating firms reporting has increased steadily from 5,293 in 1896 to 5,424 in 1897 and 5,800 in 1898.

BRICK AND TILE.

PRODUCTION.

The following table gives a statement of the brick and tile and other structural clay products in 1898 and 1897, the latter being here produced for comparative purposes:

Brick and tile products of the United States in 1898.

State.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
	Thousands.			*Thousands.*			*Thousands.*		
Alabama	51, 945	$280, 567	$5. 40	1, 166	$15, 880	$13. 62	4, 870	$56, 450	$11. 59
Arizona	12, 265	79, 509	6. 48	120	2, 000	16. 67			
Arkansas	33, 156	206, 804	6. 24	723	7, 298	10. 09	(*a*)	(*a*)	8. 40
California	108, 076	598, 823	5. 54	1, 942	42, 700	21. 99			
Colorado	34, 232	196, 499	5. 74	11, 296	101, 608	9. 00	1, 691	15, 407	9. 11
Connecticut and Rhode Island	120, 380	670, 880	5. 57	(*a*)	(*a*)	15. 37	(*a*)	(*a*)	12. 58
Delaware	12, 305	81, 435	6. 62	360	5, 880	16. 33			
District of Columbia	42, 699	257, 932	6. 04	472	6, 693	14. 18	(*a*)	(*a*)	8. 02
Florida	19, 837	112, 587	5. 68	(*a*)	(*a*)	8. 18			
Georgia	114, 309	530, 346	4. 64	2, 433	26, 250	10. 79	(*a*)	(*a*)	8. 02
Idaho	3, 830	27, 365	7. 14						
Illinois	558, 204	3, 123, 202	5. 60	26, 953	246, 416	9. 14	71, 999	639, 153	8. 88

a Included in other States.

Brick and tile products of the United States in 1898—Continued.

State.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
	Thousands.			*Thousands.*			*Thousands.*		
Indiana	277, 136	$1, 359, 596	$4. 91	9, 883	$101, 935	$10. 31	28, 216	$264, 796	$9. 38
Indian Territory	5, 575	35, 633	6. 39	....	....	....	....	....	....
Iowa	194, 060	1, 164, 247	6. 00	6, 722	54, 752	8. 15	35, 357	289, 963	8. 20
Kansas	40, 263	221, 481	5. 50	1, 957	13, 209	6. 75	27, 632	200, 022	7. 24
Kentucky	84, 540	422, 458	5. 00	3, 659	27, 004	7. 38	(*a*)	(*a*)	9. 00
Louisiana	90, 074	457, 018	5. 07	5, 920	44, 625	7. 54	....	....	....
Maine	57, 656	309, 488	5. 37	890	10, 600	11. 91	(*a*)	(*a*)	25. 00
Maryland	120, 588	714, 674	5. 93	5, 868	87, 304	14. 88	50	600	12. 00
Massachusetts	192, 117	1, 057, 806	5. 51	5, 383	118, 170	21. 95	(*a*)	(*a*)	9. 00
Michigan	158, 741	748, 339	4. 71	2, 335	15, 500	6. 64	3, 198	34, 395	10. 76
Minnesota	125, 473	611, 357	4. 87	2, 250	22, 370	9. 94	(*a*)	(*a*)	20. 00
Mississippi	50, 989	277, 953	5. 45	1, 290	10, 530	8. 16	....	....	....
Missouri	219, 679	1, 046, 669	4. 76	22, 447	258, 786	11. 53	28, 036	264, 092	9. 42
Montana	27, 244	178, 728	6. 56	374	5, 485	14. 67	(*a*)	(*a*)	8. 00
Nebraska	74, 081	446, 126	6. 02	2, 232	29, 921	13. 41	3, 254	26, 315	8. 09
New Hampshire	74, 110	365, 511	4. 93	478	6, 118	12. 80	....	....	....
New Jersey	269, 654	1, 315, 922	4. 88	30, 876	568, 106	18. 40	(*a*)	(*a*)	14. 00
New Mexico	6, 470	41, 940	6. 48	....	....	....	....	....	....
New York	900, 977	4, 381, 257	4. 86	19, 017	260, 135	13. 68	27, 532	302, 680	10. 99

Brick and tile products of the United States in 1898—Continued.

State.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
	Thousands.			*Thousands.*			*Thousands.*		
North Carolina	66, 871	$347, 468	$5. 20	454	$4, 200	$9. 25	(*a*)	(*a*)	$9. 93
North Dakota	11, 900	72, 900	6. 13						
Ohio	340, 535	1, 701, 719	5. 00	27, 661	289, 519	10. 47	115, 104	$796, 935	6. 92
Oklahoma	12, 372	77, 060	6. 23	79	1, 078	13. 65			
Oregon	14, 368	90, 369	6. 29	240	4, 275	17. 81			
Pennsylvania	613, 462	3, 424, 154	5. 58	56, 115	671, 671	11. 97	59, 014	513, 391	8. 70
South Carolina	51, 380	212, 447	4. 13	1, 105	8, 210	7. 43			
South Dakota	3, 250	24, 050	7. 40	(*a*)	(*a*)	12. 00			
Tennessee	70, 295	369, 944	5. 26	2, 928	25, 014	8. 54	3, 521	25, 049	7. 11
Texas	100, 844	587, 116	5. 82	746	8, 974	12. 03	(*a*)	(*a*)	9. 33
Utah	23, 583	134, 525	5. 70	2, 914	26, 582	9. 12	(*a*)	(*a*)	5. 45
Vermont	10, 958	56, 578	5. 16	(*a*)	(*a*)	6. 89			
Virginia	98, 549	586, 170	5. 95	14, 700	225, 652	15. 35	(*a*)	(*a*)	10. 00
Washington	21, 845	148, 881	6. 82	805	13, 200	16. 40	1, 156	14, 777	12. 78
West Virginia	28, 516	157, 425	5. 52	1, 690	12, 690	7. 51	33, 416	290, 266	8. 69
Wisconsin	119, 492	645, 209	5. 40	8, 237	61, 596	7. 48	(*a*)	(*a*)	10. 00
Wyoming	475	3, 825	8. 05						
Other States *c*				4, 045	53, 761		18, 453	188, 351	
United States	5, 669, 360	29, 961, 992	5. 28	288, 765	3, 495, 697	12. 11	462, 499	3, 922, 642	8. 48
Per cent of total clay products		41. 85			4. 88			5. 48	

a Included in other States.

Brick and tile products of the United States in 1898—Continued.

State.	Fancy or ornamental brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value).	Tile (not drain) (value).	Miscellaneous (value). *a*	Total value.
Alabama	(*b*)	$87,200	....	....	....	....	....	....	$440,747
Arizona	....	....	....	....	....	....	....	....	81,509
Arkansas	(*b*)	(*b*)	$980	....	(*b*)	....	....	$225	227,266
California	(*b*)	19,505	6,660	$305,833	$19,300	(*b*)	(*b*)	2,610	1,004,456
Colorado	(*b*)	48,145	4,740	(*b*)	....	(*b*)	(*b*)	44,650	488,872
Connecticut and Rhode Island	(*b*)	(*b*)	....	....	....	(*b*)	(*b*)	25,000	875,580
Delaware	....	....	(*b*)	....	....	....	....	....	90,555
District of Columbia	(*b*)	....	(*b*)	34,000	....	(*b*)	....	17,600	320,320
Florida	....	(*b*)	900	(*b*)	....	....	....	....	122,987
Georgia	....	25,650	(*b*)	181,000	(*b*)	(*b*)	(*b*)	410	834,908
Idaho	....	....	....	....	....	....	....	....	27,365
Illinois	$30,453	109,465	797,597	200,312	510,000	$202,374	$146,063	17,821	6,067,856
Indiana	9,437	29,766	622,198	134,980	43,100	74,629	247,990	56,343	2,944,770
Indian Territory	....	....	....	....	....	....	....	....	35,633
Iowa	993	5,525	343,265	33,000	(*b*)	2,161	429	221,712	2,116,397
Kansas	....	(*b*)	4,172	....	....	(*b*)	....	680	440,864
Kentucky	....	202,077	19,533	(*b*)	....	....	(*b*)	....	898,704
Louisiana	(*b*)	....	791	....	....	....	(*b*)	5,500	513,[illegible]59
Maine	....	(*b*)	(*b*)	(*b*)	....	....	....	1,500	588,301
Maryland	3,669	77,672	1,649	....	(*b*)	....	(*b*)	16,000	949,907

Brick and tile products of the United States in 1898—Continued.

State.	Fancy or ornamental brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value).	Tile (not drain) (value).	Miscellaneous (value).*a*	Total value.
Massachusetts	(*b*)	$175,180	....	(*b*)	$29,730	(*b*)	$19,594	$7,197	$1,534,505
Michigan	$4,500	(*b*)	$146,816	$45,567	....	$2,800	....	1,655	1,000,412
Minnesota	(*b*)	(*b*)	5,170	(*b*)	(*b*)	16,800	(*b*)	720	794,967
Mississippi	....	(*b*)	....	....	....	....	....	....	289,683
Missouri	65,581	268,173	85,748	403,075	168,000	92,272	30,673	294,910	2,996,948
Montana	(*b*)	65,164	....	(*b*)	....	(*b*)	(*b*)	860	273,626
Nebraska	(*b*)	....	(*b*)	....	....	....	(*b*)	9,350	513,565
New Hampshire	....	(*b*)	....	....	....	(*b*)	....	....	401,989
New Jersey	15,852	519,688	13,462	34,808	635,007	762,370	292,644	256,097	4,568,925
New Mexico	....	....	....	....	....	....	....	....	41,940
New York	8,665	386,624	74,072	89,224	367,854	87,152	83,910	38,072	6,079,645
North Carolina	(*b*)	4,775	3,383	(*b*)	....	(*b*)	....	3,750	401,636
North Dakota	....	....	....	....	....	....	....	....	72,900
Ohio	23,070	528,278	800,003	1,264,756	7,384	343,770	661,921	232,652	6,652,978
Oklahoma	....	....	(*b*)	....	....	....	....	....	78,258
Oregon	(*b*)	2,550	13,460	(*b*)	....	(*b*)	....	....	131,864
Pennsylvania	76,043	2,846,331	11,461	224,385	147,000	98,717	136,706	521,836	8,689,645

a Including acid-proof brick, adobes, aquaria ornaments, building blocks, burnt clay ballast, chimney pipe, chimney tops and protectors, cistern brick, clay furnaces, condensers used in zinc furnaces, crucibles, cylinder brick, faience, fire-clay tile, fire kindlers, floor brick, flue linings, gas logs, glass-melting pots, hollow brick, invert blocks, muffles, refractory fire clay furnace linings, retorts and settings, saggers scorifiers, sidewalk tile and blocks, sewer tile, statuary, steam pipes and bonnets, steel-work shapes, sleeves, nozzles, etc., tank blocks, terra cotta grave markers, terra cotta conduit for underground wires, terra cotta flues, terra vitræ, tile steps, vitrified sewer brick, wall coping, and well brick and tile.

b Included in other States.

Brick and tile products of the United States in 1898—Continued.

State.	Fancy or ornamental brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value).	Tile (not drain) (value).	Miscellaneous (value). *a*	Total value.
South Carolina	(*b*)	$6,475	(*b*)						$234,232
South Dakota		(*b*)							30,770
Tennessee	$4,774	30,547	$13,896	(*b*)		(*b*)			474,424
Texas	1,463	5,435	2,600	$26,150		(*b*)	(*b*)	$40,514	702,869
Utah	(*b*)	7,000	4,130	(*b*)				325	180,162
Vermont			(*b*)						56,974
Virginia	21,591	4,476	7,830	(*b*)					875,857
Washington		23,250	3,605	43,300	(*b*)	(*b*)			250,988
West Virginia	(*b*)	5,155	1,310	(*b*)		(*b*)	(*b*)		509,357
Wisconsin	(*b*)		19,757				(*b*)	100	731,706
Wyoming									3,825
Other States *c*	87,081	95,655	17,025	630,816	$52,450	$163,047	$111,094		(*e*)
United States	*d*632,165	5,579,761	3,026,213	3,651,206	1,979,825	1,846,092	1,731,024	1,818,089	57,644,706
Per cent of total clay products	.88	7.79	4.23	5.10	2.77	2.58	2.42	2.54	80.51

a Including acid-proof brick, adobes, aquaria ornaments, building blocks, burnt clay ballast, chimney pipe, chimney tops and protectors, cistern brick, clay furnaces, condensers used in zinc furnaces, crucibles, cylinder brick, faience, fire-clay tile, fire kindlers, floor brick, flue linings, gas logs, glass-melting pots, hollow brick, invert blocks, muffles, refractory fire clay furnace linings, retorts and settings, saggers, scorifiers, sidewalk tile and blocks, sewer tile, statuary, steam pipes and bonnets, steel-work shapes, sleeves, nozzles, etc., tank blocks, terra cotta grave markers, terra cotta conduit for underground wires, terra cotta flues, terra vitræ, tile steps, vitrified sewer brick, wall coping, and well brick and tile.

b Included in other States.

c Including all products made by less than three producers in one State, in order that the operations of individual establishments may not be disclosed.

d Including enameled brick, valued at $278,993, made in the following States: Alabama, Illinois, Maryland, Missouri, Montana, New Jersey, Ohio, Pennsylvania, Texas, and Wisconsin.

e The total of other States is distributed among the States to which it belongs, in order that they may be fully represented in the totals.

Brick and tile products of the United States in 1897.

State.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
	Thousands.			*Thousands.*			*Thousands.*		
Alabama	54,189	$289,253	$5.34	1,130	$13,175	$11.66	(*a*)	(*a*)	$10.05
Arizona	8,510	49,393	5.80	205	4,250	20.73			
Arkansas	23,455	133,555	5.69	1,013	8,656	8.54	(*a*)	(*a*)	9.23
California	88,890	509,955	5.74	843	31,950	37.90	(*a*)	(*a*)	15.00
Colorado	26,950	134,920	5.01	10,312	101,494	9.84	708	$7,004	9.89
Connecticut and Rhode Island	200,130	1,017,250	5.08	(*a*)	(*a*)	27.94	(*a*)	(*a*)	12.52
Delaware	9,293	64,111	6.90	(*a*)	(*a*)	17.00			
District of Columbia	36,950	209,110	5.66	695	8,075	11.62	(*a*)	(*a*)	8.00
Florida	16,390	87,335	5.33	(*a*)	(*a*)	10.42			
Georgia	134,296	599,158	4.46	3,340	35,381	10.59	(*a*)	(*a*)	10.00
Idaho	2,192	14,824	6.76	(*a*)	(*a*)	10.00			
Illinois	516,263	2,376,498	4.60	24,342	218,788	8.99	87,169	719,371	8.25
Indiana	224,042	1,012,547	4.52	8,394	94,935	11.31	27,239	266,638	9.78
Indian Territory	2,080	13,799	6.63	(*a*)	(*a*)	8.00			
Iowa	152,446	850,834	5.58	7,823	57,230	7.32	56,315	426,056	7.57
Kansas	18,543	103,081	5.56	1,791	14,887	8.31	17,463	127,600	7.31
Kentucky	71,642	355,313	4.96	2,349	19,390	8.25	(*a*)	(*a*)	9.00
Louisiana	64,807	322,328	4.97	4,241	40,382	9.52			

a Included in other States.

Brick and tile products of the United States in 1897—Continued.

State.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
	Thousands.			*Thousands.*			*Thousands.*		
Maine	53, 133	$273, 929	$5. 16	1, 280	$11, 200	$8. 75	(*a*)	(*a*)	$13. 55
Maryland	116, 841	702, 957	6. 02	5, 316	92, 344	17. 37	150	$1, 200	8. 00
Massachusetts	257, 539	1, 457, 683	5. 66	6, 946	126, 420	18. 20			
Michigan	120, 377	546, 638	4. 54	1, 990	10, 515	5. 28	1, 905	22, 332	11. 72
Minnesota	79, 474	366, 734	4. 61	2, 965	31, 750	10. 71	(*a*)	(*a*)	11. 13
Mississippi	45, 510	236, 650	5. 20	2, 225	18, 600	8. 36	(*a*)	(*a*)	8. 00
Missouri	221, 102	999, 352	4. 52	21, 537	224, 016	10. 40	19, 620	182, 625	9. 31
Montana	20, 658	122, 494	5. 93	1, 110	15, 468	13. 94			
Nebraska	47, 656	288, 980	6. 06	3, 064	31, 706	10. 35	3, 092	26, 169	8. 46
New Hampshire	82, 221	417, 272	5. 08	(*a*)	(*a*)	15. 00			
New Jersey	263, 641	1, 188, 191	4. 51	30, 022	670, 282	22. 33	550	7, 300	13. 27
New Mexico	4, 656	28, 302	6. 08	(*a*)	(*a*)	20. 00	(*a*)	(*a*)	9. 78
New York	828, 868	3, 657, 750	4. 41	18, 046	263, 166	14. 58	28, 145	309, 564	11. 00
North Carolina	61, 451	303, 305	4. 94	1, 219	8, 588	7. 05	(*a*)	(*a*)	7. 00
North Dakota	10, 218	62, 420	6. 11						
Ohio	290, 522	1, 358, 333	4. 68	36, 229	357, 613	9. 87	85, 665	597, 905	6. 98
Oklahoma Territory	5, 230	30, 217	5. 78						
Oregon	9, 548	58, 130	6. 09	445	4, 100	9. 21	236	2, 475	10. 49
Pennsylvania	558, 084	3, 178, 190	5. 69	73, 627	873, 057	11. 86	41, 620	336, 413	8. 08

Brick and tile products of the United States in 1897—Continued.

State.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.			Vitrified paving brick.		
	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
	Thousands.			*Thousands.*			*Thousands.*		
South Carolina	56,760	$258,897	$4.56	1,940	$16,150	$8.32	....	....	....
South Dakota	2,450	17,600	7.18	(*a*)	(*a*)	10.00	....	....	....
Tennessee	81,241	406,236	5.00	5,154	41,351	8.02	(*a*)	(*a*)	$6.25
Texas	120,152	706,312	5.88	6,319	71,655	11.94	3,635	$32,475	8.93
Utah	18,614	97,691	5.25	1,425	11,065	7.76	(*a*)	(*a*)	8.00
Vermont	10,790	53,485	4.96	....	....	....	....	....	....
Virginia	94,782	574,269	6.06	11,037	153,422	13.90	(*a*)	(*a*)	10.00
Washington	14,837	86,607	5.84	575	10,063	17.50	1,875	20,250	10.80
West Virginia	30,594	164,177	5.37	2,033	19,246	9.47	38,271	289,886	7.57
Wisconsin	134,025	640,592	4.78	6,243	48,670	7.80	....	....	....
Wyoming	490	3,550	7.24	....	....	....	....	....	....
Other States	....	....	....	3,693	95,993	....	22,193	206,774	....
United States	5,292,532	26,430,207	4.99	310,918	3,855,033	12.40	435,851	3,582,037	8.22
Per cent of total clay products	....	42.38	....	....	6.18	....	....	5.74	....

a Included in other States.

Brick and tile products of the United States in 1897—Continued.

State.	Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value).*a*	Tile (not drain) (value).*b*	Miscellaneous (value).*c*	Total value.
Alabama	(*d*)	$67,000	(*d*)						$411,028
Arizona					(*d*)	(*d*)			54,143
Arkansas	(*d*)	(*d*)	$2,000		(*d*)		(*d*)		167,439
California	(*d*)	7,720	5,300	$90,430	(*d*)	(*d*)		$4,697	659,202
Colorado		38,465	1,750	(*d*)		(*d*)	(*d*)	44,041	389,354
Connecticut and Rhode Island	(*d*)	44,750	(*d*)		(*d*)	(*d*)	(*d*)		1,265,170
Delaware			(*d*)						68,458
District of Columbia	(*d*)		(*d*)	66,360		(*d*)		1,890	288,981
Florida			(*d*)	(*d*)	(*d*)				89,435
Georgia	(*d*)	12,904	(*d*)	238,500	(*d*)	(*d*)	(*d*)		948,313
Idaho								90	15,914
Illinois	$61,067	106,377	531,993	165,071	$418,500	$177,782	$97,000	7,227	4,879,674
Indiana	(*d*)	24,245	559,524	156,450	(*d*)	121,835	223,750	20,010	2,514,584
Indian Territory							(*d*)		14,135
Iowa	2,800	8,700	372,070	44,300	500	7,540	6,700	5,501	1,782,231
Kansas		(*d*)	5,450						252,418
Kentucky		157,499	28,065	(*d*)		(*d*)	(*d*)		680,938
Louisiana	(*d*)	(*d*)	(*d*)				(*d*)	5,700	370,910
Maine		(*d*)	(*d*)	(*d*)					800,739
Maryland	35,100	141,650	25,524		6,000		18,470	47,020	1,070,265

Brick and tile products of the United States in 1897—Continued.

State.	Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra-cotta (value).	Fireproofing (value). *a*	Tile (not drain) (value). *b*	Miscellaneous (value). *c*	Total value.
Massachusetts	(*d*)	$184,665	(*d*)	....	(*d*)	(*d*)	(*d*)	$5,594	$1,950,052
Michigan	(*d*)	(*d*)	$165,564	$20,361	....	$2,200	(*d*)	600	769,570
Minnesota	(*d*)	$5,550	3,810	(*d*)	(*d*)	(*d*)	(*d*)	....	567,394
Mississippi	(*d*)	(*d*)	(*d*)	....	....	....	....	300	263,100
Missouri	$86,723	157,502	25,800	458,368	(*d*)	14,404	(*d*)	175,959	2,484,069
Montana	(*d*)	79,486	....	(*d*)	....	....	....	....	231,649
Nebraska	(*d*)	(*d*)	(*d*)	....	....	....	....	....	351,385
New Hampshire	(*d*)	(*d*)	....	....	....	(*d*)	....	....	439,672
New Jersey	170,721	277,670	11,225	31,973	$539,512	987,637	$191,735	118,888	4,195,134
New Mexico	....	(*d*)	....	....	....	....	....	....	33,270
New York	2,680	339,740	25,385	116,000	420,601	56,410	150,360	90,583	5,432,239
North Carolina	(*d*)	2,950	3,148	(*d*)	....	....	....	2,008	355,324
North Dakota	....	....	....	....	....	....	....	....	62,420
Ohio	104,426	510,878	737,754	1,495,974	37,159	314,800	563,353	269,220	6,347,415
Oklahoma Territory	....	....	....	....	....	....	....	....	30,217
Oregon	....	....	22,993	(*d*)	....	(*d*)	(*d*)	400	115,798
Pennsylvania	61,830	1,707,621	14,164	283,451	157,000	92,880	110,620	356,070	7,171,296

a Including terra-cotta lumber and hollow building tile or blocks.

b Including roofing tile, floor tile, encaustic and art tile.

c Including acid proof brick, aquaria ornaments, art pottery, bath brick, book tile, building blocks, burnt-clay ballast, cave blocks, chemical stoneware, chimney pipe and tops, clay conduits, clay furnaces, clay pipes, clay pots, coke-oven tile, crucibles, cupola blocks, doorknobs, fence-post stubs, ferring tile, fire-clay goods for glass manufacturers, including enamel smelters, fire mortar, flue lining, furnace brick, gas logs, gas retorts and settings, glass-melting pots, glass tank blocks, glazes, hip rolls and cresting, hollow brick, indestructible fence posts, invert blocks, lead pots, muffles, paving tile, plaques, retorts, saggers, sidewalk tile, slabs, slides, stone pumps, stoppers, supports, terra-cotta statuary, grave and lot markers, toy marbles, wall coping, wash tubs, and well tubing.

d Included in other States.

Brick and tile products of United States in 1897—Continued.

State.	Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value). *a*	Tile (not drain) (value). *b*	Miscellaneous (value). *c*	Total value.
South Carolina	....	$12,750	(*d*)	(*d*)	(*d*)	....	(*d*)	....	$290,497
South Dakota	....	(*d*)	....	....	....	....	....	....	21,800
Tennessee	$4,026	35,497	$27,950	(*d*)	....	(*d*)	....	....	571,923
Texas	1,060	23,235	4,180	$48,115	(*d*)	(*d*)	....	$245,647	1,134,829
Utah	....	26,625	....	....	....	....	....	....	135,781
Vermont	....	....	....	....	....	....	....	....	53,485
Virginia	29,000	2,755	1,800	....	(*d*)	....	(*d*)	12,000	804,846
Washington	....	21,800	(*d*)	46,500	....	(*d*)	....	....	190,720
West Virginia	9,500	28,696	(*d*)	(*d*)	(*d*)	....	(*d*)	....	595,734
Wisconsin	(*d*)	(*d*)	27,750	....	....	....	....	150	724,282
Wyoming	....	....	....	....	....	....	....	....	3,550
Other States *e*	116,115	67,974	20,106	807,681	$262,150	$203,771	$114,650	....	(*f*)
United States	685,048	4,094,704	2,623,305	4,069,534	1,841,422	1,979,259	1,476,638	1,413,595	52,050,782
Per cent of total clay products	1.10	6.57	4.21	6.53	2.95	3.17	2.37	2.27	83.47

a Including terra-cotta lumber and hollow building tile or blocks.

b Including roofing tile, floor tile, encaustic and art tile.

c Including acid-proof brick, aquaria ornaments, art pottery, bath brick, book tile, building blocks, burnt-clay ballast, cave blocks, chemical stoneware, chimney pipe and tops, clay conduits, clay furnaces, clay pipes, clay pots, coke-oven tile, crucibles, cupola blocks, doorknobs, fence-post stubs, ferring tile, fire-clay goods for glass manufacturers, including enamel smelters, fire mortar, flue lining, furnace brick, gas logs, gas retorts and settings, glass-melting pots, glass tank blocks, glazes, hip rolls and cresting, hollow brick, indestructible fence posts, invert blocks, lead pots, muffles, paving tile, plaques, retorts, saggers, sidewalk tile, slabs, slides, stone pumps, stoppers, supports, terra-cotta statuary, grave and lot markers, toy marbles, wall coping, wash tubs, and well tubing.

d Included in other States.

e Including all products made by less than three producers in one State in order that the operations of individual establishments may not be disclosed.

f The total of other States is distributed among the States to which it belongs in order that they may be fully represented in the totals.

As will be noted by these tables, the number of common brick made in 1898 was 5,669,360,000, valued at $29,961,992, or $5.28 per thousand, as compared with 5,292,532,000, worth $26,430,207, or $4.99 per thousand, in 1897. In 1897 this class of brick constituted 42.38 per cent of the total product; in 1898 it was 41.85 per cent of the product, while in 1896 it was 47.74 per cent of the total. New York continues to be the largest producer of common brick, reporting 900,977,000 brick in 1898, as against 828,868,000 in 1897, in spite of the prolonged strike at one of its chief producing centers—Haverstraw. The value per thousand in this State also increased from $4.41 in 1897 to $4.86 in 1898. In 1896 New York's product of common brick was 931,565,000, valued at $4.45 per thousand. Pennsylvania was second in the production of this variety of brick in 1898, as in 1897 and 1896, with an output of 613,462,000, 558,084,000, and 675,444,000, valued at $5.58, $5.69, and $6.10 per thousand, respectively. In 1898 the pressed-brick output, including buff, gray, and other fancy-colored brick, was 288,765,000, valued at $3,495,697, or $12.11 per thousand, while in 1897 the product was 310,918,000, worth $3,855,033, or $12.40 per thousand. In 1897 6.18 per cent of the total value of the clay products was pressed brick, while in 1898 it constituted but 4.88 per cent of it. Pennsylvania, New Jersey, and Ohio were the largest producers, in point of value, of pressed brick in 1898, 1897, and 1896, in the order named.

The value of the vitrified paving brick product in 1897 increased over that of 1896 $787,452, or 28.18 per cent. If this rate of increase had been maintained, as was expected, the product in 1898 would have been $4,591,455; but the increase was only 9.51 per cent, and the value of the product in 1898 was $3,922,642, as compared with $3,582,037 in 1897. The quantities were 435,851,000 in 1897 and 462,499,000 in 1898. The average value per thousand was $8.22 and $8.48, respectively, in 1897 and 1898. Notwithstanding the small increase in this product in 1898 over 1897, it is a branch of the industry that is sure to grow in importance, not only on account of the increased use of the product for a paving material, for which it is certainly admirably adapted, especially in the smaller cities, but on account of the desirability of this class of product for many other uses, such as for buildings, particularly for foundations, sewers, etc. As in former years, the region of the Ohio-Mississippi valleys, comprising the States of Iowa, Illinois, Indiana, Ohio, and West Virginia, produces the bulk of this product. In 1897 these States produced $2,299,856 worth, or 64.21 per cent, of the product, and in 1898 they produced $2,281,113 worth of vitrified paving brick, or 58.15 per cent of the total. The percentage of this product of the total clay products in 1897 was 5.74; in 1898 it was 5.48. Ohio, Illinois, and Pennsylvania were the largest producers of this product in 1898, in the order named, while in 1897 the order was Illinois, Ohio, and Iowa. Kansas and Pennsylvania made notable gains in 1898, while Iowa suffered quite a decline in this branch of the industry.

The fancy or ornamental product, including enameled brick, showed a decline from $685,048 in 1897 to $632,165 in 1898, which is a decrease of $52,883, or 7.72 per cent. In 1897 the decrease from 1896—the year of maximum output in this branch of the industry, when the product was valued at $763,140—was $78,092, or 10.23 per cent. The percentage of the total clay products of this class of ware in 1897 was 1.10; in 1898 it was 0.88 per cent.

In 1898 for the first time an effort was made to obtain statistics of the value of enameled brick, and the value of this product was found to be $278,993. It will be interesting to watch the development of this branch of the industry, which is undoubtedly growing in importance. Since in no State are there as many as three producers, it is impossible to give the production by States without disclosing the operations of individual establishments.

The fire-brick product, which showed a decrease in 1897 of $850,019, or 17.19 per cent, went from $4,094,704 in 1897 to $5,579,761 in 1898, its maximum output—an increase of $1,485,057, or 36.27 per cent, over 1897. This large gain is, of course, due to the increased activity in the iron and smelting industries and the accompanying increase in the coke industry. Pennsylvania continues to be the largest producer of this product, the value of her output in 1897 being $1,707,621, or nearly 42 per cent of the total, while in 1898 it was $2,846,331, or over 50 per cent of the product of the country. This is, however, no cause for wonderment when her rank as an iron maker and coke producer is considered. Ohio was second, with a production valued at $528,278, or less than one-fifth that of Pennsylvania, while New Jersey was a close third, having wrested that place, with a value of $519,688, from New York, while the latter State takes fourth place with a value of $386,624. The percentages of the total product were 6.57 in 1897 and 7.79 in 1898.

The draintile product, which made a gain of only $9,067 in 1897, increased $402,908 in 1898, or from $2,623,305 in 1897 to $3,026,213 in 1898. As in former years, this product comes almost entirely from the middle West, Iowa, Illinois, Indiana, and Michigan producing in 1898 $2,709,879 worth of draintile, or 90.45 per cent of the total. In 1897 these States produced $2,366,905 worth, or 90.23 per cent of the total. Of these States, Ohio was the largest producer in 1898, with Illinois a very close second, and Indiana, Iowa, and Michigan ranking in the order named. In 1897 this product constituted 4.21 per cent of the total; in 1898 it was 4.23; in 1896, 4.21, thus keeping its relative proportion remarkably well.

The sewer pipe product decreased from $4,069,534 in 1897, or 6.53 per cent of the grand total, to $3,651,206 in 1898, or 5.10 per cent—a loss of $418,328. Ohio continues to be the largest producer of sewer pipe, with Missouri second and California third.

The ornamental terra-cotta product increased from $1,841,422 in 1897 to $1,979,825 in 1898—an increase of $138,403, or 7.52 per cent. In 1897 the product declined $518,561 as compared with 1896, or 21.97 per cent. In 1897 its percentage of the total product was 2.95; in 1898 it was 2.77. New Jersey, Illinois, and New York continue to be the largest producers of this material.

The fireproofing product showed a slight decrease, or from $1,979,259 in 1897 to $1,846,092 in 1898—a loss of $133,167, or 6.73 per cent. In 1897 this product showed quite an increase over 1896 of $272,755, or 15.93 per cent, and the wonder is that it did not continue this increase during 1898. New Jersey, Ohio, and Illinois are the chief producing States. Its percentage of the total in 1897 was 3.17; in 1898 it was 2.58.

The value of the tile product followed the general course of the clay industries and increased. In 1897 it was $1,476,638, compared with $1,731,024 in 1898—a gain of $254,386, or 17.23 per cent. Its percentage of the grand total in 1897 was 2.37 and 2.42 in 1898. This gain is partially due, no doubt, to the increased use of tile as a roofing material. This is another branch of the clay-working industries which gives promise of a large increase in the near future.

The miscellaneous products, comprising a large variety of wares which can not properly be classified with any of the foregoing, but which are enumerated in a footnote to the table, increased from $1,413,595 in 1897 to $1,818,089 in 1898.

The total value of the brick and tile and other forms of clay structural materials, as shown by these tables, in 1898 was $57,644,706, as compared with $52,050,782 in 1897—an increase of $5,593,924, or 10.75 per cent. In 1897 its percentage of the grand total was 83.47; in 1898 it was 80.51.

RANK OF STATES.

The following tables show the rank of States in the output of brick and tile products, as distinguished from pottery products, and the percentage of the total made by each State in 1897 and 1898, and will be of interest to those engaged exclusively in this line of industry.

Rank of States and output of brick and tile products in 1897 and 1898.

1898.

Rank.	State.	Value.	Per cent of total product.
1	Pennsylvania	$8,689,645	15.07
2	Ohio	6,652,978	11.54
3	New York	6,079,645	10.55
4	Illinois	6,067,856	10.53
5	New Jersey	4,568,925	7.93
6	Missouri	2,996,948	5.20
7	Indiana	2,944,770	5.11
8	Iowa	2,116,397	3.67
9	Massachusetts	1,534,505	2.66

Rank of States and output of brick and tile products in 1897 and 1898—Continued.

1898—Continued.

Rank.	State.	Value.	Per cent of total product.
10	California	$1,004,456	1.74
11	Michigan	1,000,412	1.74
12	Maryland	949,907	1.65
13	Kentucky	898,704	1.56
14	Virginia	875,857	1.52
15	Connecticut and Rhode Island	875,580	1.52
16	Georgia	834,908	1.45
17	Minnesota	794,967	1.38
18	Wisconsin	731,706	1.27
19	Texas	702,869	1.22
20	Maine	588,301	1.02
21	Nebraska	513,565	.89
22	Louisiana	513,059	.89
23	West Virginia	509,357	.88
24	Colorado	488,872	.85
25	Tennessee	474,424	.82
26	Kansas	440,864	.76
27	Alabama	440,747	.76
28	New Hampshire	401,989	.70
29	North Carolina	401,636	.70
30	District of Columbia	320,320	.56
31	Mississippi	289,683	.50
32	Montana	273,626	.47
33	Washington	250,988	.43
34	South Carolina	234,232	.41
35	Arkansas	227,266	.39
36	Utah	180,162	.31
37	Oregon	131,864	.23
38	Florida	122,987	.21
39	Delaware	90,555	.16
40	Arizona	81,509	.14
41	Oklahoma	78,258	.14
42	North Dakota	72,900	.13
43	Vermont	56,974	.10
44	New Mexico	41,940	.07
45	Indian Territory	35,633	.06
46	South Dakota	30,770	.05
47	Idaho	27,365	.05
48	Wyoming	3,825	.01
	United States	57,644,706	100

Rank of States and output of brick and tile products in 1897 and 1898—Continued.

1897.

Rank.	State.	Value.	Per cent of total product.
1	Pennsylvania	$7,171,296	13.78
2	Ohio	6,347,415	12.19
3	New York	5,432,239	10.44
4	Illinois	4,879,674	9.37
5	New Jersey	4,195,134	8.06
6	Indiana	2,514,584	4.83
7	Missouri	2,484,069	4.77
8	Massachusetts	1,950,052	3.75
9	Iowa	1,782,231	3.42
10	Connecticut and Rhode Island	1,265,170	2.43
11	Texas	1,134,829	2.18
12	Maryland	1,070,265	2.06
13	Georgia	948,313	1.82
14	Virginia	804,846	1.55
15	Maine	800,739	1.54
16	Michigan	769,570	1.48
17	Wisconsin	724,282	1.39
18	Kentucky	680,938	1.31
19	California	659,202	1.27
20	West Virginia	595,734	1.14
21	Tennessee	571,923	1.10
22	Minnesota	567,394	1.09
23	New Hampshire	439,672	.84
24	Alabama	411,028	.79
25	Colorado	389,354	.75
26	Louisiana	370,910	.71
27	North Carolina	355,324	.68
28	Nebraska	351,385	.68
29	South Carolina	290,497	.56
30	District of Columbia	288,981	.55
31	Mississippi	263,100	.51
32	Kansas	252,418	.49
33	Montana	231,649	.45
34	Washington	190,720	.37
35	Arkansas	167,439	.32
36	Utah	135,781	.26
37	Oregon	115,798	.22
38	Florida	89,435	.17
39	Delaware	68,458	.13
40	North Dakota	62,420	.12

Rank of States and output of brick and tile products in 1897 and 1898—Continued.

1897—Continued.

Rank.	State.	Value.	Per cent of total product.
41	Arizona	$54,143	0.10
42	Vermont	53,485	.10
43	New Mexico	33,270	.06
44	Oklahoma Territory	30,217	.06
45	South Dakota	21,800	.04
46	Idaho	15,914	.03
47	Indian Territory	14,135	.03
48	Wyoming	3,550	.01
	United States	52,050,782	100

As will be seen by these tables, all of the States and Territories participate in this total except Nevada and Alaska. When these products only are considered, it will be observed that Pennsylvania is the leading State, with a product valued at $8,689,645 in 1898 or 15.07 per cent of the entire product, while in 1897 she produced $7,171,296 worth of brick and tile or 13.78 per cent of the total. Ohio was second each year, producing $6,652,978 in 1898 or 11.54 per cent of the product, and $6,347,415 in 1897 or 12.19 per cent of the total. The other leading States vary but little. In 1897 and 1898 New York and Illinois were third and fourth, respectively. New Jersey was fifth both years, while Indiana and Missouri exchanged places, Missouri advancing from seventh in 1897 to sixth in 1898, and Indiana falling from sixth in 1897 to seventh in 1898. Iowa, which was ninth in 1897, became eighth in 1898, exchanging places with Massachusetts. Some of the other notable changes are: Texas, which was eleventh in 1897, fell to nineteenth in 1898; California rose from nineteenth in 1897 to tenth in 1898; Connecticut and Rhode Island, which occupied tenth place in 1897, fell to fifteenth in 1898; Michigan, which rose from sixteenth place in 1897 to eleventh in 1898, and Minnesota, which rose from twenty-second in 1897 to sixteenth in 1898.

PRICES.

The following table shows the average value per thousand of the several kinds of brick made in the United States in 1898, by States:

Average price of brick per thousand in 1898, by States.

COMMON BRICK.

State.	Price.	State.	Price.
Wyoming	$8.05	California	$5.54
South Dakota	7.40	West Virginia	5.52
Idaho	7.14	Massachusetts	5.51
Washington	6.82	Kansas	5.50
Delaware	6.62	Mississippi	5.45
Montana	6.56	Alabama	5.40
Arizona	6.48	Wisconsin	5.40
New Mexico	6.48	Maine	5.37
Indian Territory	6.39	Tennessee	5.26
Oregon	6.29	North Carolina	5.20
Arkansas	6.24	Vermont	5.16
Oklahoma	6.23	Louisiana	5.07
North Dakota	6.13	Kentucky	5.00
District of Columbia	6.04	Ohio	5.00
Nebraska	6.02	New Hampshire	4.93
Iowa	6.00	Indiana	4.91
Virginia	5.95	New Jersey	4.88
Maryland	5.93	Minnesota	4.87
Texas	5.82	New York	4.86
Colorado	5.74	Missouri	4.76
Utah	5.70	Michigan	4.71
Florida	5.68	Georgia	4.64
Illinois	5.60	South Carolina	4.13
Pennsylvania	5.58		
Connecticut and Rhode Island	5.57	Average for United States	5.28

PRESSED BRICK.

State.	Price.	State.	Price.
California	$21.99	Virginia	$15.35
Massachusetts	21.95	Maryland	14.88
New Jersey	18.40	Montana	14.67
Oregon	17.81	District of Columbia	14.18
Arizona	16.67	New York	13.68
Washington	16.40	Oklahoma	13.65
Delaware	16.33	Alabama	13.62
Connecticut and Rhode Island	15.37	Nebraska	13.41
		New Hampshire	12.80

Average price of brick per thousand in 1898, by States—Continued.

PRESSED BRICK—Continued.

State.	Price.	State.	Price.
Texas	$12.03	Florida	$8.18
South Dakota	12.00	Mississippi	8.16
Pennsylvania	11.97	Iowa	8.15
Maine	11.91	Louisiana	7.54
Missouri	11.53	West Virginia	7.51
Georgia	10.79	Wisconsin	7.48
Ohio	10.47	South Carolina	7.43
Indiana	10.31	Kentucky	7.38
Arkansas	10.09	Vermont	6.89
Minnesota	9.94	Kansas	6.75
North Carolina	9.25	Michigan	6.64
Illinois	9.14	Average for United States	12.11
Utah	9.12		
Colorado	9.00		
Tennessee	8.54		

VITRIFIED PAVING BRICK.

State.	Price.	State.	Price.
New Jersey	$14.00	Illinois	$8.88
Washington	12.78	Pennsylvania	8.70
Connecticut and Rhode Island	12.58	West Virginia	8.69
Maryland	12.00	Arkansas	8.40
Alabama	11.59	Iowa	8.20
New York	10.99	Nebraska	8.09
Michigan	10.76	District of Columbia	8.02
Virginia	10.00	Georgia	8.02
Wisconsin	10.00	Montana	8.00
North Carolina	9.93	Kansas	7.24
Missouri	9.42	Tennessee	7.11
Indiana	9.38	Ohio	6.92
Texas	9.33	Utah	5.45
Colorado	9.11	Average for United States	8.48
Kentucky	9.00		
Massachusetts	9.00		

From these tables it appears that the price of common brick in 1898 ranged from $8.05 per thousand in Wyoming to $4.13 per thousand in South Carolina, while the average for the whole country was $5.28. In 1897 Wyoming and New York were the extremes, with $7.24 and

$4.41 per thousand, respectively. In 1897 the average price in Tennessee was almost identical with that for the United States, and in 1898 this State again most nearly approached the general average of $5.28, it being $5.26.

The average price of pressed brick, including buff, gray, and other fancy-colored brick, varied in 1898 from $21.99 in California to $6.64 in Michigan, the average for the whole country being $12.11. In 1897 the same States were the extremes, with averages of $37.90 and $5.28 per thousand.

The vitrified paving brick varied in price from $14 per thousand in New Jersey to $5.45 in Utah, while the average for the whole country was $8.48. In 1897 California and Tennessee were the extremes, with averages of $15 and $6.25 per thousand, respectively, and the general average $8.22. While in Minnesota and Maine this product is reported with much higher averages, still the outputs are small, and the price can hardly be considered as representative of the values in those States.

POTTERY.

INTRODUCTION.

The third statistical canvass of the pottery industry of the United States by the Geological Survey has been most gratifying in its results. So complete have been the returns that the figures for 1898 amount practically to a census, and the potters are hereby thanked for their cordial cooperation.

In the following States every potter has replied, which makes the figures for those States absolutely complete: Arkansas, Colorado, Connecticut, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Ohio, Oregon, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, and Wisconsin, leaving only Alabama, California, Iowa, New Jersey, New York, North Carolina, Pennsylvania, and Tennessee incomplete. In these eight States there are only 17 potteries not reporting, making an average of about two potters in each State from whom no replies have been received.

Of the 517 firms on our list, 447 report an output in 1898; 53 potteries were idle and 17 not reporting, giving a percentage of 96.71 reporting for 1898.

PRODUCTION.

In the following tables will be found a statement of the pottery products of the United States by varieties of products, by States, in 1897 and 1898:

Value of pottery products of the United States in 1898, by States.

State.	Operating firms reporting.	Red earthenware.	Stoneware.	Yellow and Rockingham ware.	C. C. ware.	White granite and semiporcelain ware.	Semivitreous porcelain ware.
Alabama	8	$1,750	$11,900				
Arkansas	4		16,900				
California	5	13,147					
Colorado							
Connecticut	5	16,100					
Georgia	6	3,300	13,500				
Illinois	23	5,725	431,812				
Indiana	18	6,210	36,532				
Iowa	15	6,100	24,825				
Kansas	4		3,700				
Kentucky	10	13,165	76,521				
Maryland	8	8,854					
Massachusetts	15	160,078	22,746				
Michigan	3	17,900					
Minnesota	5						
Missouri	9	3,880	49,378				
New Hampshire							
New Jersey	44	13,900	9,200		$733,958	$483,917	$439,356
New York	22	29,723	76,620				
North Carolina	28	1,311	12,815				
Ohio	108	120,026	529,691	$187,649	663,530	2,224,264	1,337,495
Pennsylvania	39	132,967	245,243				
Tennessee	16	1,500	37,814				
Texas	18	4,750	50,592				
Virginia	8	2,126	4,274				
West Virginia	5						
Other States *a*	*b* 21	*c* 27,864	*d* 361,782	*e* 205,163	*f* 452,964	*g* 868,508	*h* 257,643
United States	447	590,376	2,015,845	392,812	1,850,452	3,576,689	2,034,494
Per cent of total clay products.		.82	2.82	.55	2.58	5.00	2.84

a Includes all products made by less than three producers in one State, in order that the operations of individual establishments may not be disclosed.

b Includes Colorado, District of Columbia, Florida, Idaho, Louisiana, Maine, Nebraska, New Hampshire, Oregon, South Carolina, Utah, Washington, and Wisconsin.

c Includes Arkansas, District of Columbia, Florida, Idaho, Kansas, Louisiana, Maine, Mississippi, Montana, Nebraska, Oregon, South Carolina, Utah, Washington, West Virginia, and Wisconsin.

d Includes California, Colorado, Connecticut, Florida, Idaho, Maryland, Minnesota, Mississippi, Nebraska, Oregon, South Carolina, Washington, and West Virginia.

e Includes Georgia, Idaho, Illinois, Maryland, Minnesota, New Jersey, New York, Pennsylvania, and South Carolina.

f Includes Illinois, Maryland, Massachusetts, New York, Pennsylvania, and West Virginia.

g Includes Illinois, Indiana, Maryland, Pennsylvania, and West Virginia.

h Includes New Hampshire, Pennsylvania, and West Virginia.

Value of pottery products of the United States in 1898, by States—Continued.

State.	Chinaware.	Bone china, delft and belleek ware.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous. *a*	Total.
Alabama						$13,650
Arkansas						17,100
California						30,274
Colorado						17,350
Connecticut					$55,000	72,600
Georgia						22,350
Illinois						637,537
Indiana					1,000	266,742
Iowa					3,400	34,425
Kansas						4,111
Kentucky						89,686
Maryland						303,518
Massachusetts					9,441	242,265
Michigan						17,900
Minnesota					100	322,864
Mississippi					600	14,100
Missouri						58,258
New Hampshire						31,200
New Jersey	$424,060	$52,500	$1,477,192	$182,000	206,159	4,030,442
New York			38,213		30,225	369,344
North Carolina						18,146
Ohio	218,000			178,919	292,885	5,759,459
Pennsylvania					29,277	952,453
Tennessee						39,314
Texas						55,342
Virginia					7,626	14,026
West Virginina						518,218
Other States *b*			*c* 196,946	*d* 88,463		
United States	642,060	52,500	1,712,351	449,382	635,713	13,952,674
Per cent of total clay products	.90	.07	2.39	.63	.89	19.49

a Including art, chemical, and "Grueby" pottery, battery cups, bath and laundry tubs, sinks, ceramic mosaics, doorknobs, decorated cuspidors and jardinieres, filter tubes, toy marbles, pins, stilts, and spurs for potters' use, oval ware roasters, shuttle eyes and thread guides, smoking pipes, umbrella stands and pedestals.

b Includes all products made by less than three producers in one State, in order that the operations of individual establishments may not be disclosed.

c Includes Indiana, Iowa, Missouri, Ohio, Pennsylvania, and West Virginia.

d Includes New York.

Value of pottery products of the United States in 1897, by States.

State.	Operating firms reporting.	Earthenware and stoneware.	Yellow and Rockingham ware.	C. C. and white granite ware.	Sanitary ware.	Porcelain or china.	Porcelain electrical supplies.	Total.
Alabama	9	$32,350						$32,350
Arkansas	5	16,660						16,660
California	4	15,703						44,208
Colorado								17,509
Connecticut	5	71,500						71,500
Georgia	5	10,700						14,200
Illinois	22	498,900						618,900
Indiana	15	29,725						197,725
Iowa	12	38,641						39,016
Kansas	3	4,100						4,100
Kentucky	11	119,930						125,430
Maryland	8	124,277	$7,740			$100,000		235,017
Massachusetts	13	186,515						229,344
Michigan	3	22,300						22,300
Minnesota	3	303,875						314,675
Mississippi								12,500
Missouri	10	52,459						52,459
New Hampshire								25,500
New Jersey	22	414,960		$460,608	$1,036,445	49,800	$14,200	1,985,713
New York	13	179,265						183,265
North Carolina	29	10,170						13,870
Ohio	95	1,709,884	271,453	1,644,246	24,552	912,434	157,700	4,720,269
Pennsylvania	34	426,949		276,350				703,399
Tennessee	15	40,120						40,370
Texas	21	62,210						62,210
Virginia	7	7,200						7,200
West Virginia	7	169,520						519,520
Other States *a*	*b* 20	*c* 58,909	*d* 54,580	*e* 382,000	*f* 101,200	*g* 200,050	*h* 9,029	
United States	391	4,606,822	333,773	2,763,204	1,162,197	1,262,284	180,929	10,309,209
Per cent of total clay products		7.39	.54	4.43	1.86	2.02	.29	16.53

a Includes all products made by less than three producers in one State, in order that the operations of individual establishments may not be disclosed.

b Includes District of Columbia, Florida, Idaho, Louisiana, Maine, Nebraska, Oregon, South Carolina, Utah, Washington, and Wisconsin.

c Includes Colorado, District of Columbia, Florida, Idaho, Louisiana, Maine, Mississippi, Montana, Nebraska, Oregon, South Carolina, Utah, Washington, and Wisconsin.

d Includes Idaho, Illinois, Indiana, Iowa, Kentucky, New Jersey, Oregon, and Pennsylvania.

e Includes California, Illinois, Indiana, Massachusetts, and West Virginia.

f Includes Indiana, Iowa, New York, and West Virginia.

g Includes Massachusetts, New Hampshire, New York, North Carolina, Tennessee, and West Virginia.

h Includes Massachusetts and New Hampshire.

An inspection of these tables shows that the value of the pottery products of the United States, as reported to this office, in 1898, was $13,952,674, as compared with $10,309,209 in 1897, a gain of $3,643,465, or 35.34 per cent. It will also be seen that the operating firms reporting increased from 391 in 1897 to 447 in 1898, a gain of 56, or 14.32 per cent, which indicates that the pottery industry was in a more prosperous condition in 1898 than in 1897, which is undoubtedly true. Its percentage of the total clay products in 1897 was 16.53; in 1898 it was 19.49.

RANK OF STATES.

The following tables show the rank of States in the production of pottery, together with the value of the product of each State and the percentage of the total product made by each State in 1897 and 1898:

Rank of States and output of pottery products in 1897 and 1898.

1898.

Rank.	State.	Number of operating firms reporting.	Value.	Per cent of total product.
1	Ohio	108	$5,759,459	41.28
2	New Jersey	44	4,030,442	28.89
3	Pennsylvania	39	952,453	6.83
4	Illinois	23	637,537	4.57
5	West Virginia	5	518,218	3.71
6	New York	22	369,344	2.65
7	Minnesota	*a* 5	322,864	2.31
8	Maryland	*b* 9	303,518	2.17
9	Indiana	18	266,742	1.91
10	Massachusetts	15	242,265	1.74
11	Kentucky	10	89,686	.64
12	Connecticut	5	72,600	.52
13	Missouri	9	58,258	.42
14	Texas	18	55,342	.40
15	Tennessee	16	39,314	.28
16	Iowa	15	34,425	.25
17	New Hampshire	*c* 2	31,200	.22
18	California	*d* 8	30,274	.22
19	Georgia	*e* 7	22,350	.16
20	North Carolina	*f* 32	18,146	.13
21	Michigan	3	17,900	.13
22	Colorado	*g* 7	17,350	.12
23	Arkansas	4	17,100	.12
24	Mississippi	*h* 3	14,100	.10
25	Virginia	8	14,026	.10
26	Alabama	8	13,650	.10
27	Kansas	4	4,111	.03
	United States	447	13,952,674	100

a Includes Wisconsin.
b Includes the District of Columbia.
c Includes Maine.
d Includes Washington and Oregon.
e Includes Florida.
f Includes South Carolina.
g Includes Idaho, Montana, Nebraska, and Utah.
h Includes Louisiana.

Rank of States and output of pottery products in 1897 and 1898—Continued.

1897.

Rank.	State.	Number of operating firms reporting.	Value.	Per cent of total product.
1	Ohio	95	$4,720,269	45.79
2	New Jersey	22	1,985,713	19.26
3	Pennsylvania	34	703,399	6.83
4	Illinois	22	618,900	6.01
5	West Virginia	7	519,520	5.03
6	Minnesota	*a* 4	314,675	3.05
7	Maryland	*b* 9	235,017	2.27
8	Massachusetts	13	229,344	2.23
9	Indiana	15	197,725	1.91
10	New York	13	183,265	1.78
11	Kentucky	11	125,430	1.23
12	Connecticut	5	71,500	.69
13	Texas	21	62,210	.60
14	Missouri	10	52,459	.51
15	California	*d* 7	44,208	.43
16	Tennessee	15	40,370	.39
17	Iowa	12	39,016	.38
18	Alabama	9	32,350	.31
19	New Hampshire	*c* 2	25,500	.25
20	Michigan	3	22,300	.22
21	Colorado	*g* 7	17,509	.17
22	Arkansas	5	16,660	.16
23	Georgia	*e* 5	14,200	.14
24	North Carolina	*f* 31	13,870	.13
25	Mississippi	*h* 3	12,500	.12
26	Virginia	7	7,200	.07
27	Kansas	3	4,100	.04
	United States	391	10,309,209	100

a Includes Wisconsin.
b Includes the District of Columbia.
c Includes Maine.
d Includes Washington and Oregon.
e Includes Florida.
f Includes South Carolina.
g Includes Idaho, Montana, Nebraska, and Utah.
h Includes Louisiana

Ohio continues to be the leading pottery-producing State, with a product in 1898 valued at $5,759,459, or 41.28 per cent of the pottery products of the country, as compared with $4,720,269 in 1897, or 45.79 per cent of the total. In 1897 there were 95 operating firms reporting in this State, while in 1898 there were 108 reporting. New Jersey is second in each year with a production of $4,030,442 in 1898, or 28.89 per cent of the total, as compared with $1,985,713, or 19.26 per cent of the total. It is only fair to state, however, that the figures for New Jersey for 1897 are below the actual output on account of the large number of potters making no return for that year, the number reporting in 1898 being 44, while in 1897 but 22 reported.

It will be noted that Ohio and New Jersey together in 1898 produced 70.44 per cent of the pottery of the entire country. The next three States—Pennsylvania, Illinois, and West Virginia—maintained their relative positions of three, four, and five, respectively, in both 1897 and 1898. Minnesota, which was sixth in 1897, became seventh in 1898, and New York, which was tenth in 1897, rose to sixth in 1898.

The following table shows the number of active and idle potteries reporting in 1898:

Number of operating and idle potteries in the United States reporting in 1898.

State.	Operating.	Idle.	Total.
Alabama	8	3	11
Arkansas	4	2	6
California	5	3	8
Connecticut	5	0	5
Georgia	6	2	8
Illinois	23	4	27
Indiana	18	4	22
Iowa	15	0	15
Kansas	4	1	5
Kentucky	10	2	12
Maryland	8	1	9
Massachusetts	15	2	17
Michigan	3	0	3
Minnesota	3	1	4
Missouri	9	3	12
New Jersey	44	3	47
New York	22	2	24
North Carolina	28	0	28
Ohio	108	9	117
Pennsylvania	39	2	41
South Carolina	4	1	5
Tennessee	16	1	17
Texas	18	0	18
Virginia	8	3	11
West Virginia	5	1	6
Other States (*a*)	19	3	22
Total	447	53	500

a Including Colorado, District of Columbia, Florida, Idaho, Louisiana, Maine, Mississippi, Montana, Nebraska, New Hampshire, Oregon, Utah, and Wisconsin.

CONSUMPTION.

A reference to the table of imports shows that the imports of pottery has been steadily decreasing since the year of its maximum, 1895, which must be very gratifying to the domestic potters. The total consumption of pottery in the United States was, in 1898, according to the data at hand, which are practically complete and will serve for a basis of comparison, $20,915,284, of which the imports, $6,962,610, was 33.29 per cent, and the domestic production, $13,952,674, was 66.71 per cent.

RAW CLAY.

PRODUCTION.

The following tables show the production and value of the clay produced in 1897 and 1898 by miners who do not manufacture the clay into wares, but sell it to clay workers. The increase in 1897 over 1898 is due to more complete statistics rather than a more prosperous condition, though undoubtedly this branch of industry participated in the general improvement in trade conditions during 1898.

Production and value of raw clay in the United States in 1897 and 1898, by States.

1898.

[Tons of 2,000 pounds.]

State.	Kaolin or china.		Ball.	
	Quantity.	Value.	Quantity.	Value.
Alabama	50	$350		
California				
Colorado	60	135	4,361	$3,943
Connecticut	1,500	18,750		
Delaware	14,958	82,286		
Florida	7,200	42,000		
Illinois	6,100	6,435	26,087	21,063
Indiana			11,500	11,275
Iowa			105	170
Kentucky	100	2,000	6,625	18,901
Maryland			292	384
Michigan	120	300	*a* 550	1,450
Missouri	1,850	6,990	4,041	21,381
Montana				
Nebraska				
New Jersey	16,234	26,811	25,113	58,884
New York	60	60	*a* 1,500	5,400
North Carolina	10,000	90,000	82	35

a Including slip clay.

Production of raw clay in the United States, etc.—Continued.

1898—Continued.

[Tons of 2,000 pounds.]

State.	Kaolin or china.		Ball.	
	Quantity.	Value.	Quantity.	Value.
Ohio	300	$850	20,705	$11,807
Oregon				
Pennsylvania	13,502	67,462		
South Carolina	22,450	97,250		
Tennessee			100	25
Texas				
Vermont	1,050	7,800		
Virginia			50	25
West Virginia				
Wisconsin	5,000	47,500		
United States	100,534	496,979	101,111	154,743

State.	Fire.		Miscellaneous. *a*		Total value.
	Quantity.	Value.	Quantity.	Value.	
Alabama	11,190	$7,041			$7,391
California	7,000	6,800			6,800
Colorado	13,220	13,160			17,238
Connecticut					18,750
Delaware					82,286
Florida					42,000
Illinois	24,650	18,080			45,578
Indiana	13,150	21,135			32,410
Iowa	77	77			247
Kentucky					20,901
Maryland	1,118	1,051			1,435
Michigan					1,750
Missouri	19,416	210,611			238,982
Montana	854	1,462			1,462
Nebraska	7,000	2,100			2,100
New Jersey	152,840	277,113	21,456	$28,064	390,872
New York	2,374	11,768			17,228
North Carolina	173	244	6	36	90,315
Ohio	24,167	19,023	2,571	3,790	35,470
Oregon	300	300			300
Pennsylvania	35,656	58,192	1,160	7,792	133,446

a Including flint-brick clay, flint-glass pot clay, paper clay, clay for smoking pipes, and clay for wall paper, plaster, and boiler covering.

Production of raw clay in the United States, etc.—Continued.

1898—Continued.

[Tons of 2,000 pounds.]

State.	Fire.		Miscellaneous. *a*		Total value.
	Quantity.	Value.	Quantity.	Value.	
South Carolina	3,000	$5,000	6,000	$21,000	$123,250
Tennessee	981	942			967
Texas	710	710			710
Vermont	100	200			8,000
Virginia	20	45			70
West Virginia	34,616	17,308			17,308
Wisconsin					47,500
United States	352,612	672,362	31,193	60,682	1,384,766

a Including flint-brick clay, flint-glass pot clay, paper clay, clay for smoking pipes, and clay for wall paper, plaster, and boiler covering.

1897.

[Tons of 2,000 pounds.]

State.	Kaolin.		Ball.	
	Quantity.	Value.	Quantity.	Value.
Alabama				
California				
Colorado	550	$1,250	9,999	$11,554
Delaware	12,166	99,441		
Florida	6,948	39,500		
Illinois	10,029	7,154		
Indiana	1,250	1,000		
Kentucky			7,500	22,500
Maryland				7,607
Michigan	420	1,260		
Missouri	2,498	5,901	3,000	16,500
Montana				
New Jersey			77,597	137,097
New York	873	1,642		2,000
North Carolina	5,000	40,000		
Ohio	100	250	500	300
Pennsylvania	8,409	50,482	10,050	11,638
South Carolina	16,000	77,200		
Vermont	1,000	7,000		
West Virginia			4,280	4,370
Wisconsin	3,500	35,000		
Total	68,743	367,080	112,926	213,566

Production and value of raw clay in the United States, etc.—Continued.

1897—Continued

[Tons of 2,000 pounds.]

State.	Fire.		Total.	
	Quantity.	Value.	Quantity.	Value.
Alabama	....	$4,000	....	$4,000
California	3,700	4,250	3,700	4,250
Colorado	7,463	9,713	18,012	22,517
Delaware	....	....	12,166	99,441
Florida	....	....	6,948	39,500
Illinois	17,022	14,622	27,051	21,776
Indiana	3,500	3,500	4,750	4,500
Kentucky	....	....	7,500	22,500
Maryland	....	....	....	7,607
Michigan	....	....	420	1,260
Missouri	177,600	178,600	183,098	201,001
Montana	1,087	1,087	1,087	1,087
New Jersey	105,679	121,879	183,276	258,976
New York	14,577	14,669	15,450	18,311
North Carolina	....	....	5,000	40,000
Ohio	10,861	8,398	11,461	8,948
Pennsylvania	21,957	22,084	40,416	84,204
South Carolina	3,000	6,000	19,000	83,200
Vermont	....	....	1,000	7,000
West Virginia	15,000	9,000	19,280	13,370
Wisconsin	....	....	3,500	35,000
Total	381,446	397,802	563,115	978,448

An inspection of these tables show that New Jersey was the largest producer of clay in each year for which statistics have been collected by this office, having a production valued at $258,976 in 1897, as compared with $390,872 in 1898. Missouri was also second each year, with a value of $201,001 and $238,982 in 1897 and 1898, respectively. Pennsylvania was third in 1898, with a value of $133,446, displacing Delaware, which had a product valued at $82,286. In 1897 Delaware's product was valued at $99,441; in 1898 it was valued at $82,286, with a rank of fifth State. South Carolina was the fourth largest producer in 1898 and fifth in 1897.

THE CLAY INDUSTRY IN INDIVIDUAL STATES.

The following series of tables show the output and value of clay products in the more important clay-working States from 1895 to 1898, inclusive, and will be interesting as a means of comparing the products of each State for a term of years.

The statistics of the pottery industry, except of stoneware, were not collected by this office prior to 1896, which accounts for the blanks under this head in 1895.

CALIFORNIA.

Clay products of California from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	144, 403, 000	74, 240, 000	88, 890, 000	108, 076, 000
Value	$922, 712	$391, 567	$509, 955	$598, 823
Average per M	$6. 40	$5. 27	$5. 74	$5. 54
Pressed—				
Quantity	3, 885, 000	1, 039, 000	843, 000	1, 942, 000
Value	$71, 286	$34, 424	$31, 950	$42, 700
Average per M	$18. 34	$33. 13	$37. 90	$21. 99
Vitrified—				
Quantity		(a)	(a)	
Value		(a)	(a)	
Average per M		$11. 66	$15. 00	
Fancy ...... value	(a)	(a)	(a)	(a)
Fire brick .... do	$10, 836	$11, 875	$7, 720	$19, 505
Draintile .... do	$8, 980	$4, 528	$5, 300	$6, 660
Sewer pipe .... do	$261, 536	$208, 000	$90, 430	$305, 833
Ornamental terra cotta, value	$48, 300	(a)	(a)	$19, 300
Fireproofing .... value		(a)	(a)	(a)
Tile, not drain .... do	$58, 450			(a)
Pottery:				
Earthenware and stoneware. value		$17, 022	$15, 703	$13, 147
C. C. and white granite ... value			(a)	
Miscellaneous b ... do	$39, 054	$12, 791	c $42, 352	c $28, 762
Total value	$1, 421, 154	$680, 207	$703, 410	$1, 034, 730
Number of operating firms reporting		60	58	77
Rank of State	10	21	21	12

a Included in miscellaneous.

b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

c Including pottery products of Washington and Oregon.

CONNECTICUT AND RHODE ISLAND.

Clay products of Connecticut and Rhode Island from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	146, 550, 000	194, 995, 000	200, 130, 000	120, 380, 000
Value	$817, 462	$1, 141, 738	$1, 017, 250	$670, 880
Average per M	$5. 57	$5. 85	$5. 08	$5. 57
Pressed—				
Quantity	(*a*)	(*a*)	(*a*)	(*a*)
Value	(*a*)	(*a*)	(*a*)	(*a*)
Average per M	$15. 71	$15. 17	$27. 94	$15. 37
Vitrified—				
Quantity	(*a*)	(*a*)	(*a*)	(*a*)
Value	(*a*)	(*a*)	(*a*)	(*a*)
Average per M	$12. 00	$12. 03	$12. 52	$12. 58
Fancy or ornamental .... value	$10, 600	(*a*)	(*a*)	(*a*)
Fire brick ..... do	$67, 000	$74, 800	$44, 750	(*a*)
Draintile .... do	(*a*)	(*a*)	(*a*)	....
Sewer pipe .... do	(*a*)	(*a*)	....	....
Ornamental terra cotta, value	$44, 563	(*a*)	(*a*)	....
Fireproofing .... value	....	(*a*)	(*a*)	(*a*)
Tile, not drain .... do	(*a*)	(*a*)	(*a*)	(*a*)
Pottery:				
Earthenware and stoneware . value	$56, 300	$48, 700	$71, 500	$16, 100
Miscellaneous *b* ... do	$133, 000	$183, 360	$203, 170	$261, 200
Total value	$1, 128, 925	$1, 448, 598	$1, 336, 670	$948, 180
Number of operating firms reporting	....	42	48	47
Rank of Connecticut	20	11	10	15
Rank of Rhode Island	29	30		

a Included in miscellaneous.
b Includes all products not otherwise classified, and those made by less than three producers; in order that the operations of individual establishments may not be disclosed.

DISTRICT OF COLUMBIA.

The figures given below will be found to differ somewhat from those given for the District of Columbia in other portions of this report. This is because in these figures are included the products manufactured by the firms in Alexandria County, Va., five or six in number, who have offices in Washington, D. C., and whose market is almost entirely the District of Columbia, and whose product should really be credited to the District of Columbia.

Clay products of District of Columbia from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	71,118,000	65,648,000	60,530,000	70,599,000
Value	$410,149	$372,145	$359,590	$432,502
Average per M	$5.77	$5.67	$5.94	$6.13
Pressed—				
Quantity	8,403,000	8,791,000	10,202,000	7,733,000
Value	$135,058	$129,131	$138,875	$134,248
Average per M	$16.07	$14.69	$13.61	$17.36
Vitrified—				
Quantity	(*a*)	(*a*)	(*a*)	(*a*)
Value	(*a*)	(*a*)	(*a*)	(*a*)
Average per M	$8.26	$10.00	$8.00	$8.02
Fancy or ornamental, value	$39,919	$21,743	$31,000	$22,091
Drain tile .... value	(*a*)	(*a*)	(*a*)	(*a*)
Sewer pipe .... do	$64,631	$39,558	$66,360	$34,000
Fireproofing .... value	....	(*a*)	(*a*)	(*a*)
Tile, not drain .... do	(*a*)	(*a*)	....	....
Pottery:				
Earthenware and stoneware. value	....	(*a*)	(*a*)	(*a*)
Miscellaneous *b* .... do	$14,363	$88,379	$6,436	$25,695
Total value	$664,120	$650,956	$602,261	$648,536
Number of operating firms reporting	20	18	21	22

a Included in miscellaneous.
b Includes all products not otherwise classified and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

GEORGIA.

Clay products of Georgia from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	135,480,000	132,469,000	134,296,000	114,309,000
Value	$655,275	$615,771	$599,158	$530,346
Average per M	$4.83	$4.64	$4.46	$4.64
Pressed—				
Quantity	4,783,000	2,390,000	3,340,000	2,433,000
Value	$46,265	$21,678	$35,381	$26,250
Average per M	$9.69	$9.07	$10.59	$10.79
Vitrified—				
Quantity	(a)	390,000	(a)	(a)
Value	(a)	$5,660	(a)	(a)
Average per M	$8.00	$14.51	$10.00	$8.02
Fancy or ornamental value	$27,560	$1,000	(a)	....
Fire brick do	$29,950	$25,297	$12,904	$25,650
Drain tile do	(a)	$8,740	(a)	(a)
Sewer pipe do	(a)	$172,662	$242,450	$181,000
Ornamental terra cotta, value	$34,850	$32,280	(a)	(a)
Fireproofing value	....	$15,565	(a)	(a)
Tile, not drain do	(a)	....	(a)	(a)
Pottery:				
Earthenware and stoneware value	(a)	$7,160	$10,700	$16,800
Yellow and Rockingham ware value	....	....	....	(a)
Miscellaneous *b* do	$73,455	....	*c*$61,920	*c*$77,212
Total value	$867,355	$905,813	$962,513	$857,258
Number of operating firms reporting	....	55	51	57
Rank of State	15	15	14	17

a Included in miscellaneous.

b Includes all products not otherwise classified and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

c Including Florida.

ILLINOIS.

Clay products of Illinois from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	717,079,000	586,506,000	516,263,000	558,204,000
Value	$3,786,747	$2,831,752	$2,376,498	$3,123,202
Average per M	$5.28	$4.83	$4.60	$5.60
Pressed—				
Quantity	29,093,000	21,995,000	24,342,000	26,953,000
Value	$330,318	$196,658	$218,788	$246,416
Average per M	$11.35	$8.94	$8.99	$9.14
Vitrified—				
Quantity	82,526,000	60,955,000	87,169,000	71,999,000
Value	$643,997	$486,519	$719,371	$639,153
Average per M	$7.80	$7.98	$8.25	$8.88
Fancy or ornamental ....value	$19,500	*a* $52,624	*a* $61,067	$30,453
Fire brick ....do	$117,040	$125,408	$106,377	$109,465
Drain tile ....do	$1,028,581	$517,684	$531,993	$797,597
Sewer pipe ....do	$389,680	$187,350	$165,071	$200,312
Ornamental terra cotta, value	$722,500	$720,100	$418,500	$510,000
Fireproofing ....value	(*b*)	$213,315	$177,782	$202,374
Tile, not drain ...do	$231,166	$110,355	$97,000	$146,063
Pottery:				
Earthenware and stoneware ..value	$276,070	$401,482	$498,900	$437,537
Yellow and Rockingham ware...value	....	(*b*)	(*b*)	(*b*)
C. C. and white granite ware.....value	....	(*b*)	(*b*)	(*b*)
Miscellaneous *c* ..do	$74,285	$95,000	$127,227	$262,821
Total value	$7,619,884	$5,938,247	$5,498,574	$6,705,393
Number of operating firms reporting	....	566	570	616
Rank of State	3	4	5	4

a Including enameled brick.
b Included in miscellaneous.
c Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

INDIANA.

Clay products of Indiana from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	319,751,000	262,936,000	224,042,000	277,136,000
Value	$1,488,370	$1,207,247	$1,012,547	$1,359,596
Average per M	$4.65	$4.59	$4.52	$4.91
Pressed—				
Quantity	17,085,000	9,071,000	8,394,000	9,883,000
Value	$161,336	$99,954	$94,935	$101,935
Average per M	$9.44	$11.01	$11.31	$10.31
Vitrified—				
Quantity	22,313,000	18,792,000	27,239,000	28,216,000
Value	$204,000	$175,670	$266,638	$264,796
Average per M	$9.14	$9.35	$9.78	$9.38
Fancy or ornamental........value	$13,439	$36,050	(*a*)	$9,437
Fire brick....do	$12,510	$28,350	$24,245	$29,766
Drain tile........do	$820,602	$475,919	$559,524	$622,198
Sewer pipe.......do	$42,000	$125,839	$156,450	$134,980
Ornamental terra cotta, value	(*a*)	(*a*)	(*a*)	$43,100
Fireproofing ....value	(*a*)	$136,461	$121,835	$74,629
Tile, not drain ...do	$139,463	$175,390	$223,750	$247,990
Pottery:				
Earthenware and stoneware.value	$111,900	$51,345	$29,725	$42,742
Yellow and Rockingham ware.value	....	....	(*a*)	....
C. C. and white granite ware, value	....	(*a*)	(*a*)	(*a*)
Sanitary ware.do	....	(*a*)	(*a*)	(*a*)
Porcelain or china, value	....	(*a*)	....	....
Miscellaneous *b*. value	$123,990	$162,100	$222,660	$280,343
Total value	$3,117,520	$2,674,325	$2,712,309	$3,211,512
Number of operating firms reporting	....	556	580	592
Rank of State	6	7	6	6

a Included in miscellaneous.
b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

IOWA.

Clay products of Iowa from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	180, 664, 000	174, 195, 000	152, 446, 000	194, 060, 000
Value	$1, 095, 074	$1, 003, 624	$850, 834	$1, 164, 247
Average per M	$6.06	$5.76	$5.58	$6.00
Pressed—				
Quantity	11, 159, 000	6, 088, 000	7, 823, 000	6, 722, 000
Value	$87, 130	$47, 386	$57, 230	$54, 752
Average per M	$7.81	$7.78	$7.32	$8.15
Vitrified—				
Quantity	31, 704, 000	14, 385, 000	56, 315, 000	35, 357, 000
Value	$243, 928	$112, 985	$426, 056	$289, 963
Average per M	$7.69	$7.85	$7.57	$8.20
Fancy or ornamental........value	$2, 300	....	$2, 800	$993
Fire brick ...do	$5, 920	$5, 198	$8, 700	$5, 525
Draintile ....do	$290, 515	$225, 650	$372, 070	$343, 265
Sewer pipe........do	$55, 131	$73, 039	$44, 300	$33, 000
Ornamental terra cotta, value	$2, 800	(a)	$500	(a)
Fireproofing ....value	(a)	$7, 685	$7, 540	$2, 161
Tile, not drain...do	$16, 094	(a)	$6, 700	$429
Pottery:				
Earthenware and stoneware.value	$28, 100	$42, 710	$38, 641	$30, 925
Yellow and Rockingham ware.value	....	(a)	(a)	....
Sanitary ware.do	....	(a)	(a)	(a)
Porcelain and electrical supplies, value	....	(a)	....	....
Miscellaneous *b*..value	$43, 300	$176, 125	$5, 876	$225, 112
Total value	$1, 870, 292	$1, 694, 402	$1, 821, 247	$2, 150, 822
Number of operating firms reporting	....	339	330	357
Rank of State	9	9	9	8

a Included in miscellaneous.

b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

KENTUCKY.

Clay products of Kentucky from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	86, 521, 000	63, 675, 000	71, 642, 000	84, 540, 000
Value	$455, 927	$317, 749	$355, 313	$422, 458
Average per M	$5. 27	$4. 99	$4. 96	$5. 00
Pressed—				
Quantity	1, 800, 000	1, 475, 000	2, 349, 000	3, 659, 000
Value	$14, 240	$15, 550	$19, 390	$27, 004
Average per M	$7. 91	$10. 54	$8. 25	$7. 38
Vitrified—				
Quantity	3, 850, 000	(*a*)	(*a*)	(*a*)
Value	$33, 150	(*a*)	(*a*)	(*a*)
Average per M	$8. 61	$10. 00	$9. 00	$9. 00
Fancy brick..value	(*a*)	....	....	....
Fire brick ....do	$126, 539	$168, 210	$157, 499	$202, 077
Draintile ....do	$17, 322	$24, 025	$28, 065	$19, 533
Sewer pipe.........do	(*a*)	(*a*)	(*a*)	(*a*)
Fireproofing ....do	....	$7, 400	(*a*)	....
Tile, not drain ....do	(*a*)	(*a*)	(*a*)	(*a*)
Pottery:				
Earthenware and stoneware .value	$33, 120	$85, 750	$119, 930	$89, 686
Yellow and Rockingham ware, value	....	(*a*)	(*a*)	....
Miscellaneous *b*	$158, 900	$211, 000	$126, 171	$227, 632
Total value	$839, 198	$829, 684	$806, 368	$988, 390
Number of operating firms reporting	....	80	82	88
Rank of State	19	18	17	18

a Included in miscellaneous.

b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

MAINE.

Clay products of Maine from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	72,594,000	68,604,000	53,133,000	57,656,000
Value	$403,217	$375,353	$273,929	$309,488
Average per M	$5.55	$5.47	$5.16	$5.37
Pressed—				
Quantity	1,370,000	1,695,000	1,280,000	890,000
Value	$13,520	$15,650	$11,200	$10,600
Average per M	$9.86	$9.23	$8.75	$11.91
Vitrified—				
Quantity	....	(*a*)	(*a*)	(*a*)
Value	....	(*a*)	(*a*)	(*a*)
Average per M	....	$17.00	$13.55	$25.00
Fancy brick.value	$4,400	$2,450	....	....
Fire brick.....do	(*a*)	(*a*)	(*a*)	(*a*)
Draintile ....do	$5,168	$4,738	(*a*)	(*a*)
Sewer pipe........do	(*a*)	(*a*)	(*a*)	(*a*)
Ornamental terra cotta, value	(*a*)	(*a*)	....	....
Fireproofing ......do	....	(*a*)	....	....
Pottery:				
Earthenware and stoneware.value	....	$250	(*c*)	(*c*)
Miscellaneous *b*	$310,799	$596,290	$515,610	$268,213
Total value	$737,104	$994,731	$800,739	$588,301
Number of operating firms reporting	....	72	64	75
Rank of State	21	13	18	21

a Included in miscellaneous.
b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.
c Included with New Hampshire.

MARYLAND.

Clay products of Maryland from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	117,016,000	144,519,000	116,841,000	120,588,000
Value	$743,023	$987,706	$702,957	$714,674
Average per M	$6.35	$6.83	$6.02	$5.93
Pressed—				
Quantity	2,555,000	4,572,000	5,316,000	5,868,000
Value	$35,229	$97,426	$92,344	$87,304
Average per M	$13.78	$21.35	$17.37	$14.88
Vitrified—				
Quantity	(*a*)	186,000	150,000	50,000
Value	(*a*)	$2,382	$1,200	$600
Average per M	....	$12.80	$8.00	$12.00
Fancy brick.value	(*a*)	*b* $37,300	*b* $35,100	$3,669
Fire brick.....do	$232,270	$150,655	$141,650	$77,672
Draintile..........do	$3,079	$1,945	$25,524	$1,649
Ornamental terra cotta, value	(*a*)	$5,075	$6,000	(*a*)
Tile, not drain...value	(*a*)	$27,003	$18,470	(*a*)
Pottery:				
Earthenware and stoneware.value	....	$27,696	*d* $127,277	*d* $8,854
Yellow and Rockingham ware.value	....	....	$7,740	(*a*)
C.C. and white granite ware...value	....	....	....	(*a*)
Porcelain or china, value	....	....	$100,000	....
Miscellaneous *c*	$53,386	$112,867	$47,020	$359,003
Total value	$1,066,987	$1,450,055	$1,305,282	$1,253,425
Number of operating firms reporting	....	96	98	69
Rank of State	13	10	11	10

a Included in miscellaneous.
b Including enameled brick.
c Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.
d Including District of Columbia.

MASSACHUSETTS.

Clay products of Massachusetts from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	245,423,000	274,956,000	257,539,000	192,117,000
Value	$1,443,677	$1,601,537	$1,457,683	$1,057,806
Average per M	$5.88	$5.82	$5.66	$5.51
Pressed—				
Quantity	8,509,000	4,240,000	6,946,000	5,383,000
Value	$200,234	$109,780	$126,420	$118,170
Average per M	$23.53	$25.89	$18.20	$21.95
Vitrified—				
Quantity	(*a*)	....	....	(*a*)
Value	(*a*)	....	....	(*a*)
Average per M	$8.00	....	....	$9.00
Fancy brick.value	$91,675	(*a*)	(*a*)	(*a*)
Fire brick....do	$187,710	$131,950	$184,665	$175,180
Draintile ....do	....	....	(*a*)	....
Sewer pipe.......do	....	....	....	(*a*)
Ornamental terra cotta, value	(*a*)	(*a*)	(*a*)	$29,730
Fireproofing ....value	(*a*)	(*a*)	(*a*)	(*a*)
Tile, not drain.....do	(*a*)	(*a*)	(*a*)	$19,594
Pottery:				
Earthenware and stoneware.value	$137,026	$159,193	$186,515	$182,824
C.C. and white granite ware..value	(*a*)	(*a*)	(*a*)	(*a*)
Porcelain or china, value	....	....	(*a*)	....
Porcelain electrical supplies ..value	....	(*a*)	(*a*)	....
Miscellaneous *b* ....do	$30,900	$262,514	$224,113	$193,466
Total value	$2,221,590	$2,264,974	$2,179,396	$1,776,770
Number of operating firms reporting	....	99	109	104
Rank of State	8	8	8	9

a Included in miscellaneous.

b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

MICHIGAN.

Clay products of Michigan from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	168, 574, 000	110, 523, 000	120, 377, 000	158, 741, 000
Value	$767, 203	$590, 095	$546, 638	$748, 339
Average per M	$4. 55	$5. 34	$4. 54	$4. 71
Pressed—				
Quantity	6, 530, 000	2, 157, 000	1, 990, 000	2, 335, 000
Value	$47, 719	$13, 827	$10, 515	$15, 500
Average per M	$7. 31	$6. 41	$5. 28	$6. 64
Vitrified—				
Quantity	1, 300, 000	(*a*)	1, 905, 000	3, 198, 000
Value	$12, 755	(*a*)	$22, 332	$34, 395
Average per M	$9. 81	$11. 16	$11. 72	$10. 76
Fancy brick. value	$5, 850	$4, 600	(*a*)	$4, 500
Fire brick ... do	$3, 575	(*a*)	(*a*)	(*a*)
Draintile ... do	$200, 893	$225, 293	$165, 564	$146, 816
Sewer pipe ... do	$76, 000	$105, 140	$20, 361	$45, 567
Ornamental terra cotta, value	...	(*a*)	...	...
Fireproofing .... value	...	$2, 450	$2, 200	$2, 800
Tile, not drain ... do	$2, 900	(*a*)	(*a*)	...
Pottery:				
Earthenware and stoneware. value	(*a*)	$20, 150	$22, 300	$17, 900
Miscellaneous *b* .. do	$12, 300	$43, 850	$1, 960	$2, 495
Total value	$1, 129, 195	$1, 005, 405	$791, 870	$1, 018, 312
Number of operating firms reporting	...	156	149	172
Rank of State	11	12	19	14

a Included in miscellaneous.

b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

MINNESOTA.

Clay products of Minnesota from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	127, 244, 000	87, 844, 000	79, 474, 000	125, 473, 000
Value	$578, 345	$398, 872	$366, 734	$611, 357
Average per M	$4. 55	$4. 54	$4. 61	$4. 87
Pressed—				
Quantity	5, 061, 000	2, 839, 000	2, 965, 000	2, 250, 000
Value	$30, 635	$21, 368	$31, 750	$22, 370
Average per M	$6. 05	$7. 52	$10. 71	$9. 94
Vitrified—				
Quantity	....	(*a*)	(*a*)	(*a*)
Value	....	(*a*)	(*a*)	(*a*)
Average per M	....	$25. 00	$11. 13	$20. 00
Fancy brick . value	(*a*)	(*a*)	(*a*)	(*a*)
Fire brick ... do	(*a*)	$1, 375	$5, 550	(*a*)
Draintile .... do	$2, 775	$5, 240	$3, 810	$5, 170
Sewer pipe .... do	(*a*)	(*a*)	(*a*)	(*a*)
Ornamental terra cotta, value	....	....	(*a*)	(*a*)
Fireproofing ..... do	(*a*)	(*a*)	(*a*)	$16, 800
Tile, not drain ... do	(*a*)	(*a*)	(*a*)	(*a*)
Pottery:				
Earthenware and stoneware . value	$259, 515	$141, 436	*c* $314, 675	*c* $303, 215
Miscellaneous *b* .. do	$228, 865	$128, 410	$159, 550	$158, 919
Total value	$1, 100, 135	$696, 701	$882, 069	$1, 117, 831
Number of operating firms reporting	....	88	87	112
Rank of State	12	20	15	11

a Included in miscellaneous.
b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.
c Including Wisconsin.

MISSOURI.

Clay products of Missouri from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	234, 201, 000	263, 037, 000	221, 102, 000	219, 679, 000
Value	$1, 251, 200	$1, 317, 916	$999, 352	$1, 046, 669
Average per M	$5. 34	$5. 00	$4. 52	$4. 76
Pressed—				
Quantity	29, 674, 000	31, 260, 000	21, 537, 000	22, 447, 000
Value	$275, 725	$293, 193	$224, 016	$258, 786
Average per M	$9. 29	$9. 37	$10. 40	$11. 53
Vitrified—				
Quantity	6, 816, 000	(*a*)	19, 620, 000	28, 036, 000
Value	$54, 640	(*a*)	$182, 625	$264, 092
Average per M	$8. 01	$8. 20	$9. 31	$9. 42
Fancy ...... value	(*a*)	*b* $136, 964	*b* $86, 723	$65, 581
Fire brick .... do	$484, 415	$328, 148	$157, 502	$268, 173
Drain tile .... do	$15, 820	$23, 383	$25, 800	$85, 748
Sewer pipe .... do	(*a*)	(*a*)	$458, 368	$403, 075
Ornamental terra cotta, value	(*a*)	(*a*)	(*a*)	$168, 000
Fireproofing .... value	(*a*)	$44, 956	$14, 404	$92, 272
Tile, not drain ... do	(*a*)	(*a*)	(*a*)	$30, 673
Pottery:				
Earthenware and stoneware. value	(*a*)	$50, 933	$52, 459	$53, 258
Miscellaneous *c* ... do	$807, 418	$614, 752	$335, 279	$318, 879
Total value	$2, 889, 218	$2, 810, 245	$2, 536, 528	$3, 055, 206
Number of operating firms reporting	....	206	203	227
Rank of State	7	6	7	7

a Included in miscellaneous.
b Including enameled brick.
c Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

NEW JERSEY.

Clay products of New Jersey from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	248,831,000	237,781,000	263,641,000	269,654,000
Value	$1,097,063	$950,113	$1,188,191	$1,315,922
Average per M	$4.40	$3.99	$4.51	$4.88
Pressed—				
Quantity	18,417,000	15,655,000	30,022,000	30,876,000
Value	$387,737	$340,919	$670,282	$568,106
Average per M	$21.05	$21.77	$22.33	$18.40
Vitrified—				
Quantity	(*a*)	(*a*)	550,000	(*a*)
Value	(*a*)	(*a*)	$7,300	(*a*)
Average per M	$12.00	$13.82	$13.27	$14.00
Fancy brick . value	$179,828	*b* $188,819	*b* $170,721	$15,852
Fire brick ... do	$456,825	$604,983	$277,670	$519,688
Drain tile ... do	$14,024	$37,850	$11,225	$13,462
Sewer pipe ... do	$101,316	$16,205	$31,973	$34,808
Ornamental terra cotta, value	$763,420	$618,502	$539,512	$635,007
Fireproofing ... value	$285,165	$721,694	$987,637	$762,370
Tile, not drain ... do	$850,014	$143,292	$191,735	$292,644
Pottery:				
Earthenware and stoneware . value	$162,946	$216,216	$414,960	$23,100
Yellow and Rockingham ware, value	....	(*a*)	(*a*)	(*a*)
C. C. ware .. value } White granite ware, value }	(*a*)	$358,175	$460,608	$733,958 $483,917
Semivitreous porcelain ware . value	....	....	....	$439,356
Porcelain or China, value	(*a*)	(*a*)	$49,800	(*a*)
Sanitary ware, value	(*a*)	$376,151	$1,036,445	$1,477,192
Bone China, Delft, and Belleek ware, value	....	....	....	$52,500
Porcelain electrical supplies .. value	....	$109,000	$14,200	$182,000
Miscellaneous *c*	$600,782	$46,084	$128,588	$1,049,485
Total value	$4,899,120	$4,728,003	$6,180,847	$8,599,367
Number of operating firms reporting	....	103	124	133
Rank of State	5	5	3	3

a Included in miscellaneous.

b Including enameled brick.

c Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

NEW YORK.

Clay products of New York from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	955,442,000	931,565,000	828,868,000	900,977,000
Value	$4,396,027	$4,141,973	$3,657,750	$4,381,257
Average per M	$4.60	$4.45	$4.41	$4.86
Pressed—				
Quantity	18,437,000	18,409,000	18,046,000	19,017,000
Value	$290,910	$298,515	$263,166	$260,135
Average per M	$15.78	$16.22	$14.58	$13.68
Vitrified—				
Quantity	10,896,000	23,723,000	28,145,000	27,532,000
Value	$121,892	$259,550	$309,564	$302,680
Average per M	$11.19	$10.94	$11.00	$10.99
Fancy brick.value	(*a*)	$17,854	$2,680	$8,665
Fire brick....do	$302,407	$345,485	$339,740	$386,624
Drain tile........do	$56,740	$292,954	$25,385	$74,072
Sewer pipe.......do	(*a*)	$85,289	$116,000	$89,224
Ornamental terra cotta, value	$336,000	$484,113	$420,601	$367,854
Fireproofing ....value	....	$72,410	$56,410	$87,152
Tile (not drain)..do	$143,465	$99,060	$150,360	$83,910
Pottery:				
Earthenware and stoneware.value	$44,033	$100,733	$179,265	$106,343
Yellow and Rockingham ware.value	....	....	....	(*a*)
C. C. and white granite ware, value	....	(*a*)	....	(*a*)
Sanitary ware, value	....	(*a*)	(*a*)	$38,213
Porcelain or china, value	....	(*a*)	(*a*)	....
Porcelain electrical supplies ..value	....	(*a*)	....	(*a*)
Miscellaneous *b* ..do	$198,022	$216,270	$94,583	$262,860
Total value	$5,889,496	$6,414,206	$5,615,504	$6,448,989
Number of operating firms reporting	....	262	231	264
Rank of State	4	3	4	5

a Included in miscellaneous.

b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

OHIO.

Clay products of Ohio from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity.......	381,065,000	314,005,000	290,522,000	340,535,000
Value..........	$1,887,023	$1,516,088	$1,358,333	$1,701,719
Average per M..	$4.95	$4.83	$4.68	$5.00
Pressed—				
Quantity.......	44,396,000	29,890,000	36,229,000	27,661,000
Value..........	$518,717	$337,567	$357,613	$289,519
Average per M..	$11.68	$11.29	$9.87	$10.47
Vitrified—				
Quantity.......	96,555,000	72,254,000	85,665,000	115,104,000
Value..........	$787,878	$619,463	$597,905	$796,935
Average per M..	$8.16	$8.57	$6.98	$6.92
Fancy brick.value..	$57,767	*a* $62,982	*a* $104,426	$23,070
Fire brick....do....	$696,175	$575,748	$510,878	$528,278
Drain tile.........do....	$884,638	$569,871	$737,754	$800,003
Sewer pipe........do....	$1,746,503	$2,058,210	$1,495,974	$1,264,756
Ornamental terra cotta, value................	$49,678	$63,100	$37,159	$7,384
Fireproofing ....value..	$59,600	$279,264	$314,800	$343,770
Tile, not drain...do....	$797,985	$805,198	$563,353	$661,921
Pottery:				
Earthenware and stoneware.value..	$1,003,955	$1,169,788	$1,709,884	$649,717
Yellow and Rockingham ware.value..	$476,768	$260,892	$271,453	$187,649
C. C. ware ..do....				$663,530
White granite ware, value............	$1,142,549 (C. C. ware and white granite ware)	$1,612,380 (C. C. ware and white granite ware)	$1,644,246 (C. C. ware and white granite ware)	$2,224,264
Semivitreous porcelain ware.value	....	....	....	$1,337,495
Porcelain or china, value............	(*b*)	$377,130	$912,434	$218,000
Sanitary ware, value............	(*b*)	$139,160	$24,552	(*b*)
Porcelain electrical supplies ..value..	(*b*)	....	$157,700	$178,919
Miscellaneous *c* ..do....	$540,146	$162,730	$269,220	$535,508
Total value	$10,649,382	$10,609,571	$11,067,684	$12,412,437
Number of operating firms reporting	....	814	843	866
Rank of State..........	1	1	1	1

a Including enameled brick.
b Included in miscellaneous.
c Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

PENNSYLVANIA.

Clay products of Pennsylvania from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	612,492,000	675,444,000	558,084,000	613,462,000
Value	$3,570,536	$4,118,206	$3,178,190	$3,424,154
Average per M	$5.82	$6.10	$5.69	$5.58
Pressed—				
Quantity	56,810,000	47,213,000	73,627,000	56,115,000
Value	$1,018,682	$662,188	$873,057	$671,671
Average per M	$17.93	$14.03	$11.86	$11.97
Vitrified—				
Quantity	36,268,000	47,229,000	41,620,000	59,014,000
Value	$305,035	$404,182	$336,413	$513,391
Average per M	$8.41	$8.57	$8.08	$8.70
Fancy brick . value	$48,032	$30,545	$61,830	$76,043
Fire brick ... do	$2,250,790	$2,083,414	$1,707,621	$2,846,331
Draintile ... do	$13,320	$49,039	$14,164	$11,461
Sewer pipe ... do	$360,475	$323,239	$283,451	$224,385
Ornamental terra cotta, value	$263,000	$142,200	$157,000	$147,000
Fireproofing ... value	(*a*)	$104,401	$92,880	$98,717
Tile, not drain ... do	$95,529	$122,707	$110,620	$136,706
Pottery:				
Earthenware and stoneware . value	$280,630	$367,201	$426,949	$378,210
Yellow and Rockingham ware . value	....	(*a*)	(*a*)	(*a*)
C. C. and white granite ware, value	$455,000	(*a*)	$276,350	(*a*)
Porcelain or china, value	....	(*a*)	....	....
Sanitary ware, value	....	....	....	(*a*)
Miscellaneous*b* .. value	$146,132	$656,507	$356,170	$1,114,029
Total value	$8,807,161	$9,063,829	$7,874,695	$9,642,098
Number of operating firms reporting	....	457	435	473
Rank of State	2	2	2	2

a Included in miscellaneous.

b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

TENNESSEE.

Clay products of Tennessee from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	69, 034, 000	65, 548, 000	81, 241, 000	70, 295, 000
Value	$355, 420	$364, 463	$406, 236	$369, 944
Average per M	$5. 14	$5. 56	$5. 00	$5. 26
Pressed—				
Quantity	2, 633, 000	7, 881, 000	5, 154, 000	2, 928, 000
Value	$25, 352	$66, 865	$41, 351	$25, 014
Average per M	$9. 62	$8. 48	$8. 02	$8. 54
Vitrified—				
Quantity	....	7, 503, 000	(*a*)	3, 521, 000
Value	....	$54, 030	(*a*)	$25, 049
Average per M	....	$7. 20	$6. 25	$7. 11
Fancy brick . value	(*a*)	(*a*)	$4, 026	$4, 774
Fire brick ... do	$24, 956	$4, 372	$35, 497	$30, 547
Draintile ... do	(*a*)	$8, 575	(*a*)	$13, 896
Sewer pipe ... do	(*a*)	(*a*)	(*a*)	(*a*)
Ornamental terra cotta, value	(*a*)	....	....	....
Fireproofing .... value	....	....	(*a*)	(*a*)
Tile, not drain ... do	....	(*a*)	....	....
Pottery:				
Earthenware and stoneware . value	$24, 300	$37, 661	$40, 120	$39, 314
Porcelain or china, value	....	....	(*a*)	....
Miscellaneous *b* .. value	$92, 506	$1, 359	$85, 063	$5, 200
Total value	$522, 534	$537, 325	$612, 293	$513, 738
Number of operating firms reporting	....	82	90	88
Rank of State	24	23	22	22

a Included in miscellaneous.

b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

TEXAS.

Clay products of Texas from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	138,465,000	113,027,000	120,152,000	100,844,000
Value	$805,772	$665,091	$706,312	$587,116
Average per M	$5.81	$5.88	$5.88	$5.82
Pressed—				
Quantity	16,143,000	12,891,000	6,319,000	746,000
Value	$103,255	$142,500	$71,655	$8,974
Average per M	$6.39	$11.05	$11.94	$12.03
Vitrified—				
Quantity	1,492,000	(*a*)	3,635,000	(*a*)
Value	$12,466	(*a*)	$32,475	(*a*)
Average per M	$8.36	$6.57	$8.93	$9.33
Fancy brick.value	$1,024	$3,150	$1,060	$1,463
Fire brick....do	$7,060	$8,315	$23,235	$5,435
Draintile ....do	....	(*a*)	$4,180	$2,600
Sewer pipe.......do	(*a*)	$21,626	$48,115	$26,150
Ornamental terra cotta, value	(*a*)	....	(*a*)	....
Fireproofing ....value	(*a*)	....	(*a*)	(*a*)
Tile, not drain ...do	(*a*)	(*a*)	....	(*a*)
Pottery:				
Earthenware and stoneware.value	$46,600	$58,081	$62,210	$55,342
Miscellaneous *b* ..do	$54,260	$16,990	$247,797	$71,131
Total value	$1,030,446	$915,753	$1,197,039	$758,211
Number of operating firms reporting	....	125	149	145
Rank of State	14	14	12	19

a Included in miscellaneous.

b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

VIRGINIA.

Clay products of Virginia from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	96,407,000	101,311,000	94,782,000	98,549,000
Value	$560,316	$604,161	$574,269	$586,170
Average per M	$5.81	$5.96	$6.06	$5.95
Pressed—				
Quantity	11,176,000	12,317,000	11,037,000	14,700,000
Value	$204,078	$199,056	$153,422	$225,652
Average per M	$18.25	$16.16	$13.90	$15.35
Vitrified—				
Quantity	(*a*)	(*a*)	(*a*)	(*a*)
Value	(*a*)	(*a*)	(*a*)	(*a*)
Average per M	$10.00	$10.00	$10.00	$10.00
Fancy brick . value	$36,919	$24,283	$29,000	$21,591
Fire brick . . . do	(*a*)	$2,678	$2,755	$4,476
Draintile . . . do	$4,980	$2,918	$1,800	$7,830
Sewer pipe . . . do	(*a*)	....	....	(*a*)
Ornamental terra cotta, value	....	....	(*a*)	....
Tile, not drain . value	(*a*)	....	(*a*)	....
Pottery:				
Earthenware and stoneware . value	$6,025	$10,440	$7,200	$6,400
Miscellaneous *b* . . do	$43,450	$40,000	$43,600	$37,764
Total value	$855,768	$883,536	$812,046	$889,883
Number of operating firms reporting	....	86	75	92
Rank of State	18	17	16	16

a Included in miscellaneous.

b Includes all products not otherwise classified and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

WEST VIRGINIA.

Clay products of West Virginia from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	35,815,000	29,462,000	30,594,000	28,516,000
Value	$208,337	$164,831	$164,177	$157,425
Average per M	$5.82	$5.59	$5.37	$5.52
Pressed—				
Quantity	1,845,000	972,000	2,033,000	1,690,000
Value	$18,400	$11,370	$19,246	$12,690
Average per M	$9.97	$11.70	$9.47	$7.51
Vitrified—				
Quantity	62,330,000	21,485,000	38,271,000	33,416,000
Value	$449,388	$177,856	$289,886	$290,266
Average per M	$7.21	$8.28	$7.57	$8.69
Fancy brick . value	$4,262	$32,237	$9,500	(*a*)
Fire brick . . . do	(*a*)	(*a*)	$28,696	$5,155
Draintile . . . do	(*a*)	$22,972	(*a*)	$1,310
Sewer pipe . . . do	$196,000	(*a*)	(*a*)	(*a*)
Ornamental terra cotta, value	(*a*)	....	(*a*)	....
Fireproofing . . . value	....	....	....	(*a*)
Tile, not drain . . . do	....	....	(*a*)	(*a*)
Pottery:				
Earthenware and stoneware . value	(*a*)	$130,000	$169,520	(*a*)
C. C. and white granite ware . . . value	....	(*a*)	(*a*)	(*a*)
Semivitreous porcelain ware . value	....	....	....	(*a*)
Sanitary ware . do	....	(*a*)	(*a*)	(*a*)
Porcelain or china, value	....	(*a*)	(*a*)	....
Miscellaneous *b* . value	$19,390	$360,178	$434,229	$560,729
Total value	$895,777	$899,444	$1,115,254	$1,027,575
Number of operating firms reporting	....	39	49	45
Rank of State	17	16	13	13

a Included in miscellaneous.
b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.

WISCONSIN.

Clay products of Wisconsin from 1895 to 1898.

	1895.	1896.	1897.	1898.
Brick:				
Common—				
Quantity	141,018,000	116,001,000	134,025,000	119,492,000
Value	$782,552	$662,617	$640,592	$645,209
Average per M	$5.54	$5.71	$4.78	$5.40
Pressed—				
Quantity	12,530,000	5,404,000	6,243,000	8,237,000
Value	$123,505	$48,671	$48,670	$61,596
Average per M	$9.85	$9.00	$7.80	$7.48
Vitrified—				
Quantity	....	....	....	(*a*)
Value	....	....	....	(*a*)
Average per M	....	....	....	$10.00
Fancy brick..value	$3,425	$15,710	(*a*)	(*a*)
Fire brick ....do	(*a*)	....	(*a*)	....
Draintile ....do	$32,314	$27,797	$27,750	$19,757
Sewer pipe ....do	....	(*a*)	....	....
Tile (not drain)...do	....	(*a*)	....	(*a*)
Pottery:				
Earthenware and stoneware..value	....	(*a*)	(*c*)	(*c*)
Miscellaneous *b*	$2,400	$34,200	$7,270	$5,144
Total	$944,196	$788,995	$724,282	$731,706
Number of operating firms reporting	....	130	127	145
Rank of State	16	19	20	20

a Included in miscellaneous.
b Includes all products not otherwise classified, and those made by less than three producers, in order that the operations of individual establishments may not be disclosed.
c Included with Minnesota.

IMPORTS.

In the following tables will be found a statement of the clay and manufactured goods imported into the United States in recent years:

Classified imports of clay from 1885 to 1898.

Calendar year—	Kaolin or china clay.		All other clays.						Totals.	
			Unwrought.		Wrought.		Common blue.			
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Long tons.		*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
1885......	10,626	$83,722	9,736	$76,899	3,554	$29,839	....	....	23,916	$190,460
1886......	16,590	123,093	13,740	113,875	1,654	20,730	....	....	31,984	257,698
1887......	23,486	141,360	17,645	139,405	2,187	22,287	....	....	43,318	303,052
1888......	18,150	102,050	20,604	152,694	6,832	53,245	....	....	45,586	307,989
1889......	19,843	113,538	19,237	145,983	8,142	64,971	....	....	47,222	324,492
1890......	29,923	270,141	21,049	155,486	2,978	29,143	....	....	53,950	454,770
1891......	39,901	294,458	16,094	118,689	6,297	56,482	....	....	62,292	469,629
1892......	49,468	375,175	20,132	155,047	4,551	64,818	5,172	$59,971	79,323	655,011
1893......	49,713	374,460	14,949	113,029	6,090	67,280	4,304	51,889	75,056	606,658
1894......	62,715	465,501	13,146	98,776	4,768	60,786	2,528	28,886	83,157	653,949
1895......	75,447	531,714	18,419	125,417	5,160	60,775	3,869	40,578	102,895	758,484
1896......	76,718	536,081	13,319	88,029	4,514	56,701	4,983	54,695	99,534	735,506
1897......	71,938	493,431	9,405	56,264	7,839	52,232	4,562	50,954	93,744	652,881
1898......	85,586	573,595	16,130	98,434	1,412	24,959	5,312	58,280	108,440	755,268

Value of earthenware, China, brick, and tile imported and entered for consumption in the United States, 1867 to 1898, inclusive.

Year ending—	Brown earthen and common stoneware.	China and porcelain, not decorated.	China and decorated porcelain.	Other earthen, stone, or crockery ware, glazed, etc.	Brick, fire brick, and tile.	Total.
June 30—						
1867	$48,618	$418,493	$439,824	$4,280,924	....	$5,187,859
1868	47,208	309,960	403,555	3,244,958	....	4,005,712
1869	34,260	400,894	555,425	3,468,970	....	4,459,549
1870	47,457	420,442	530,805	3,461,524	....	4,460,228
1871	96,695	391,374	571,032	3,573,254	....	4,632,355
1872	127,346	470,749	814,134	3,896,664	....	5,308,893
1873	115,253	479,617	867,206	4,289,868	....	5,751,944
1874	70,544	397,730	676,656	3,686,794	....	4,831,724
1875	68,501	436,883	654,965	3,280,867	....	4,441,216
1876	36,744	409,539	718,156	2,948,517	....	4,112,956
1877	30,403	326,956	668,514	2,746,186	....	3,772,059
1878	18,714	389,133	657,485	3,031,393	....	3,996,725
1879	19,868	296,591	813,850	2,914,567	....	4,044,876
1880	31,504	234,371	1,188,847	3,945,666	....	5,500,388
1881	27,586	321,259	1,621,112	4,413,369	....	6,383,326
1882	36,023	316,811	2,075,708	4,438,237	....	6,866,779
1883	43,864	368,943	2,587,545	5,685,709	....	6,686,061
1884	50,172	982,499	2,664,231	(*a*)	$666,595	4,363,497
1885	44,701	823,334	2,834,718	....	963,422	4,666,175
December 31—						
1886	37,820	865,446	3,350,145	....	951,293	5,204,704
1887	43,079	967,694	3,888,509	....	1,008,360	5,907,642
1888	55,558	1,054,854	4,207,598	....	886,314	6,204,324
1889	48,824	1,148,026	4,580,321	....	788,391	6,565,562
1890	56,730	974,627	3,562,851	....	563,568	5,157,776
1891	99,983	1,921,643	6,288,088	....	353,736	8,663,450
1892	63,003	2,022,814	6,555,172	....	380,520	9,021,509
1893	57,017	1,732,481	6,248,255	....	338,143	8,375,896
1894	47,114	1,550,950	5,392,648	....	189,631	7,180,343
1895	61,424	2,117,425	8,055,473	....	211,473	10,445,795
1896	41,585	1,511,542	7,729,942	....	247,455	9,530,524
1897	*b* 32,227	1,406,019	7,057,261	....	146,668	8,642,175
1898	*b* 54,672	1,002,729	5,905,209	....	117,324	7,079,934

a Not separately classified after 1883.

b Including Rockingham ware.

CEMENT.

PORTLAND CEMENT.

By SPENCER B. NEWBERRY.

PRODUCTION.

The production of Portland cement in the United States in 1898 was 3,692,284 barrels, an increase of 1,014,509 barrels, or 37.9 per cent over the product of 1897. Since 1896 the annual increase of production has been more than 1,000,000 barrels, and there is good reason to believe that this rate of increase will be greatly exceeded in the near future. The growth of the industry continues to be most marked in the neighborhood of Lehigh County, Pennsylvania.

The following table shows the product of Portland cement in the United States in 1897 and 1898, by States:

Product of Portland cement in the United States in 1897 and 1898.

State.	1897.			1898.		
	Number of works.	Product.	Value, not including packages.	Number of works.	Product.	Value, not including packages.
		Barrels.			*Barrels.*	
Arkansas	1	15,000	$26,250			
California	1	15,000	30,000	1	50,000	$100,000
South Dakota	1	39,890	79,780	1	31,000	62,000
Illinois	1	15,000	26,250			
Indiana	1	2,823	2,117	1	2,500	4,375
Maryland				1	10,000	17,500
Michigan	2	15,000	26,250	2	77,000	134,750
New York	7	394,398	690,197	7	554,358	970,126
New Jersey	2	430,335	753,086	2	587,163	1,027,535
Ohio	4	146,452	256,291	6	265,872	465,276
Pennsylvania	7	1,579,724	2,369,586	8	2,095,141	3,142,711
Texas	1	7,778	23,334	1	8,000	24,000
Utah	1	16,375	32,750	1	11,250	22,500
Total	29	2,677,775	4,315,891	31	3,692,284	5,970,773

This table shows that two small factories, in Arkansas and Illinois, respectively, were not in operation in 1898, while the production of Portland cement was begun at one factory in Maryland. New York, New Jersey, Ohio, and Pennsylvania show striking increases, and a considerable gain is also to be noted in Michigan. In other sections the industry is still insignificant.

The relative extent of development of the Portland cement industry in the United States since 1890 is shown in the following table:

Table showing development of Portland cement industry in the United States since 1890.

Section.	1890.			1894.		
	Number of works.	Product.	Per cent.	Number of works.	Product.	Per cent.
		Barrels.			*Barrels.*	
New York	4	65,000	19.4	4	117,275	14.7
Lehigh County, Pa., and Phillipsburg, N. J.	5	201,000	60.0	7	485,329	60.8
Ohio	2	22,000	6.5	4	80,653	10.1
All other sections	5	47,500	14.1	9	115,500	14.4
Total	16	335,500	100.0	24	798,757	100.0

Section.	1897.			1898.		
	Number of works.	Product.	Per cent.	Number of works.	Product.	Per cent.
		Barrels.			*Barrels.*	
New York	7	394,398	14.7	7	554,358	15.0
Lehigh County, Pa., and Phillipsburg, N. J.	8	2,002,059	74.8	9	2,674,304	72.4
Ohio	4	146,452	5.5	6	265,872	7.2
All other sections	10	134,866	5.0	9	197,750	5.4
Total	29	2,677,775	100.0	31	3,692,284	100.0

It will be noted that the product of Lehigh County, Pennsylvania, and the neighboring region near Phillipsburg, New Jersey, has increased in eight years to more than ten times what it was in 1890. This section now produces nearly three-fourths of the total product of the country. New York and Ohio also show an increase nearly proportional to that which has taken place in the country as a whole. In other sections the development of the industry has been slow, and the percentage of the total product has greatly declined.

IMPORTS.

The imports of Portland cement in 1898 were 2,013,818 barrels, a decrease of 77,106 barrels from the quantity imported in 1897. This decrease is largely due to the greatly increased demand for cement in Germany and England during the past year, and the consequent indifference of foreign manufacturers toward the American market. Germany has at present 70 Portland cement factories, the product of which in 1898 was over 18,000,000 barrels. The exports were about 3,000,000 barrels, leaving 15,000,000 barrels as the quantity consumed in Germany. The consumption of Portland cement per capita was therefore more than six times that in the United States. In view of the far greater magnitude of the building and engineering operations carried on in this country there is good reason to believe that the consumption of Portland cement in the United States will eventually exceed that in Germany.

The following table shows the imports, by countries, in 1896, 1897, and 1898.

Imports of cement into the United States in 1896, 1897, and 1898, by countries.

[Barrels.]

Country.	1896.	1897.	1898.
United Kingdom	742, 169	344, 336	241, 198
Belgium	742, 237	529, 686	651, 204
France	26, 714	19, 319	17, 294
Germany	1, 366, 909	1, 109, 280	1, 032, 429
Other Europe	99, 184	46, 916	51, 582
British North America	11, 334	4, 907	4, 635
Other countries	1, 050	36, 480	15, 476
Total	2, 989, 597	2, 090, 924	2, 013, 818

This table shows that the chief decline in imports since 1896 has been in those from Great Britain. This is due to the growing preference for German cements over the English, and also to the increased demand for cement in Great Britain and the consequent falling off in exports from that country. Trade reports show that the demand for cement in all European countries was most active during the past year and that prices advanced in a marked degree.

The total exports from the chief producing countries in 1898 were as follows:

	Barrels.
United Kingdom	1,958,550
Germany	3,096,234
Belgium	2,495,370

RELATION OF DOMESTIC PRODUCTION TO IMPORTATION.

The total consumption of Portland cement in the United States in 1898 exceeded that in 1897 by nearly 1,000,000 barrels. During the latter part of the year a veritable cement famine prevailed, and many important engineering works were delayed or suspended for lack of cement. In consequence, the actual amount consumed was considerably less than that required by the country. The same condition appears to have existed throughout the world, and is due to the multitude of new applications which Portland cement is constantly finding and its rapidly increasing use in place of stone in constructions of all kinds. It is difficult to set a limit to the possible further growth of the demand for Portland cement, and it is not improbable that the next few years may see the industry, both here and abroad, reach a magnitude at present undreamed of.

Owing to the great increase in domestic production and the slightly decreased imports the proportion of domestic to imported cement consumed has advanced materially, as the following table shows:

Comparison of the domestic production of Portland cement with the imports.

[Barrels.]

	1891.	1896.	1897.	1898.
Production in the United States	454,813	1,543,023	2,677,775	3,692,284
Imports	2,988,313	2,989,597	2,090,924	2,013,818
Total	3,443,126	4,532,620	4,768,699	5,706,102
Exports	....	85,486	53,466	36,732
Total consumption	3,443,126	4,447,134	4,715,233	5,669,370
Percentage of total consumption produced in the United States	13.2	34.7	56.8	65.1

It will be noted that nearly two-thirds of the Portland cement consumed in this country in 1898 was of domestic manufacture.

The remarkable growth of the production and consumption of

Portland cement in the United States in the last nine years appears strikingly in the following diagram:

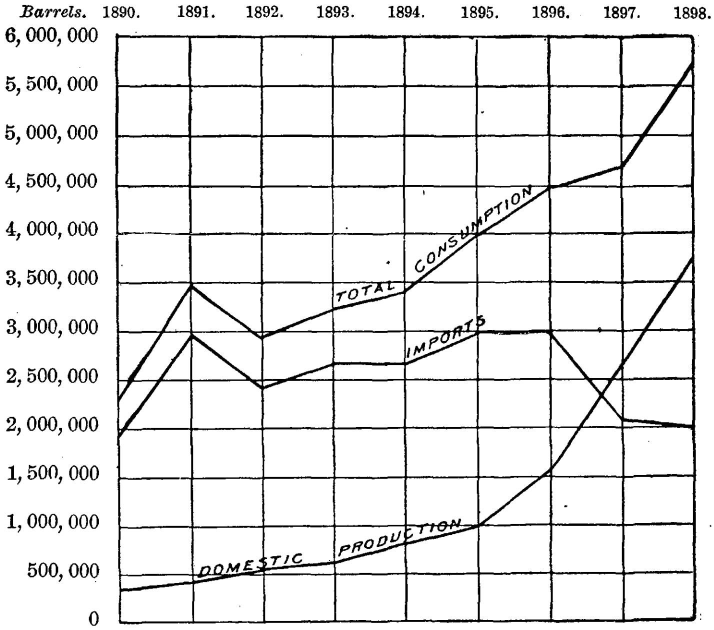

FIG. 2.—Graphic representation of the production, importation, and total consumption of Portland cement from 1890 to 1898.

This table shows that the consumption of Portland cement has more than doubled since 1890, while the domestic production has increased more than tenfold. As the imports in 1898 were almost exactly the same as in 1890, the table allows no conclusion to be drawn as to the probable time that must elapse before the whole demand is supplied by domestic factories. When it is considered that the period from 1893 to the middle of 1897 was one of great industrial depression in the United States, the fact that the increase in demand for Portland cement has equaled the great increase in domestic production is highly significant and points to the continuance of favorable conditions for the industry for some time to come.

In the report for 1897 it was foretold that the product in 1898 would reach 3,500,000 barrels, an increase of more than 1,000,000 barrels over 1897. The actual amount produced was, in fact, 3,692,284 barrels, slightly exceeding the above estimate. All indications point to a considerable further increase in the present year, and an enormous one in 1900. In the Lehigh Valley region four of the principal factories are undergoing enlargements which will add not less than 1,000 barrels per day to the product of each, and it is claimed that one factory, already the largest in the world, will soon reach a production of 10,000 barrels per day. A new producing region, that of La Salle, Illinois, has come into the field of Portland cement production, and three works are at present being erected at that point. Large factories are also under construction at Coldwater and Quincy, Michigan, and at Syracuse, Indiana. None of these new enterprises will greatly affect the product of the present year, which will probably reach 4,400,000 barrels. In 1900 the total output of Portland cement will probably reach 7,000,000 barrels. The steadily increasing demand will, however, probably provide a market for this amount, even without any considerable reduction of imports.

THE PORTLAND CEMENT INDUSTRY IN THE VARIOUS STATES.

Illinois.—Three factories are under construction near La Salle by the Chicago Portland Cement Company, the Marquette Cement Company, and the Hemmoor Portland Cement Company, of Germany. The materials to be used are limestone and clay. The Marquette Company gives the following analysis:

Analysis of ingredients of Portland cement from Illinois.

Limestone.	Per cent.	Clay.	Per cent.
Calcium carbonate	88.16	Silica	54.30
Magnesium carbonate	1.78	Alumina	19.33
Silica	8.20	Iron	5.57
Iron oxide }	1.30	Lime	3.29
Alumina }		Magnesia	2.57
		Sulphur	2.36

The limestone, as shown by this analysis, contains about one-half the silica and alumina required for a correct cement mixture. The clay evidently contains a good deal of iron sulphide, which may prove an obstacle to its successful use. The rotary-kiln process will be used at two of these factories and vertical continuous kilns at the third.

The Illinois Steel Company, of Chicago, one of the largest manufacturers of slag cement, has practically abandoned this industry, and now proposes to make a true Portland cement by grinding blast-furnace slag with the necessary proportion of limestone and burning the mixture in rotary kilns.

Indiana.—The factory of the Sandusky Portland Cement Company at Syracuse is in process of construction. Works are proposed at Bedford to utilize the oolitic limestone.

Kentucky.—Designs have been made for a factory at Litchfield. The materials to be used have the following composition.

Analysis of ingredients of Portland cement from Kentucky.

Limestone.	Per cent.	Clay.	Per cent.
Calcium carbonate	97.63	Silica	55.82
Magnesium carbonate	0.65	Iron oxide	6.19
Silica	0.49	Alumina	19.77
Alumina	Trace.	Lime	0.70
Iron oxide	0.22	Loss, alkalies, etc	19.52
Sulphuric acid	0.34		

Michigan.—The factory of the Peerless Portland Cement Company at Union City was destroyed by fire in October.

A factory is under construction by the Michigan Alkali Company at Wyandotte, at which Portland cement will be made from caustic soda waste (a very pure form of precipitated calcium carbonate) and clay.

MATERIALS.

Limestone continues to be the chief material for the manufacture of Portland cement. This is due to the immense development of the industry in the Lehigh Valley region, where unlimited quantities of a natural Portland cement rock occur. This material is similar to the argillaceous limestone deposits of Belgium, and contains a slight excess of clay over the amount required; a small proportion of pure limestone is therefore ground with the rock to produce a correct mixture. The grinding is not required to be very fine, since the coarse particles remaining in the raw material are of nearly correct composition. The case is very different, however, when pure limestone and clay are employed. In this case the stone must be ground to such a fineness as to leave practically no residue on a sieve of 180 meshes to the linear inch, or an inferior product will result. The cost of grinding large quantities of hard limestone to this degree of fineness is very great. Several attempts to make Portland cement in this country from pure limestone and clay have been made, but none have resulted satisfactorily in respect of cost of manufacture or quality of product.

The following table shows the comparative product from limestone and from marl in 1897 and 1898:

Comparative product of Portland cement from limestone and marl.

	1897.		1898.	
	Number.	Product.	Number.	Product.
		Barrels.		*Barrels.*
Factories using limestone	18	2,282,126	20	3,112,492
Factories using marl	11	395,649	11	579,792
Total	29	2,677,775	31	3,692,284

PROCESSES.

The use of the rotary kiln for burning cement continues to increase rapidly, as may be seen from the following table:

Amount of Portland cement made in kilns of various kinds.

[Barrels.]

	1893.	1896.	1897.	1898.
Rotary kilns	149, 000	632, 370	1, 311, 319	2, 170, 782
Vertical kilns (continuous and intermittent)	441, 653	910, 653	1, 366, 456	1, 521, 502
Total	590, 653	1, 543, 023	2, 677, 775	3, 692, 284
Per cent of total product burned in rotary kilns	25. 2	41. 0	49. 0	58. 8

More than one-half the whole product of Portland cement in the United States is now burned in rotary kilns. This proportion will be greatly increased in the next two years, as practically all the new plants now building are to be equipped with kilns of the rotary type. Several of the eastern plants which have heretofore used vertical kilns exclusively are now making large additions in which the new type of kiln will be employed.

AMERICAN ROCK CEMENT.

By URIAH CUMMINGS.

PRODUCTION AND PRICE.

During the season of 1898 there were 8,418,924 barrels of rock cement placed upon the market. This is the largest amount ever produced in a single season. The prices realized were practically the same as those for 1897. The following table gives the amount and value of the rock cement produced in the United States during 1897 and 1898. The values are based on the selling prices in bulk at mills.

Product of rock cement in 1897 and 1898.

State.	1897.			1898.		
	Number of works.	Product.	Value.	Number of works.	Product.	Value.
		Barrels (a).			*Barrels (a).*	
Florida	......	....	....	1	7, 500	$7, 500
Georgia	1	18, 165	$10, 899	1	18, 000	13, 500
Illinois	3	510, 000	209, 000	3	630, 228	220, 580
Indiana and Kentucky.	15	1, 731, 287	692, 515	19	2, 040, 000	816, 000
Kansas	2	160, 000	64, 000	2	160, 000	120, 000
Maryland	4	296, 000	118, 400	4	297, 475	118, 989
West Virginia	1	....	....	1	42, 874	17, 150
Minnesota	2	111, 731	55, 865	2	128, 436	64, 218
New York	29	4, 259, 186	2, 123, 771	29	4, 157, 917	2, 065, 658
Ohio	3	23, 697	14, 218	3	26, 724	13, 362
Pennsylvania	7	775, 000	387, 500	5	499, 956	249, 978
Tennessee	......	....	....	1	10, 000	8, 000
Texas	1	11, 390	17, 085	1	11, 000	16, 500
Virginia	3	15, 232	9, 139	3	8, 835	5, 301
Wisconsin	1	400, 000	160, 000	1	379, 979	151, 992
Total	72	8, 311, 688	3, 862, 392	76	8, 418, 924	3, 888, 728

a Of 300 pounds.

In the following table the larger figures represent the number of barrels of cement and the smaller ones give their percentage of the total production for the years named:

Consumption of cement of all kinds in the United States.

Year.	American rock cement.	Imported Portland.	American Portland.	Total number.
	Barrels (a).	*Barrels (b).*	*Barrels (b).*	*Barrels.*
1893	7,411,815	2,674,149	590,652	10,676,616
	69.42	25.05	5.53	
1894	7,563,488	2,638,107	798,757	11,000,352
	68.76	23.98	7.26	
1895	7,741,077	2,997,395	990,324	11,728,796
	66.00	25.56	8.44	
1896	7,970,450	2,989,597	1,543,023	12,503,070
	63.75	23.91	12.34	
1897	8,311,688	2,090,924	2,677,775	13,080,387
	63.54	15.99	20.47	
1898	8,418,924	2,013,818	3,692,284	14,125,026
	59.60	14.26	26.14	

a Of 300 pounds. *b* Of 380 pounds.

It will be observed that the demand for foreign Portland cement during 1898 fell about 12 per cent below the average for the six years, and the American Portlands have supplied the increased demand for that class of cement, while the average yearly gains of the combined Portlands over the rock cements for the period named amount to 1.64 per cent. It is evident from the foregoing table that the prejudice heretofore existing against the use of American Portland is fast disappearing. Within the last few years there has been a rapidly increasing demand for cement sidewalks, and the use of Portland for this purpose alone will account for the increased demand for that product.

That the great engineering works of the country are still being laid in American rock cement is evinced by the annual consumption of over 8,000,000 barrels.

The use of nearly 169,000,000 barrels of this class of cement in this country since the establishment of the industry eighty-one years ago shows that its reputation for durability and real worth is well founded.

There seems to be a general impression in the public mind that the great difference in the prices of rock cement and Portland is due to the superior quality of the latter. The prices of each are based on the cost of production. In the entire absence of combinations or trusts the successful manufacturer of either class, in making up his selling prices, is guided by two important factors: First, the cost of production, which includes the cost of manufacture and sale; second, the condition of the market. If the demand is brisk, he is apt to increase his margin of profit all it will bear. Thus far in the history of the industry rock cement has afforded a higher per cent of profit than Portland, and the opinion that this condition is likely to endure for many years to come is based on the following reasons:

First. A fierce competition among the manufacturers of rock cement has existed for several years and the prices have been beaten down as far as it seems possible. Rock cement being a cheap and heavy commodity, the freights paid by the purchaser oftentimes exceed the amount of the invoice for the cement. The freight rates in many instances not only protect and preserve some of the rock-cement works from annihilation, but afford a fair profit to such works. This is due to the fortunate circumstance of the plants being fairly distributed throughout the country.

Second. The change in public sentiment in favor of American Portland bids fair to continue until the foreign brands are entirely displaced by the domestic product.

Third. This change has stimulated the construction of Portland works in this country to an extraordinary degree, and it is clearly evident that, at the present rate of increase in capacity, in the near future the price of Portland will fall below the cost of production at many of the plants.

Fourth. It is clear, therefore, that while the price of rock cement has evidently reached the bottom it is not so with the Portlands, and at the much higher cost of the Portlands over that of the rock cements the ratio of freight rates is much less, and the latter does not afford the protection to the Portlands that it does to the rock cements.

NEW DEVELOPMENTS.

California.—The remarkable cement-rock deposit in Riverside County, which was described in Mineral Resources, 1890, page 463, will undoubtedly be operated for the production of both rock and Portland cement in the near future. Steps are now being taken to erect a large plant for the purpose. The prospects are therefore that southern California and Arizona will soon be supplied with cements of first quality of both classes at greatly reduced prices.

Florida.—Probably the most remarkable natural hydraulic-cement-rock deposit in the known world occurs near River Junction. From this point the deposit extends for several miles along the left bank of the Appalachicola River southerly to Aspalaga. On a recent visit to this locality the writer made a careful examination of this truly remarkable formation. It comprises something over 2,000 acres and has a thickness of 80 feet above the river. How far it may be below has not been ascertained. Enough is exposed, however, to warrant the assertion that the deposit contains sufficient raw material to produce over two billions of barrels of cement. The material is usually soft enough to be cut out with a spade, but the lumps, when placed in kilns, harden sufficiently to prevent them from crumbling while undergoing calcination.

Several analyses of samples taken from various parts of the formation show a remarkable uniformity of proportions of the ingredients essential to the production of a first-class hydraulic cement.

But the distinguishing feature of this deposit consists in its perfect purity of color. The raw material is white and the manufactured product is as white as the whitest marble. In this respect it is an ideal cement for the architect, as it will not stain the walls of fine masonry. Bricks made of one part of this cement and two parts white sand are in use in many buildings in the South, and they are extremely hard and beautiful. So far as is known to the writer, this is the only deposit of white hydraulic-cement material in the world. A small but convenient plant is in operation at River Junction, and the proprietors term the manufactured product "White Roman hydraulic cement of Florida."

Indiana.—Since the last report four new plants have been erected in the Louisville, Kentucky, district for the production of rock cement.

Minnesota.—The rock-cement works at Austin, which were destroyed by fire, are being rebuilt.

Pennsylvania.—The cement-rock deposit on the left bank of the Susquehanna River near Larrys Creek, which was rather fully described in Mineral Resources, 1895, page 889, is about to be operated on an extensive scale for the production of both rock and Portland cements.

Virginia.—The plant of the James River Cement Works, which were destroyed by flood at Balcony Falls, have been rebuilt in a most substantial manner at Locher, on the James River, near Glasgow.

SOAPSTONE.

By Edward W. Parker.

PRODUCTION.

Exclusive of the production of fibrous talc from St. Lawrence County, New York, which is considered separately, and including 300 tons of verd antique, or serpentine, from California, the amount of soapstone produced in the United States in 1898 was 22,231 short tons, worth, at first hands, $287,112. As compared with 1897, the production in 1898 showed an increase of 308 short tons in quantity, with a decrease in the value of $78,517, or 21.5 per cent. This seemingly decided decline in values is due chiefly to the fact that a larger percentage of the product of 1898 was sold crude or ground, and a smaller percentage was manufactured before being sold. There was, however, a general falling off in prices, but not enough to account for the entire decrease in value. The average price for rough soapstone declined from $12.50 per short ton in 1897 to $11.92 in 1898, and the product sold rough increased from 1,020 tons to 1,380 tons. The product sawed into slabs in 1897 was 1,107 short tons, which brought an average of $19.63; in 1898 this portion of the product increased to 1,305 short tons, but the average price was only a little over $10 per ton. The manufactured product in 1898 was 11,336 short tons, a decrease of 759 tons from 1897, while the average price declined from $22.12 to a little less than $17. The production of ground soapstone increased about 500 tons, and the average price declined from $8.28 to $8.

One of the reasons for the decline in value of manufactured soapstone is given by one concern manufacturing slate pencils as due to the decreased use of slates by school children, on sanitary claims.

The following table shows the amount and value of soapstone produced in the United States during the last six years and the conditions in which the product was sold:

Production of soapstone during the last six years.

Condition in which marketed.	1893.		1894.		1895.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Rough	5,760	$51,600	5,620	$50,780	1,041	$8,886
Sawed into slabs	104	4,400	1,303	19,500	863	12,320
Manufactured articles (*a*)	7,070	123,600	6,425	244,000	10,789	170,791
Ground (*b*)	8,137	75,467	9,796	87,045	8,802	74,498
Total (*c*)	21,071	255,067	23,144	401,325	21,495	266,495

Condition in which marketed.	1896.		1897.		1898.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Rough	1.550	$13,375	1,020	$12,535	1,380	$16,453
Sawed into slabs	923	15,481	1,107	21,726	1,305	13,240
Manufactured articles (*a*)	10,133	232,261	12,095	267,583	11,336	191,923
Ground (*b*)	9,577	92,948	7,701	63,785	8,210	65,496
Total (*c*)	22,183	354,065	21,923	365,629	22,231	287,112

a Includes bath and laundry tubs; fire brick for stoves, heaters, etc.; hearthstones, mantels, sinks, griddles, slate pencils, and numerous other articles of everyday use.

b For foundry facings, paper making, lubricators, dressing skins and leather, etc.

c Exclusive of the amount used for pigment, which is included among mineral paints.

Distributed by States, the production in 1898 was as follows:

Production of soapstone in 1898, by States.

State.	Quantity.	Value.
	Short tons.	
Georgia	639	$4,054
North Carolina	1,695	27,320
Pennsylvania	3,778	25,436
Virginia	10,059	119,480
Other States (*a*)	6,060	110,822
Total	22,231	287,112

a California, Maryland, New Hampshire, and New Jersey.

In the following table are shown the amount and value of soapstone produced in the United States since 1880, exclusive of soapstone ground for paint, and fibrous talc:

Annual product of soapstone since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	8,441	$66,665	1890	13,670	$252,309
1881	7,000	75,000	1891	16,514	243,981
1882	6,000	90,000	1892	23,208	423,449
1883	8,000	150,000	1893	21,071	255,067
1884	10,000	200,000	1894	23,144	401,325
1885	10,000	200,000	1895	21,495	266,495
1886	12,000	225,000	1896	22,183	354,065
1887	12,000	225,000	1897	21,923	365,629
1888	15,000	250,000	1898	22,231	287,112
1889	12,715	231,708			

FIBROUS TALC.

The production of this variety of talc or soapstone, which is used principally as a filler and makeweight in the medium grades of paper, is carried on exclusively in St. Lawrence County, New York. There is no other known occurrence of fibrous talc in the United States. The product in 1898 amounted to 54,356 short tons, valued at $411,430, as compared with 57,009 short tons in 1897, worth $396,936, showing a decrease in the quantity mined of 2,653 short tons, and an increase in value of $14,494. The larger value in 1898 was due to the small amount of talc sold crude, nearly all of the output in 1898 having been ground and prepared before marketed. There was an actual decline in value of ground talc, tonnage considered, the average price per ton in 1898 being $7.61, against $7.95 in 1897 and $8.87 in 1896.

The following table shows the amount and value of fibrous talc produced in the United States since 1895:

Disposition of fibrous talc produced since 1895.

	1895.		1896.		1897.		1898.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
Sold crude	....	....	1,363	$2,726	9,800	$21,500	500	$1,250
Paper filling	39,021	$369,007	44,726 (paper filling, paint, and wall plasters)	396,717	47,209	375,436	53,856	410,180
Paint	48	552						
Wall plasters	171	1,338						
Total	39,240	370,897	46,089	399,443	57,009	396,936	54,356	411,430

The development of the fibrous talc industry since 1880 is graphically exhibited in the following table. It also shows that the product in 1898 was the largest on record except that of 1897, and that the value of the product in 1898 was less than that of the smaller production in 1891, 1892, and 1894.

Production of fibrous talc since 1880.

Year.	Quantity.	Value.
	Short tons.	
1880	4,210	$54,730
1881	5,000	60,000
1882	6,000	75,000
1883	6,000	75,000
1884	10,000	110,000
1885	10,000	110,000
1886	12,000	125,000
1887	15,000	160,000
1888	20,000	210,000
1889	23,746	244,170
1890	41,354	389,196
1891	53,054	493,068
1892	41,925	472,485
1893	35,861	403,436
1894	39,906	435,060
1895	39,240	370,897
1896	46,089	399,443
1897	57,009	396,936
1898	54,356	411,430

IMPORTS.

The following table exhibits the imports of talc of all kinds since 1880. From 1880 to 1889 the imports were fairly regular. Since 1889 they have been very irregular. From 19,229 short tons, valued at $30,993, in 1889, they dropped to 1,044 tons, worth $1,560, in 1890, and 81 tons, worth $1,121, in 1891. They increased in 1892 to 531 tons, and again in 1893 to 1,360 tons, decreasing in 1894 to 622 tons. In 1895 they increased to 3,165 short tons, valued at $26,843, decreasing in 1896 to 1,966 tons, worth $18,693, and again in 1897 to 796 tons, worth $8,423. In 1898 the imports amounted to 761 short tons valued at $9,338.

Talc imported into the United States from 1880 to 1898, inclusive.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	....	$22,807	1890	1,044	$1,560
1881	....	7,331	1891	81	1,121
1882	....	25,641	1892	531	5,546
1883	....	14,607	1893	1,360	12,825
1884	....	41,165	1894	622	6,815
1885	....	24,356	1895	3,165	26,843
1886	....	24,514	1896	1,966	18,693
1887	(*a*)	49,250	1897	796	8,423
1888	24,165	22,446	1898	761	9,338
1889	19,229	30,993			

a Quantity not reported previous to 1888.

CANADIAN PRODUCTION.

In the following table is shown the output of soapstone in Canada for a period of thirteen years. It will be observed that the values are usually much less than those given for the United States product, and the fluctuations in value are even more pronounced than in this country. In 1886 and 1887 the product was valued at $8 per ton. The output in both years was small. In 1888, with an increase of only 40 tons in product, the value fell to $2 per ton. In 1889 the output increased 55 tons and the price went up to $6 per ton. In 1890 the output increased to 917 tons, nearly five times the amount obtained in 1889, but the value increased only $69, the price per ton declining to $1.35. No output was reported in 1891. In 1892 the product was 50 per cent more than in 1890, the value increasing five times, or to $4.54 per ton. In 1893, with a decrease of nearly 50 per cent in the product, there was a decline to $2.68 per ton. The price declined again in 1894 to $1.78 per ton, and in 1895 advanced to $4.50 per ton, the output of 475 tons being valued at $2,138. In 1896 the production fell off 65 tons to 410 tons, while the price declined to $3 per ton, and dropped to 157 tons in 1897, and the price declined to $2.27. No output has been reported for 1898.

These figures are obtained from the annual report of the geological survey of Canada:

Production of soapstone in Canada from 1886 to 1898.

Calendar year.	Tons.	Value.
1886	50	$400
1887	100	800
1888	140	280
1889	195	1,170
1890	917	1,239
1891	None.	None.
1892	1,374	6,240
1893	717	1,920
1894	916	1,640
1895	475	2,138
1896	410	1,230
1897	157	350
1898	None.	None.

PRECIOUS STONES.

By George F. Kunz.

INTRODUCTION.

Some of the salient features of the year are the finding of rock crystal at Mokelumne Hill, California, of such purity and size as to almost rival the Japanese, and the successful cutting of these in the United States up to 7 inches in diameter; the increased output of Fergus County, Montana, sapphire mines, and the yielding of fine blue gems up to 2 carats each, and the discovery of a new locality where the stones are more varied in color than those of any known locality; the continued output of the New Mexican turquoise mines and the opening up of mines in Nevada; the finding of magnificent green and other colored tourmalines at Paris Hill, Maine, and Haddam Neck, Connecticut; the increased sale of Australian opal; greater use of all the fancy or semiprecious stones; the greater importation of uncut diamonds, and the increase of the diamond-cutting industry in the United States; the unprecedented increase in the importation of cut diamonds; the revival of the precious stone industry in the United States, and the positive great future advance in the price of pearls and emeralds, and the advance in the price of diamonds.

DIAMOND.

UNITED STATES.

No more diamonds have been found during the last year in the region of the terminal moraine of Wisconsin. One of 6 carats, however, has been obtained at Milford, Ohio, not far from Cincinnati, about the extreme southernmost point to which the moraine extends, and considerably east of any heretofore found. Prof. W. H. Hobbs, of the University of Wisconsin, who has taken so much interest in the investigation of this matter, is proposing a systematic search along the line of the moraine in which a number of geologists will cooperate. He believes that many more diamonds must have been found from time to time and be now lying unsuspected, as did some of the others for years, among local gatherings of odd pebbles, etc., in farm houses near the morainal line. He proposes to publish the general facts in the newspapers, endeavor to bring to light any such stones that exist, and encourage search for others. He hopes thus to gain additional data for locating the source whence the diamonds came. This he is now disposed to believe to be the unexplored wilderness between Labrador and James Bay.

Thus far seventeen have been discovered, ranging from 21 carats to less than ½ carat in weight. But these must be only a small fraction of those distributed through the great mass of morainal material, and would indicate considerable abundance at the unknown source or sources.

In California Mr. H. W. Turner, of the United States Geological Survey, will make a study of the California diamond fields and will prepare the results of his investigation in a future memoir.

SOUTH AFRICA.[1]

The great diamond production at Kimberley has gone on during the last year at much the same rates of cost, profit, and yield as given in the reports for the two preceding years. The work is thoroughly understood and systematized, and the production is limited to an amount sufficient to maintain the supply and meet the demand without lowering prices. Indeed, in his address to the stockholders, Mr. Cecil Rhodes states that, in view of somewhat higher rates obtained from the diamond syndicate which purchases the entire product by contract from year to year, it is proposed to reduce the output to some extent for the next twelvemonth, while maintaining equal dividends. The De Beers Company controls essentially the Bultfontein and Dutoitspan mines, but does not operate them, its workings being confined to the De Beers, Kimberley, and Premier mines. The last-named is less rich than the others, but has a large area and is very easily worked, so that a much less cost of production compensates for a smaller yield. The Premier has thus far been worked only to a depth of 125 feet, but lower levels are now to be opened. The De Beers Mine has been carried down to and beyond 1,400 feet, and the Kimberley to 1,900 feet; but the main work of taking out rock is done at higher levels—in the Kimberley between 1,200 and 1,400 feet.

Diamond mining in South Africa proved even more successful in 1898 than in the previous year. With the regulated output sold ahead to June, 1900, and with the return of prosperity over nearly all of the civilized globe, the demand for diamonds was greater than ever.

The annual report of Mr. Gardner F. Williams, manager of the great De Beers mine, made to that corporation, tells us that the cost of extraction has been somewhat reduced, but that the yield of diamonds per "load" (16 cubic feet) has fallen from 0.92 to 0.80 carat. This is

[1] Report of the De Beers Consolidated Mines for the Year ending June 30, 1898; London, 1898.

explained in the reports by the statement that a good deal of "waste" and "reef" rock has been sent up, and that certain poor portions have been worked. Mr. Williams claims that this is due partly to carelessness, and that otherwise the indications are generally as favorable as ever.

The force of men employed has been largely increased. Native labor has been abundant and cheap, owing to the heavy losses of cattle by the rinderpest, whereby the natives have been forced to seek employment at the mines. There were over 11,000 negroes in the compounds at the time of the last report, and 1,819 whites engaged—an increase of nearly 200 whites and 4,000 blacks since the previous year.[1]

The automatic sorter described in the last report[2] has proved so successful that twelve of the machines have been constructed and are in operation; this has resulted in a large reduction in the force of hand sorters, both white and black.

The cost of production has been lowered, in the De Beers and Kimberley mines, about 9d. per load, involving a total saving of £130,000 during the year. This is chiefly due to a very large output and to abundant cheap labor. The cost per load averaged at these two mines 6s. 7.4d., and at the Premier 2s. 7.1d.; and the yield in diamonds was, respectively, 0.80 carat and 0.27 carat.

The actual results for the year were:

Operations at De Beers, Kimberley, and Premier mines, with output and value of diamonds produced.

	Loads of blue hoisted.	Loads of blue washed.	Carats of diamonds found.	Prices realized therefrom.		
				£	s.	d.
De Beers and Kimberley	3, 332, 688	3, 259, 692	2, 603, 250	3, 451, 214	15	3
Premier	1, 146, 984	691, 722	189, 356	196, 659	18	8
Total	4, 479, 672	3, 951, 414	2, 792, 606	3, 647, 874	13	11

The amount of "blue ground" reported as "in sight" was estimated as 5,000,000 loads in the De Beers and 4,000,000 in the Kimberley; while in the Premier there were 2,750,000 loads above the 125-foot level, and 4,000,000 loads brought to view by further exploration to 167 feet, in all 6,275,000 loads. The total in the three mines would thus be over 15,000,000 loads.

[1] See table in report for 1897: Nineteenth Ann. Rept. U. S. Geol. Survey, Part VI (cont'd), p. 499.
[2] Ibid., p. 499.

The financial statement of the company for the year ending June 30, 1898, is as follows:

Financial statement De Beers consolidated mines.

	£	s.	d.	£	s.	d.
Amount realized from diamonds produced				3,647,874	13	11
Expenses, including—						
Amounts written off machinery and plant account	76,260	11	8			
Redemption of debentures and obligations	132,000	0	0			
Interest on above	177,226	14	6			
				1,870,079	1	3
Profit				1,777,795	12	8

Profit and loss account.

	£	s.	d.	£	s.	d.
Balance as above				1,777,795	12	8
Investments and rents				22,242	7	3
Interest on consols				31,036	0	10
From other sources				3,375	7	1
Balance from previous year	683,047	17	11			
Less life governor's remuneration	158,003	15	2			
				525,044	2	9
Total				2,359,493	10	7
Of which—						
Dividends paid and provided for				1,579,582	0	0
Reserve fund				31,423	4	0
Balance to next year				748,488	6	7
				2,359,493	10	7

The dividends have been maintained at the same rate—40 per cent—and the balance is seen to be considerably larger than that from the previous year. The reserve fund, invested in English consols, has been increased from £1,148,133 12s. 7d. to a present amount of £1,179,556 16s. 7d.

Unofficially it is understood that the entire output has been arranged for with the syndicate until June 30, 1900. There has been an upward tendency in the diamond market for some months, and the year 1900 will chronicle the greatest importation into the United States that has ever been known, and never have so many stones been cut. In fact, many sizes and kinds can be purchased in the United States, of American cutting, at a lower rate than abroad.

SOURCE OF THE DIAMOND.

As regards the actual source of the African diamonds, the trend of recent opinion has been rather toward the view that they are not indigenous to the blue ground, but have been brought up from greater depths, although there has been a vast amount of discussion of the problem, as has been noticed in these reports for several years past.

Some new facts have lately come to view, reported by Prof. T. G. Bonney in a recent lecture before the Royal Society of London, that would clearly indicate a deep-seated source. In Griqualand West, about 40 miles from Kimberley, are situated the Newlands mines. Here, some two years ago, the manager, Mr. Trubenbach, picked up a specimen containing small diamonds apparently embedded in garnet. He at once began to collect and examine certain garnetiferous bowlders that occur in the blue ground, sometimes at depths of 200 or 300 feet. One or two of these bowlders were found to contain diamonds, visible either on the surface or on breaking. They consist of the somewhat rare rock eclogite, a mixture of red garnet and a light-green augitic or, perhaps, hornblendic mineral. They are waterworn bowlders, and evidently represent a mass of eclogite, from which they were detached at a remote period, and which must have then been exposed at the surface, though now deeply buried. This eclogite terrane, eroded certainly prior to the deposition of the (Triassic) Karoo shales and to all the igneous outbreaks that have traversed them, would thus be indicated as the original home of the diamonds. It must have been largely decomposed, probably furnishing much of the included fragments of the "blue ground," and in that condition, together with the hard bowlders and the yet harder diamonds, have been largely carried upward in the igneous extrusions that have filled the "pipes" of the mines.

ORIGIN OF THE DIAMOND.

In a paper by Prof. T. G. Bonney, in the Edinburgh Review, a general outline was given of the diamond conditions in Africa and the theories regarding the deep-seated origin of the gem, as connected with the experiments of Moissan, and the indications derived from meteorites, etc. Beginning with a brief account of the great Karoo formation, of Triassic age, covering an area of some 200,000 square miles in South Africa—east and west from the Spitzkopf to the Red Heights near Middleburg, and north and south from the Black Mountains to the Vaal, and containing, like the Trias of our Atlantic States, interbedded sheets of igneous rock, with little indication of violent disturbance, and none whatever of volcanic outbreak—he passes to the subsequent formation of the diamontiferous "pipes" that break through the Karoo strata. These are regarded as due to explosive outbreaks from great depths caused, possibly, by access of water to highly heated regions, with outbursts of steam and heated mud carrying up quantities of fragments of the lower rocks and filling the "gigantic blow-holes" with a mixed volcanic breccia. The pipes were thus formed catastrophically and filled gradually by successive outpourings from below.

Such is the supposed history of the "blue-ground," decomposed above, but becoming hard and compact below, and diamond bearing throughout. Stress is laid on the fact that each opening is somewhat different in the character and aspect of its diamonds, so that experts can judge from which mine any stone has come. The conditions of their formation are seen to be those necessary for the liquefaction of carbon, which usually vaporizes at extreme temperatures without fusing. After discussing the experiments and calculations of Dewar, as to the boiling point and critical pressure, the methods lately employed by Moissan are described, which need not be reviewed again here.

The question of how far Moissan's artificial conditions of fused iron with dissolved carbon under enormous pressure may actually exist in the earth's lower crust is then treated. The Ovifak iron is regarded as a convincing argument in support of the view that such must be largely the case. The analogies of true meteorites, and the occurrence of carbon in some of them, form a coincident line of evidence. But in particularly the Cañon Diablo irons, containing diamond carbon, are discussed in connection with the peculiar "walled crater" of Sunset Knoll. This latter is regarded as strikingly similar in structure to the Kimberley "pipes," though on a far larger scale, a "crater of elevation," by upthrust through the surrounding strata of a plain, and surrounded by these peculiar iron-carbon ejecta. These are considered, therefore, to be terrestrial and not meteoric, and to afford strong support to the theory of diamond origin thus presented.

GENESIS OF THE DIAMOND.

The question of the genesis of the diamond has been approached from a new quarter in the last year in an elaborate paper by Prof. O. A. Derby,[1] discussing the indications and conditions of diamond occurrence in Brazil. The conclusions that have been reached on this subject as to the diamonds of South Africa, Professor Derby shows plainly, can not apply in South America; and, although the data are at present inconclusive for the formation of any definite theory, yet it is clear that the differences are so great that we must recognize distinct modes of diamond production on the two continents. The African occurrence, in "necks" or "pipes" of basic igneous outbreaks, decomposed above, but passing into peridotite below, is abundantly clear, and the only controversy is that already referred to in these reports,[2] whether the carbon is an original constituent of the igneous rock (authogenic), crystallized at great depths and pressures, after the manner of Moissan's recent experiments, or is (allothigenic) derived from carbonaceous strata broken through by the molten rock in its upward movement, as suggested by the included fragments of the Karoo shales.

But nothing of this kind occurs in the Brazilian mines, and the slight approaches to similar conditions in the neighborhood of one or two of them would never have been thought of in connection with the diamond save for the endeavor to find some African resemblance in their

[1]Brazilian evidence on the genesis of the diamond, by Orville A. Derby, Jour. Geol., Feb.-Mar, 1898, pp. 121-166.

[2]Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 1191-1196; Nineteenth Ann. Rept. U. S. Geol. Survey, Part VI (cont'd), pp. 8-10.

association. Leaving aside, of course, all beds that are plainly the result of recent surface drainage, Professor Derby goes into a very minute study of the indications as to the diamonds in situ that appear at a few localities. These present three types. In one, at Agua Suja, near Bagagem, in western Minas Geraes, micaceous and staurolitic schists are cut by granite dikes and quartz veins, and overlain by sandstone beds with intercalated trap sheets, augitic in character and judged to be Triassic in age. In the neighborhood are other eruptive rocks, of a pyroxene-magnetite-perofskite type, but not peridotites, and not distinctly connected with the diamonds, the latter being found in a bed overlying the rocks before described and containing fragments of all of them, greatly decomposed. After referring to the difference in the character of the eruptive rocks, Professor Derby adds the remark: "If, as some hold in regard to the Kimberley occurrence, the diamond is the product of metamorphic action on carbon-bearing rocks and not an element of the eruptive rock itself, this last difference would lose much of its importance. In this case the Kimberley and Agua Suja occurrences would fall into line as phases of the same phenomenon of contact metamorphism." This is almost the only Brazilian occurrence that even suggests any likeness to the African.

The other two types are in connection, the one with itacolumite, and the other with quartz veins in "residual" clays. The former association, long since noted and often described with more or less accuracy, is especially treated of in this article at Grão Mogol, 100 miles north of the celebrated diamond beds of Diamantina, in Minas Geraes. After considerable discussion Professor Derby finds the evidence inconclusive. The itacolumite, "whether one or two series are represented, is a metamorphosed clastic, and no decisive evidence can be presented to place the diamond in the class of either the authogenic or the allothigenic elements of this rock."

The third mode of occurrence is best shown and largely discussed at São João de Chapado. Here the rock is a body of clays of various types, all apparently due to the decomposition of a series of crystalline schists or phyllites, and of pegmatite veins that traversed them, of which only the quartzose portions have survived. Whether these pegmatites were originally segregation veins or intrusive dikes is not clear, though Professor Derby inclines to the latter view; and whether the diamonds in the clays originated in the pegmatite or in the schists it seems hardly possible to ascertain, even with minute examination. But the general fact remains that there is here no relation whatever to the African genesis, and that distinct modes of origin must be recognized for the diamond at different points.

A further contribution to the African discussion as to diamond origin has been made by Dr. I. Friedländer, in the Geological Magazine.[1] Moissan's method of crystallizing carbon in molten iron at enormous

[1] American Journal of Science, June, 1898.

pressure has been strongly presented by some as the probable source of the Kimberley diamonds, at great depth. As all the iron in the diamantiferous rocks is in combination, and not in the metallic state, it becomes necessary to assume that the crystals must have risen by gravity, through the supposed mass of liquid iron, into the silicates floating upon the top of it, like the slag in an iron furnace. Friedländer's experiments now indicate that the fused silicates would dissolve the carbon crystals. He melted a small piece of olivine with a gas blowpipe, and, keeping it fused, stirred it with a small rod of graphite. On cooling, the olivine was found to be full of minute crystals, which on careful examination gave all the indications of diamond—octahedral or tetrahedral form, high refraction, hardness above corundum, insensibility to acids, burning away in oxygen, etc. From these facts he infers that the action of such molten silicates, in the course of their extrusion, on carbonaceous rocks would readily explain the African mode of occurrence without recourse to hypothetical masses of fused iron at great depths and pressures—a view already discussed in this report for 1896.[1]

AUSTRALIA.

A number of diamond localities are now known in different parts of Australia, some of which are yielding good stones, though not in large quantities or of large size. In October of last year reports came from Perth, Western Australia, of much excitement over diamond discoveries at a place called Nullagine, in the northwestern part of that colony, and there was in consequence a great rush thither, but no details are given. Mr. John Plummer, of Sydney, New South Wales, has published a letter[2] in which he reviews the general subject at various Australian localities. The finest stones thus far found are those from the Cudgegong River,[3] which flows from the Australian Alps through a gold-bearing district in the northwestern part of New South Wales; but they are not numerous, and the search for them has not been pursued, as the gold industry is found to be more certain and profitable. In the northern part of the same colony the Bingera and Inverell localities[4] are regularly worked. Most of the stones are small, many are of poor color, but some are fine and bring good prices in Europe. All are very hard, a feature which makes them expensive to cut, but which gives them extreme value for industrial uses, such as drills, etc.

At Mittagong, some 75 miles south of Sydney, diamonds are found in drift. They are often straw-colored, and some are of beautiful deeper yellow shades. A few other localities are referred to where diamonds—occasionally valuable stones—have been obtained in connection with

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 13-18.
[2] Watchmaker, Jeweler, and Silversmith, Vol. XXIV, 1898.
[3] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V, 1896, p. 10.
[4] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), 1896, p. 10.

gold washing. One thus found over ten years ago was cut into a 4-carat brilliant that brought £10 and another £14 10s. They usually average about four stones to a carat, however, and the prices range from 4s. 6d. to 8s. per carat.

All the Australian occurrences are in drift or alluvial deposits, and the sources are yet unknown. One attempt was begun to seek for them in deep ground, but after cutting through an overlying basalt the enterprise was stopped by the death of its promoter and has not yet been resumed.

CHINA.

The occurrence of diamonds in Shan-tung province, China, has been occasionally noted, and United States Consul Fowler, of Chefoo, has made references to it,[1] and in April last wrote giving an account from a correspondent living near the locality where they have been found, which he describes as a low sandy ridge extending southward parallel to the main road passing through the market town of Li Chua Chuang. For some 8 miles along this ridge diamonds are found, not abundantly, because no search for them is made. The people say that this would be useless, believing the gems to be produced by the action of rain upon the soil—thus confounding washing out with production, as frequently seen in Europe and elsewhere—and being imbued with the idea that stone implements and the like, found on the surface after rains, have fallen from the clouds. The diamonds are picked up from time to time by workers in the fields, and are bought by agents or dealers who come from Pekin. Most of them are small and off-color, although some good stones are found, even "as large as a hazelnut," and the poorer ones are valuable for drills. Prices are good, the usual rate for first-water stones at the spot being about 2,000 "large cash" ($240 Mexican) per one-hundredth of a native ounce, which latter equals 1⅓ ounces avoirdupois. The correspondent states that of recent years the business has rather declined; but he thinks that the diamond field there is well worth intelligent exploitation, and that the whole neighborhood is rich in mineral resources awaiting development.

RUSSIA.

The occasional finding of diamonds on the western slopes of the Ural Mountains is quite well established. Early in the present century Humboldt suggested their possible occurrence there. In 1829 the first stone was found. More were found in 1830, and a few others at intervals until about 1874, but subsequently there has been little search, as the results do not pay expenses. These stones were found in the valley of the Poludenka, a small affluent of the Kama, about 160 miles above Perm, the chief point being what is known as Adolph Gulch. Diamonds up to 3 carats have occasionally been found in the

[1] Consular Reports, No. 198, March, 1897, p. 384.

Poludenka Valley in placer workings for gold and platinum, as with us in California. The geology of Adolph Gulch presents nothing peculiar. The valley is excavated in a fossiliferous limestone, and near the placer quartzite, occurs with argillaceous schists. The surface deposits show half a meter of soil, a like thickness of gravel, 1 or 2 meters of débris of quartz and limestone, and beneath this a gravel stratum with fragments of all the neighboring rocks, and limonite, specular iron, magnetic sand, a little gold, and occasionally diamonds.

In Russian Lapland also a few diamonds have been found along the Paatsjoki River. The bed rock is gneiss, cut by dikes of granite and pegmatite, and in the river gravel occur rolled garnets, zircon, corundum, rutile, and tourmaline, with an occasional diamond, but none of a size to warrant search. The rock conditions and associations here bring to mind the account given by Professor Derby, in his article already referred to, of the third type of diamond occurrence in Brazil under the different conditions of a glaciated and nonglaciated country.

Mr. R. Helmkacker has recently reviewed the Russian diamond occurrences,[1] and the preceding notes are abridged from his paper.

CARBON INDUSTRY OF BRAZIL.

United States Consul Furniss, of Bahia, has recently given a consular report upon the carbon industry of Brazil, which is confined to the State of Bahia. The demand for carbonado, formerly small, has of late years become very great, with the growing importance of diamond drills, etc., in modern mining. The main region lies far in the interior of the State. After going by water from Bahia to São Felix, and thence by rail to Bandeira de Mello, where the production begins, the richer district lies farther up the Paragassa River, over a rough and hilly country accessible only by mule track.

The carbons occur under three conditions, but always in the loose conglomerate known as cascalho. This is reported as found (1) overlying a clay and under the river silt, in the beds of the Paragassa and its affluent, the San Antonio; (2) above a similar clay and beneath a layer of rock (an igneous outflow?) on the slope of the adjacent Serra de Lavras Diamantinas; and (3) throughout the adjacent region generally, overlain by surface deposits of earth, etc. It is not altogether clear what relation these three occurrences of cascalho bear to one another, as described in this account. Only the first and second are worked to any extent.

The working in the river beds is confined to the dry season, about half the year, and consists of diving and filling bags with the cascalho. A spot not over 20 feet deep is chosen, where the current is slow, and here a pole is planted. The divers slide down and climb up this pole, and while below they scrape away the silt and fill their bags, which

[1] Eng. and Min. Jour., Oct. 28, 1898.

are, on a signal, drawn up by other men in "dugout" canoes. The divers acquire much skill, remaining beneath the water for a full minute, or even more, and removing the cascalho down to the clay. The bags are emptied on shore, out of reach of the river, and the contents left in heaps to be washed and picked over in the rainy season, when the rivers are too deep and too rapid for working.

In the mountains the overlying rock is drilled through, and the cascalho removed through tunnels and piled up, to be washed—by means of sluices built on the slopes—when the wet season comes. Mr. Furniss states that more carbons are produced here than from the river beds. Some little working has been done in the level country, but only along the streams, for away from the river there is a lack of water to wash the cascalho. The bed lies at about the water level and fills as soon as it is excavated.

The carbonados vary from the size of a grain of sand to the celebrated one found in 1894, which weighed 975 carats, and to that found in 1896, which weighed over 3,000 carats. Those from 1 to 3 carats are most valued, as large ones have to be broken, resulting in much loss. The one of 975 carats, mentioned above, brought $19,300 in Paris, but when broken into salable pieces did not by any means realize that amount. The present price is about $5 a grain, or $22.50 a carat, which high figure is owing to the large demand and small supply, the latter due to the crude modes of production. The material is shipped principally from Bahia to Europe, but little as yet being brought to this country.

DIAMOND CUTTING.

The Thirteenth Annual Report of the Commissioner of Labor deals extensively with subjects relating to the comparison of hand and machine work in respect to cost of production, time saved, and the like. Among other data those concerning diamond cutting are given, and it is shown that machinery applied to this industry has reduced the time, but increased the cost. Three carats are cut by machine work in thirty-nine hours, as compared with one hundred and thirty-two hours by hand, a gain in time of approximately 1 to 3.38, but the cost is increased from $14.84 to $26.25, a ratio of about 1 to 1.76. In other words, rather more than half the gain in time is lost in expense. The great increase of diamond cutting in the United States in the last year is shown by the large importations of rough diamonds, and notwithstanding so low a duty as 10 per cent on the cut stones (the greatest preventive to smuggling) there are many sizes of diamonds which can be cut and sold for less in the United States than they cost when imported. The quality of much of the material is of a higher order; hence a higher grade of cutting is produced than in most of the stones of foreign importations.

DIAMOND SAW.

The diamond-toothed saw for cutting stone, referred to in former reports, is becoming prominent in the preparations for the Paris Exposition of 1900. It has been perfected and introduced by M. Felix Fromholt, a French engineer. As thus far employed for hard stones it is of circular form, a steel disk of about 2 meters diameter, rotated by steam power, and having set in its edge, as teeth, 200 common diamond crystals, worth about $2.50 a carat. It is run at 300 turns a minute, at which rate it advances into hard stone about 1 foot in that time. For soft stones every fifth tooth is a diamond, the other teeth being of steel, and the rate of advance is much less; but at only twelve revolutions a minute this saw advances about 3 feet. These have been used in the shops at the Champs-Élysées for the past year with entire satisfaction, doing all sorts of stone cutting and dressing with sharp, clean outlines and at a cost of but one-eighth to one-tenth as compared with hand labor. An alternating saw of the same character, to cut blocks of stone several feet in height, is now to be set up.

CORUNDUM.

SAPPHIRES IN MONTANA.

A report has lately been made upon the extensive sapphire and gold mining property on Yogo Creek, in Fergus and Meagher counties, Montana, which also comprises the locality of the sapphires of that district referred to in the report for 1896.[1] The report gives many particulars as to the gold placers and the method of working them, and also treats of the sapphires, though more with reference to future than to present exploitation, and with few particulars as to color or quality. The sapphires occur in certain parts of the gold placers, and have been traced to their source in a "vein" (dike) traceable for some 3,000 feet within the property covered by the account.[2] Mr. Barnes, the engineer, states that two shafts have been sunk in this "vein," one of them over 60 feet deep, showing the size of the vein and the quality and amount of sapphires contained in it to continue unchanged to that depth. The rock above is soft, but becomes harder in descending, so that it is difficult to mine and impossible to wash when brought up. Exposed to the air, however, it disintegrates, and the stones are then easily washed out. As soon as the rather limited surface deposits are exhausted, therefore, he considers that mining by shafts, levels, and stopes will be permanently profitable. The season for outdoor operations is from five to seven months; but shaft mining can be carried on in the winter, the material being thrown out to freeze and thaw, pending a washing season in the spring and summer. An immense iron pipe system and special mining facilities have been introduced, and a greater yield is expected in 1899.

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[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V, p. 22.

[2] Ibid., p. 22.

The total amount reported as taken out during the year 1898 is 425,776 carats. Of these 2,099 were of extra fine quality—rated A 1 in the statement—25,646 were of first grade, and 101,169 were of second grade. The remainder, nearly 300,000 carats, were chiefly what are known as "culls"—small, flat, hexagonal crystals, used for watch jewels—with some of still inferior grade. Among the finer stones were some sapphires equal in color and brilliancy to any known; but unfortunately all were of small size, the largest averaging between 1 and 2 carats each. The stones are all sent to the company's offices in London, and thence to the Continent for cutting. The stones are then sorted, and the bulk of the finer ones are reimported to the United States; the poorer stones could not be cut economically enough in this country. The yield of the year for the State of Montana is estimated to be fully ten times that of all the sapphires previously found there.

ORIGIN OF CORUNDUM.

A valuable paper has recently appeared on the manner of formation of the corundum deposits of North Carolina, by Mr. J. H. Pratt, of the geological survey of that State.[1] It is coming to be seen more and more clearly that the same material may be produced in different ways, and that determinations as to its origin in one locality may be entirely inapplicable to that in another locality. This fact has been already illustrated by the article of Professor Derby, previously referred to, on the origin of the diamonds of Brazil as compared with those of Africa. The occurrence of corundum in association with crystalline limestones, as in Burma and in Orange County, New York, is widely different from its relations in the southern Appalachians or in Montana. The article of Messrs. Brown and Judd, referred to in this report for 1896,[2] discussed elaborately the mode of origin of the Burma rubies as a product of alteration. The Montana sapphires, on the other hand, are clearly seen to be crystallized out from dikes of igneous rock.[3] Mr. Pratt, in his recent article, goes into a very minute examination of the occurrence and associations of the southern corundum in relation to the "dunite" rocks, which are regarded as clearly a form of peridotite in which the olivine is so abundant as to constitute the mass of the rock, though frequently altered to serpentine. These dunites, according to Mr. Pratt and to other recent observers, are clearly igneous outbreaks and intrusions through and into the gneisses of the region, and the corundum has crystallized out from them in the process of cooling. The experiments of Morozcevicz,[4] as to the solubility of aluminum in basic molten glass and its separation on cooling, form the basis of

[1] On the origin of the corundum associated with the Peridotites of North Carolina, by J. H. Pratt: Am. Jour. Sci., Vol. VI, Part IV, p. 59.

[2] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III, pp. 905-906.

[3] Sixteenth Ann. Rept. U. S. Geol. Survey, Part IV, p. 599; Eighteenth Ann. Rept. U. S. Geol. Survey, Part V, pp. 21-23.

[4] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V, p. 23.

Mr. Pratt's argument. He traces two types of corundum veins, those between gneiss and dunite, which he calls contact veins, and those entirely in dunite, termed dunite veins, each with various combinations and alteration products flanking them, viz, chlorites, vermiculites, etc., the relations of which are discussed. The separation of the corundum from the fluid mass of intruded dunite would begin at the outer or first-cooled portions and form a peripheral zone, while in some cases it would extend inward and downward into the mass of dunite for a greater or less distance. Erosion of the upper portions of such a mass would remove the top or crest of the peripheral zone and leave the wall portions as contact veins and the penetrating portions as dunite veins, just as now found, with their original connection obliterated. The contact veins appear to strike downward indefinitely, while the dunite veins gradually narrow and "pinch out"—a condition well explained by this theory. The view that the separation of the alumina would take place in a peripheral zone is supported by comparison with recent researches by Messrs. Vogt and Adams on the separation of sulphide ores from molten gabbros, in which this mode of differentiation is shown to have occurred in the process of cooling, and it appears to correspond closely in many respects with the position and relations of these corundum deposits.

PRODUCTION OF CORUNDUM.

NORTH CAROLINA.

Mr. T. K. Bruner, of Raleigh, North Carolina, says in regard to the corundum at Corundum Hill, Macon County, North Carolina, that he is informed that last year's production "amounted to several thousand dollars."

ALASKA.

During the last year the writer has seen good gray and pink specimens of asteriated corundum from a locality on Copper River, in the Juneau Indian Reservation, Alaska.

ONTARIO.

The corundum found in Canada, in the counties of Hastings and Renfrew, Ontario, was briefly referred to in the last report.[1] Further investigation has been made under direction of the Dominion Government, and it seems as though the yield may prove highly important. A full account has been published by Mr. Archibald Blue, of Toronto, in the transactions of the American Institute of Mining Engineers.[2] In that paper, after treating of the occurrence of corundum in other regions, especially in the United States and in farther India, a sketch

[1] Nineteenth Ann. Rept. U. S. Geol. Survey, Part VI, pp. 11-12.
[2] Buffalo meeting, October, 1898.

is given of the gradual recognition of its presence in Ontario. Occasional observations had been made for some fifty years, but only recently has its abundance or its importance been recognized. The first notice of corundum crystals was by the late Dr. T. Sterry Hunt, who found them, with green diopside and other minerals, in a crystalline limestone in Burgess Township, in 1847, while engaged in a geological reconnaissance with the late Dr. Wilson, of Perth. In 1876 Henry Robillard, a farmer in Raglan Township, Renfrew County, had his attention called to a rock full of curious crystals, "like cruet stoppers," which were pronounced by a local "expert" to be apatite, and for some years efforts were made to sell the property as an apatite mine, very naturally without success.

Two years ago the mineral was identified by Professor Miller as corundum. In 1887 some bowlders of the rare rock nepheline-syenite, containing corundum crystals, were found on the shore of Lake Ontario, near Cobourg, by Professor Coleman, of the School of Practical Science at Toronto. These were recently identified with a rock found in place by Mr. Blue, in Dungannon Township, where it forms a large outcrop. About the same time Mr. Armstrong, a farmer, discovered corundum in Carlow Township, Hastings County, but did not know its character. Specimens lately came into possession of Mr. Ferrier, lithologist of the Geological Survey, who recognized them and at once began investigation. Guided by Mr. Armstrong, he found the locality in 1896, and its importance was then established.

In 1853 the late Mr. Alexander Murray made a geological reconnoissance of the country between the Ottawa and Georgian Bay, but the results were very general and of little practical consequence. Forty years later, in 1893, the Dominion geological survey delegated Dr. Frank D. Adams to make a geological reconnoissance of the same region, and he, with his assistants, has since that time been engaged upon the work. The area examined covers about 3,500 square miles, its four corners being in the townships of Digby, Finlayson, Hagarty, and Grimsthorpe. The northern part of the area is Laurentian, while the southern and eastern portions are occupied by limestones and gneisses of the Grenville series. In the townships of Faraday and Dungannon a large development of nepheline-syenite was discovered and traced for 7 miles in an east and west course.

During the last two seasons Prof. W. G. Miller, of the Kingston School of Mining, has been engaged, for the Ontario government, in a special investigation of the occurrences of corundum. From the first point of discovery in Carlow, above referred to, he traced the corundiferous belt eastward across that and the adjoining townships, Raglan and Lyndoch, to the shore of Clear Lake, near Sebastopol, in Renfrew County, a distance of 30 miles. Its width varies from a half mile to 3 miles or more, and its area covers some 60,000 acres. During his second year Professor Miller was able to trace it in the other direction from Carlow as far as Glamorgan Township, in Haliburton County, thus making a total length of 75 miles, and finding a greater breadth in the region traversed before. Corundum occurs at many points in the western portion, and largely at Dungannon. The rock is chiefly nepheline-syenite, and it occupies nearly 300 square miles. Over most of this region the mineral rights are held by the Crown.

Another belt of similar rock, with some corundum, has been located in Peterboro County, at Methuen, some 45 miles southwest from Carlow. This has been traced by Professor Miller for 6 miles, with a width of 2 miles, in a northeast and southwest course along the Blue Mountains, to the shore of Stony Lake.

Mr. Blue then describes more particularly his own observations at several points along the greater belt, viz, the Block location in Brudenell Township, the Robillard hill in Raglan Township, the Armstrong location in Carlow Township, and the Dungannon occurrence near York River, the principal affluent of the Madawaska. At the first of these the crystals are thickly studded in syenite rock, with outcrops of nepheline-syenite close by. At the second the crystals are larger, running up from small sizes to five inches long and half that diameter. They are in syenite wherever it outcrops for a mile along the hillside. They are also in nepheline-syenite, though smaller, but finely shaped. The corundum forms at times one-third of the rock mass, and the quantity in sight is enormous. At the Armstrong place a fine exposure some 300 feet long by 30 feet high is shown by the scaling off of the rock. Here the gneiss has been thrown into an arch by an upthrust of a mass of syenite, which in its turn has been cut by a dike of pegmatite. Corundum crystals abound in the exposed face of the syenite, and are also seen in the pegmatite where it joins the syenite. The rock from this point, taken without selection and tested at the Kingston School of Mining, yielded from 12.75 to 15.5 per cent of corundum. The Dungannon locality is a ridge of nepheline-syenite nearly 100 feet wide and half that height, thickly strewn with small crystals of corundum of pearly to blue tints, sometimes partly altered to a white mica (damourite?). A sample examined yielded 10 per cent of the mineral and was remarkably free from iron. As the nepheline gangue itself has 30 per cent of alumina, Mr. Blue suggests that this rock may prove a valuable ore, especially on account of the absence of iron.

The remainder of the article deals in part with the question of the manufacture of aluminum from corundum. In the ten years from 1887 to 1897 the production of aluminum in the United States advanced from 19,000 pounds to 4,000,000 pounds, while the price fell from $3.42 to 37½ cents a pound. So great a progress in so short a time implies a very rapid future development in the use of this metal. The Canadian corundum appears to be remarkably well adapted as an ore, from the readiness with which it can be separated from the gangue and from the absence of adhering products of alteration. These points are also of importance in the preparation of abrasives.

Mill tests have also been conducted under Professor DeKalb, of the engineering department of the Kingston School of Mining, to ascertain the proportion of corundum in the dike rock, the best methods of separating it, etc., with results that appear very promising as to the commercial value of the deposits. The tests indicate that the cost of milling need not exceed $1 a ton, and on a large scale might be considerably less, yielding 300 pounds of nearly pure corundum to a ton of rock, making an average of 15 per cent. Analyses made last winter at Kingston have produced corundum as fine as 99.6. If it can be worked freely at such rates as these, the material may be of great importance, not only as an abrasive but as an ore, containing as it does 53 per cent of aluminum, while bauxite and cryolite—the present main sources—have but 26 and 13 per cent, respectively. The district has abundant water power from the Madawaska River and its tributaries, which fact is of importance in the cost of milling and concentrating. It is suggested, as nepheline fuses at a low heat and as much as 25 per cent of corundum has been found in the nepheline gangue, that the corundum be separated by fusing the nepheline, which does not injure the corundum.

No gem material has thus far been obtained; but there is hope that some may be found by further examination of localities

RUBY.

BURMA.

The report of the Burma Ruby Mining Company for the year 1897 was very discouraging. Neither the reduction of the capital nor the new arrangements with the Indian Government were able to prevent a deficit in the year's returns, which amounted to £8,102, and, even deducting the surplus left from capital reduction of £5,598, a net loss of £2,504 remains. The company's income from license fees of native miners was so reduced by the prostration and distress caused by plague and famine that it was less than half that of the previous year—£9,976 in 1897 against £22,534 in 1896—and barely one-third of that of the year before, when it was £28,277. This is the company whose stock was so tumultuously taken up at enormous premiums on its first organization a few years ago, but which has never yielded a dividend.

SIAM.

During the last year an important account has appeared concerning the ruby and sapphire workings in Siam, by Mr. H. Warington Smyth, F. G. S., formerly director of the department of mines in that country.[1] Mr. Smyth visited and examined two or three localities more or less noted for these minerals. He found one to be a myth, with little or no foundation. To two—the celebrated Chantabun region, and another

[1] Five Years in Siam (1891-1896), by H. Warington Smyth, F. G. S., etc.; 2 vols.; London, John Murray, 1898.

some 600 miles to the north along the Mekong (or Cambodia) River, where it forms the boundary between the French possessions of Upper Anam and the northern extremity of Siamese territory, close to the border of Burmah—he gave careful attention. This latter locality he found to be of no great importance for sapphires, although it has yielded some, and of no importance at all for rubies. Of the Chantabun region he gives quite a full account. Lying on the east side of the Gulf of Siam, between 12° and 13° north latitude, about 125 miles due southeast from Bangkok, it extends into the interior for a considerable distance eastward toward Battambang and the borders of (French) Cambodia. It is divided by the Patat range of hills, running nearly north and south and forming the divide between the streams that flow westward into Gulf of Siam and those that are affluents of the Lower Mekong (or Cambodia) River to the east. It has been generally stated, and was so mentioned in an account given in the Seventeenth Annual Report of the United States Geological Survey, Part III (continued), page 907, that the rubies are found only on the western or gulf side of this dividing range and the sapphires on the eastern or inland side, but Mr. Smyth found this to be not altogether the case, as some fine ruby mines are worked on the interior slope, at its southern portion, on the upper waters of the Battambang River, there called the Klong Yai.

The gems are worked partly in the stream beds and partly in a definite layer that underlies much of the district at varying depths. There seem, indeed, to be frequently two gem layers, the upper one near the surface, irregular and "patchy" in distribution, doubtless due to erosion, and the other lying deeper under several feet of clay (sometimes with bowlders), and being clearly a decomposition product of an underlying basalt. Mr. Smyth describes this rock as very hard when exposed, but when encountered beneath the ruby layer, while its aspect is precisely the same, the hammer sinks into it like a paste, though every grain and crystal is apparently in situ. The ruby layer itself is a tenacious clay with harder fragments not all worn.

The basalt, sometimes hard and ringing and at other times in various degrees of decomposition, as described, is the general country rock. The hills and ridges show hard quartzite, which is perhaps an altered sandstone. No absolute recognition of the gem in the basalt rock has been noted, though hercynite and augite crystals are seen on weathered surfaces. In the ruby layer occur also poor sapphires, ordinary corundum, topaz, zircon, and ilmenite, and at some points magnetite and handsome garnets—occasionally sold by the natives to unskilled purchasers as rubies. Lower down in the valleys there is evidence of stream action in transporting and redistributing these hill-slope deposits, which are at first but little changed from the actual decomposed basalt. Mr. Smyth thinks that the streams at some places are even now redepositing in their beds gems which have been washed out from the edges of the higher and older deposits, which he regards as antedating the present lines of drainage.

These are the conditions on the west of the Patat hills in the ruby districts of Chantabun and Krat. On the east lies the Pailin district, chiefly, though, as above stated, not exclusively, yielding sapphires. Here the general facts are similar, though with many local variations which it is impossible to specify here. Again the two layers are noted, the one irregularly distributed near the surface, the other beneath several feet of clay and itself consisting of clay, doubtless derived from decomposing basalt and containing magnetite crystals and what Mr. Smyth likens to concretionary nodules or decomposed pebbles—probably the rounded forms so frequently assumed by the more resisting portions of decaying igneous rocks.

The other district, far to the north and inland along the Upper Mekong, has yielded some sapphires, but no rubies of any account. The mode of occurrence is in general similar in stream beds and in a definite layer from 12 to 20 feet below the surface. Some Burmese Shans who had had experience in gem mining, recognized small rolled crystals of hercynite in the beds of streams flowing into the Mekong from the west. They had learned to associate these with rubies and sapphires, and they searched until they found the gem layer, which is rather gravelly and full of pebbles and fragments of basalt, which forms the country rock here, as at Chantabun and Pailin, and decomposes to a claylike substance in the same way. It underlies the gem gravel and forms "a long flat-topped hill, in which all the gem-bearing streams have their rise," evidently a great outflow sheet. It is described as "a glassy basalt (porphyritic olivines and augites, in a base of lath-shaped feldspars, augite, magnetite, and glass),"[1] much like that of Chantabun.

Mr. Smyth notes rather a curious difference between rubies and sapphires, in that the latter are often found as entire rolled crystals, their hexagonal form showing distinctly even when much worn by attrition, while rubies appear far more brittle and are usually found in fragments. "In Siam," he says, "the fault of the sapphire is generally in its coloring; of the ruby, in the number of its fractures."

In both these gem districts the prospectors and workers are almost entirely the Shan people—the natives of the region known as the Shan States, in the extreme northern part of Siam, and beyond on both sides of the upper Mekong, chiefly in Burma. These people are very sturdy, active, and independent, and possess remarkable ability in searching for gems—amounting to a kind of enthusiasm—and in judging of their value when found. They are almost the only people who can live and work in the diggings in the pestilential climate of the Chantabun region, which is almost unendurable to Europeans and very wearing on even the native tribes. They are spirited and independent in a quiet, determined way, and will brook no harsh or unfair treatment or oppressive restrictions. Mr. Smyth describes the manner

[1] Prof. Henry Louis, Mineralogical Magazine, Vol. X, No. 48.

in which this quality was shown when the company that has lately secured control of much of the Chantabun region undertook to impose some restrictions on the freedom of the Shan workers, such as their selling whatever they found to a company's agent at his own valuation, attempting the right of search, and so forth. The result was simply a departure of the men for other fields or for their Burman homes, leaving the mines almost without workers. At one of the principal points he found only 200 diggers, instead of 2,800, and at another he found only 54, instead of 1,300, the desertion being due to these causes. Yet the Shans are ready enough to respond to fair treatment, and Mr. Smyth emphasizes the fact that the success of European companies in Siam will depend largely on their recognition and consideration of the rights of these people, who alone can really operate the mines.

EMERALD AND BERYL.

The emeralds of the ancient world all appear to have come from the mines of Upper Egypt. They were in use from very remote antiquity, and were greatly prized down to the later Roman and Byzantine times. The locality was then, for some reason, gradually abandoned, and it became so completely lost that the source of emeralds was long unknown. When they were found in the New World, derived from the mines near Bogota, in Colombia, it was imagined by many that these gems had formerly reached Europe from Eastern Asia by trade with America across the Pacific. The Ural emerald mines were not discovered until later, and have not been worked for years, so that Colombia has been practically the only modern source of the gems. Some years ago the ancient Egyptian mines were rediscovered by M. Caillaud, and the mystery of the former source was thus solved. It is now announced that the khedival government has granted a concession to an English syndicate, of which Mr. Streeter, the eminent jeweler and gem expert of London, is a leading member, to reopen and work these mines. They are situated in a depression in a range of hills or mountains of metamorphic rocks lying parallel to the Red Sea. There are two principal centers—that of Jebel Zabara, where M. Caillaud made his former discovery, and another some 10 miles farther south, named Sikal or Sikali. The results of this enterprise will be awaited with interest.

In 1898 the Russian mines at Takowaja have been opened up and considerable work done with some, even if not with flattering results. The mines at Untersulzbachthal in the Tyrol have also been reopened and worked, but with little financial success up to date.

New Milford, Connecticut, is yielding some fine material. During the last year, as stated by Mr. S. C. Wilson, there has been produced 200 pounds of aquamarine, valued at $400, and about 20 pounds of golden beryl, also worth $400.

In North Carolina the workings for beryl in Mitchell, Yancey, Macon, and Iredell counties, according to Mr. T. K. Bruner, of Raleigh, produced about $1,000 worth last year.

In a paper on Notes on North Carolina Minerals, by J. H. Pratt,[1] the occurrence of emeralds in Mitchell County is described. This is the same occurrence previously noted in this report for 1894.

Mr. Pratt states that the vein carrying beryl is of a pegmatitic character, consisting chiefly of quartz and an albite feldspar, with tourmaline, garnet, and the beryl as accessory minerals, the country rock being gneiss and biotite schist. The writer has seen many specimens from this locality, but only few that afford even small gems.

TOURMALINE.

The celebrated locality at Mount Mica, Oxford County, Maine, has been worked during the year past with fair success, and also that at Haddam Neck, Connecticut.

The exploitation of the Mount Mica locality during recent years has been by no means for the commercial value only of the gem material sought or found, but largely in the interest of science—a fact of almost unique interest in mining operations. In 1898 hundreds of tons of rock were blasted from the eastern side of the ledge, but at first with small result. By August and September, however, cavities were struck containing fine crystals—dark blue-green, green, and red. Some of these were magnificent as specimens, 9 or 10 inches long and 3 inches in diameter, but not of gem quality, the gem material coming chiefly from smaller crystals. In October deeper cavities were reached, with crystals of red and blue-green that yielded some fine gems. Many of these crystals were of extreme beauty, and characteristic in their color variations—pink at the base and grass-green above, with a yellow-green zone between; this latter has appeared in several cases this year, while a few years ago blue central bands occurred. A crystal 6 inches long and half an inch wide was rich clear blue, with an inch of red at the base; another, blue in its lower half, passing through white and pink to a grass-green at the upper end. The tints and combinations vary greatly in different cavities. Some colorless ones (achroites) were obtained, but most of the gem material was green. The total value for the year is estimated at over $2,000.

A special exhibition of American colored tourmalines, both cut and uncut, from this locality and that of Haddam, Connecticut, was made to the American Association for the Advancement of Science during its session at Boston in August, 1898. This was under the direction of Mr. Augustus C. Hamlin, of Paris, Maine, and also in connection with the Garland-Hamlin tourmaline collection belonging to Harvard University, with other material displayed for the occasion.

[1] Journal of the Elisha Mitchell Scientific Society, Vol. XIV, Part II, April, 1898, pp. 61-81.

An important article on the chemical composition of tourmaline, by Prof. S. L. Penfield and H. W. Foote, has lately appeared.[1] In this extended and exhaustive paper the authors begin by stating some of the difficulties that have stood in the way of the exact analysis of tourmaline and made its chemical formula a matter of some uncertainty hitherto. Passing over the earliest analyses, by Vauquelin and Klaproth, before lithium was known, or boron recognized as a constituent, and beginning in 1818, with the discovery of the former and the finding of both as present in tourmalines, the first real series of analyses was published by Gmelin in 1827. In 1845 another set of analyses was made by Hermann, in which he showed the iron to be ferrous. In 1850 Rammelsberg published thirty determinations, made with great care, but still defective in many particulars; these he reviewed and revised in 1870, reaching conclusions much more satisfactory, and developing formulas for the principal varieties that probably are nearly correct.

In 1888 Professor Riggs published twenty analyses of American tourmalines, executed with great care in the laboratory of the United States Geological Survey, and developed a general graphic formula, which several German analysts discussed, partly sustaining and partly criticising the work of Riggs. In 1895 Prof. F. W. Clarke discussed the whole subject further, and proposed four structural formulas. Comparing the results of these and some other analysts, it appears that all tend toward a single type of acid from which, by various replacements, the several varieties of tourmaline are derivable. This acid is given slightly different formulas, but one or two appear several times, from Rammelsberg down, which are—$H_{20}B_2Si_4O_{20}$ and $H_{20}B_2Si_4O_{21}$.

The authors concluded that the present need was not so much for many new analyses as for a few made with extreme care on material of special purity. They first selected for this purpose perfectly colorless tourmaline (achroite) from Dekalb, New York, and transparent green crystals from Haddam Neck, Connecticut. The methods used and precautions employed in the analyses are described in detail. The results proved so close to previous determinations that further analysis was deemed needless, and the work of studying the theoretical composition was taken up in the light of all the previous discussions.

The work of the various authorities cited is then reviewed and compared. The general result arrived at is that "all tourmalines are derivatives of a complex boro-silicic acid, $H_{20}B_2Si_4O_{21}$" (see above), and that this formula is not likely to be altered by future analysis, although its structure may be more fully understood. Two of the hydrogens are not replaced in any of the varieties, but always appear in hydroxyl; whence it is judged that they belong with the boron, and the acid becomes $H_{18}(BOH)_2Si_4O_{19}$.

Of this, aluminum replaces one-half or more of the hydrogens; and the view is reached that "an aluminum boro-silicic acid $H_9Al_3(BOH)_2$

[1] Am. Jour. Sci., February, 1899, pp. 97-125.

Si_4O_{19} is characteristic for all varieties of tourmaline." The structural formula for this body is then given, and the idea set forth that the "mass-effect" of this complex radical, with its valence of nine, controls or dominates all types of tourmaline, in their crystallographic, electrical, and optical properties, irrespective of the proportions in which the nine hydrogens are replaced by metals—aluminum, magnesium, iron, or alkalies.

Then follows a comparison of analyses, and a discussion as to the replacements just alluded to, showing the relations of the well-known types of (1) lithia tourmalines, (2) iron tourmalines, (3) magnesia-iron tourmalines, and (4) magnesia tourmalines. In all these alumina is present also, in ratios diminishing, from group (1) to group (4), from 6.7 to 1.6; and the alkaline metals diminish in nearly parallel ratios. The fusibility is highest in group (1), and falls with the increase of iron and magnesia.

The geological occurrence of these groups is of interest. The lithia group (1), often delicately colored and at times clear and gem-like, is associated in pegmatite veins with soda and potash feldspars, lepidolite, and muscovite; the second and third groups are the ordinary black or very dark tourmalines of granites, gneisses, and schists, and also occur somewhat in pegmatites, with the first group; while those of group (4) occur chiefly in crystalline magnesian limestones, associated with phlogopite mica, pyroxene, amphibole, scapolite, etc. These, and also the groups (2) and (3), are regarded as due to heated water vapors, containing fluorine compounds and boracic acid, given off during the slow cooling of intruded igneous masses; and cases are referred to in which such contact metamorphisms have been noted.

Further discussion is then given to the suggestion before alluded to, of the "mass-effect" of a highly complex radical in determining the physical characters of closely related varieties of minerals, as exemplified not only in tourmalines but in other groups, even of species that are nearly allied, as in the garnet-sodalite group, which is cited as an illustration. Even more, such a controlling radical appears to influence the chemical characters also, in allowing metals to enter into partial isomorphous replacements which they would not do in simpler salts. A very interesting field is thus opened for study.

The paper is one of much importance, and gives a better understanding of the tourmaline group than has ever before been reached.

TURQUOISE.

In last year's report mention was made of new turquoise localities in Nevada and southern California. Within the last year further discoveries have been made in both States and in Arizona; and it appears that this mineral is widely distributed through the region where these States and Arizona adjoin or approach one another. The chief localities announced are three—at a point in Nevada 18 miles east of the town of Vanderbilt, California; at Turquoise Mountain, Arizona; and throughout a considerable region south of Death Valley, in San Bernardino County, California, west of the Colorado River, but near the point of junction of the States and Territory above named.

The Nevada locality was discovered by Mr. George Simmons, a prospector familiar with the region. It lies about 5,000 feet above sea level, some 12 miles east of the California line. Mr. Simmons going out farther than usual on the desert after a rain, found a mountain showing "float-rock" with blue-green stains, suggesting copper; but as he had seen the turquoise mines in New Mexico, he recognized these as probably the same thing, and ere long, by searching, found it in place.

He sent specimens to friends in New Mexico, was assured of its genuineness, and at once located a claim and began work. He subsequently took a quantity of turquoises to Denver and had them cut, and later engaged a skilled German lapidary to come to the mine with him and do the cutting on the spot. This arrangement has been carried out, and there was at last accounts a well-fitted-up establishment on the side of the mountain, some distance below the mine, where the gems procured were cut and polished for direct shipment and sale to jewelers. One stone, found in the first explorations, of a pale, robin's-egg color, weighed 64½ carats, and another 107 carats.

The mine is high up on the mountain side, and the gem-bearing rock is described very vaguely as "a trachyte, or white, soft conglomerate," traversed by blue-green veins and streaks, which here and there expand into "kernels" or nodules, the turquoise being covered with a white "talcose" coating. Comparing this with the accounts of other localities in this report, it appears that they are generally similar, and the "chalky conglomerate" is doubtless a decomposed quartzite or quartzose pegmatite. Seams of hard, white quartz and oxide of iron stains, where pyrite crystals have decomposed and left casts, are associated with the richest parts of the gem rock, and are regarded as "signs."

As elsewhere, ancient working is evident here, from old dumps, excavations, stone tools, and a "village site" on a flat ledge lower down the mountain, with mortars, pottery, etc., and rubbing and polishing stones of especial interest. Nothing of this last kind is reported from the great mining sites in southern California, nor are there any rock carvings reported here; whence it would seem that these localities had been worked by different people.

A very interesting announcement comes from Prof. E. H. Barbour, of Lincoln, Nebraska, as to the occurrence of turquoise in the form of rounded pebbles in the drift in Brown County, Nebraska. They are said to be of fine quality, and several pieces have been cut as gems. This observation points to an entirely new and unsuspected locality for turquoise in the northern part of the country. Other minerals occur with it—barite, celestite, selenite, calcite, pyrite, etc.—which together may aid in the search for the actual source.

Turquoise in Arizona has been known for many years, but not worked to any important extent. The localities known as Turquoise Mountain, in Cochise County, and Mineral Park, in Mohave County, have both been repeatedly noticed, the former as long ago as 1858, by Prof. William P. Blake, and the latter as yielding some good material in 1883. During the last year further discoveries have been made and claims located at the former locality, which is only some 20 miles from the town of Kingman, and is now but 2 miles from a branch railroad to Chloride.

Turquoise Mountain is one of the peaks of the Cerbat Range, which runs a little west of north from Kingman toward the Colorado River. It presents no peculiar features, save much "float rock" showing traces of turquoise, remains of ancient dumps and workings, and terraced camping grounds where the aboriginal miners dwelt. On one of these terraces a cutting was made that opened an ancient "drift," about 5 feet wide, which was uncovered for 8 feet. This old shaft contained many stone hammers and chisels, all worn by use, and had been filled to within a foot or two of the top—evidently intentionally—with turquoise "float" and débris. The indications showed that the method of building fires against the rock had been pursued, as in the New Mexican turquoise mines, and then quenching them with water, and breaking up the masses thus loosened with the stone tools. Some of the latter were of great size and could have been used only by large and powerful men.

The new cutting was carried 25 feet directly into the mountain side, traversing many veins and seams of turquoise. Some of these were regular planes, others varied in thickness, developing into nodular masses. These nodules which yield the larger and thicker stones were found in a kaolin-like material and were buff or whitish externally, but blue within.[1] Toward the surface the turquoise was more or less broken up and decomposed, and the blue color altered to green; but both color and hardness improved on going deeper into the rock. The latter is described as a partly decomposed gold-bearing quartz, occasionally becoming rose quartz; farther up the mountain are porphyry dikes. It is proposed to use the blue-veined turquoise-bearing rock as a beautiful ornamental stone, and blocks of it have already been sent to New York to be worked into pedestals, mantels, etc.

One mass of pure turquoise of unusual size, though not of gem quality, weighing 9 ounces, was sent from this locality to Prof. William P. Blake, who said that it was the largest unmixed piece that he had ever seen, and regarded it as highly promising for deeper working.

Mr. Frank Aley, of Globe, Arizona, also reports an ancient mine as discovered in that vicinity with hundreds of tons of rock excavated, and the stone tools of the old workers. No particulars are as yet given, however, as to its present or prospective value.

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[1] With this account may be compared that of the Nishapur occurrence as given in this report for 1896: Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 31, 32.

During 1898 turquoise mining was carried on to some extent at Las Cruces, New Mexico, 55 miles northeast of El Paso, by A. De Menles. Unfortunately, operations were brought to a close by the assassination of the discoverer and owner of the mine.

Reference was made in this report for last year[1] to a turquoise discovery at Manvel, California, near Death Valley, with traces of old workings, and also to specimens from another point in the same neighborhood being in the California State Museum. During the spring of 1898 much more extended discoveries were announced in that region and important explorations made, with a good deal of excitement in some of the San Francisco papers over both the gem prospects and the archæological remains. This new turquoise district covers quite an extensive area in the northeastern part of San Bernardino County, near the point of junction of California with Arizona and Nevada. It is west of the Colorado River and some 60 miles northward from Manvel, the nearest railroad station, by wagon and trail over a very rugged and desert country.

On the reports of prospectors reaching San Francisco as to a great group of ancient turquoise mines with cave dwellings, stone implements, and rocks inscribed with inscriptions, an exploring party was organized by the San Francisco Call, and Mr. Gustav Eisen, of the California Academy of Sciences, became attached to it as archæological expert.

The turquoise district, as described by Mr. Eisen and others of the party, occupies an area of 30 or 40 miles in extent, but the best mines are in a smaller section, about 15 miles long by 3 or 4 in width. The region is conspicuously volcanic in aspect, being largely covered with outflows of trap or basaltic rock reaching outward from a central group of extinct craters. These flows extend for many miles in all directions, and appear as long low ridges, separated by valleys and canyons of the wildest character. Among these basaltic rocks and in the valleys are found smaller areas of low, rounded hills of decomposed sandstones and porphyries, traversed at times by ledges of harder crystalline rocks, quartzites, and schists. In the canyons and on the sides of these hills are the old turquoise mines, appearing as saucer-like pits, from 15 to 30 feet across and of half that depth, but generally much filled up with débris. They are scattered about everywhere. Around them the ground consists of disintegrated quartz rock, like sand or gravel, full of fragments and little nodules of turquoise. Whenever the quartzite ledges outcrop distinctly they show the blue veins of turquoise, sometimes in narrow seams, sometimes on nodules or in pockets. The mode of occurrence appears closely to resemble that at Turquoise Mountain, Arizona, elsewhere described in this report. A few prospectors have dug into the old, half-filled depressions and found stones of good color and quality, and ordinary ones may be picked up almost anywhere out

[1] Nineteenth Ann. Rep., Part VI (cont'd), p. 504.

of the decomposed quartz. Stone tools are abundant in the old workings, and the indications are plain that this locality was exploited on a great scale and probably for a long period, and must have been an important source of the turquoise used among the ancient Mexicans.

From an archæological point of view this locality possesses remarkable interest. The canyon walls are full of caverns, now filled up to a depth of several feet with apparently wind-blown sand and dust, but whose blackened roofs and rudely sculptured walls indicate that they were occupied for a long time by the people who worked the mines. In the blown sand were found stone implements and pottery fragments of rude type, incised but not painted. The openings to these caves are partially closed by roughly built walls composed of trap blocks piled upon one another with no attempt at fitting and no cement, but evidently made as a mere rude protection against weather and wild beasts.

The tools, found partly in the caves and largely in the mine pits, are carefully wrought and polished from hard basalt or trap, chiefly hammers and adzes or axes, generally grooved for a handle and often of large size. Some are beautifully perfect, others much worn and battered by use.

The most impressive feature, however, is the abundance of rock carvings in the whole region. These are very varied, conspicuous, and peculiar, while elsewhere they are very rare. Some are recognizable as "Aztec water signs," pointing the way to springs; but most of them are unlike any others known, and furnish a most interesting problem to American archæologists. They are numbered by many thousands, carved in the hard basalt of the cliffs or, more frequently, on large blocks of the same rock that have fallen and lie on the sides of the valleys. Some are combinations of lines, dots, and curves into various devices; others represent animals and men; a third and very peculiar type is that of the "shield figures," in which complex patterns of lines, circles, cross hatchings, etc., are inscribed within a shield-like outline perhaps 3 or 4 feet high.

One curious legend still exists among the neighboring Indians that is in no way improbable or inconsistent with the facts. The story was told Mr. Eisen by "Indian Johnny," son of the Piute chief, Tecopah, who died recently at a great age, and who in turn has received it from his father. Thousands of years ago, says the tale, this region was the home of the Desert Mojaves. Among them suddenly appeared, from the west or south, a strange tribe searching for precious stones among the rocks, who made friends with the Mojaves, learned about these mines, and worked them and got great quantities of stones. These people were unlike any other Indians, with lighter complexions and hair, very peaceful and industrious, and possessed of many curious arts. They made these rock carvings and taught the Mojaves the same things. This alarmed and excited the Piutes, who distrusted such strange novelties and thought them some form of insanity or bad medicine, and resolved on a war of extermination. This they undertook, and after a long and desperate contest most of the strangers and Mojaves were slain, since which time, perhaps one thousand years ago, the mines have been abandoned. Mr. Eisen connects this account with the existence of a fair and reddish-haired tribe, the Mayos (not Mayas), in parts of Sinaloa and Sonora, some of whom may have reached these mines and carried on a turquoise trade with Mexico.

GARNET.

Reference has been made by the writer in the report for 1893, and also in the last two reports,[1] to a very beautiful pale-red garnet, cutting into brilliant gems, found with the ruby corundum of Cowee Valley Macon County, North Carolina. This garnet was supposed to be almandite, and was so reported; but it now appears that it may prove to be more nearly related to pyrope, and it has lately been described under the proposed name of rhodolite, in two papers by Messrs. W. E. Hidden and J. H. Pratt.[2]

The paper describes its occurrence in the valleys of Masons Branch, a small stream flowing from Lyle Knob, a spur of the Cowee Mountains. No crystals have yet been found, nor has it been traced to its matrix, all the material thus far obtained being in rolled fragments. The color is light, often very beautiful, of rose-red and pink tints, and it possesses, when cut, a brilliancy unusual among garnets, and compared by the author to the green dematoid garnet of the Ural.

These marked peculiarities seemed to call for more detailed examination as to its precise character, and careful analyses were made. It was found not to be almandite in any ordinary acceptation and approached more nearly to pyrope from its large content of magnesia, averaging 17 per cent. The authors regard it as an intermediate type, and while not calling it a species, term it a new variety. The mean of two analyses, very close in themselves, gives true garnet ratios, which yet do not conform to either pyrope or almandite. The theory is presented that it is a mixed variety, consisting of two molecules of a magnesia-alumina garnet (pyrope) and one of an iron-alumina garnet (almandite). The results were recalculated on this hypothesis and found to accord quite closely with the theoretical composition of such a substance. The formula thus indicated is the following:

$$2\ Mg_3Al_2.\quad Fe_3Al_2\ (SiO_4)_3.$$

It may be here noted that several analyses of pyrope, among those given in Dana's Mineralogy, approach quite closely to the composition of this new variety in their lower percentage of magnesia and higher

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V. (cont'd), p. 19; Nineteenth Ann. Rept., Part VI. (cont'd), p. 13.

[2] Rhodolite, a new variety of garnet; Am. Jour. Sci., 4th series, Vol. V, 1898, pp. 293–296, and also in a paper on the Associated Minerals of Rhodolite, Am. Jour. Sci., Vol. VI, Dec., 1898, pp. 463–468.

amount of iron than in normal pyrope, and that these are the gem varieties from New Mexico and South Africa. This fact strongly suggests that these "Cape rubies" and "Arizona rubies" may prove to be not true pyropes, but other occurrences of the newly recognized rhodolite.

The mean of the two analyses gives the following result:

Analysis of garnet from North Carolina.

Constituent.	Per cent.
SiO_2	41.59
Al_2O_3	23.13
Fe_2O_3	1.90
FeO	15.55
MgO	17.23
CaO	.92
Total	100.32

On the theory of a mixture variety containing one molecule of almandine and two of pyrope, and recalculating the above result, with the ferric iron included with the alumina and the lime with the magnesia, the comparison appears as follows:

Theoretical and recalculated composition of North Carolina garnet.

Constituent.	Theoretical.	Recalculated.
	Per cent.	*Per cent.*
SiO_2	41.48	41.76
Al_2O_3	23.50	24.41
FeO	16.59	15.62
MgO	18.43	18.21

It will be seen by examining the analyses in Dana's Mineralogy, page 441, how markedly these results differ from normal pyrope and how near they are to analyses Nos. 7, 11, 12, and 13, as there included.

TOPAZ.

A paper has been published[1] within the last year by Mr. Arthur S. Eakle on topaz crystals in the collections of the National Museum. The discussion is entirely crystallographic, but contains much that is of interest to scientific mineralogists. After describing the forms and noting the faces on the topazes from foreign localities—Alabashka, the Ilmen Mountains, Nertchinsk, Saxony (Schneckenstein), Australia,

[1] Proc. U. S. Nat. Mus., Vol. XXI, pp. 361–369.

Japan (three localities), Brazil, and Mexico (San Luis Potosi, Zacatecas, Durango), he gives those from four North American localities—Pikes Peak and Nathrop, Colorado, the Thomas Range, Utah, and Stoneham, Maine. The first and last of these resemble those of the Ilmen Mountains, and the Nathrop and Utah crystals those of Mexico.

OLIVINE.

So much interest attaches to the remarkable occurrence of olivine in bowlders near Thetford, Vermont, that the following statement regarding the discovery and identification of it has been obtained from Prof. Oliver P. Hubbard, late of Dartmouth College, who first brought it into notice. He says:

In 1852, while driving by the farm now owned by Mr. P. W. Mont, in Thetford, Vermont, I came to a considerable rock (600 to 800 pounds) in the middle of the roadway, with a carriage track on each side (a condition of one hundred years?). Its various colors suggested a conglomerate, but removing with my sledge a scale as large as my hand, it proved trappean with nodules of olivine.

I visited the place some years later; the rock was gone—to be a header to a bar-post—and the road track was straight. I bought the rock and sent it by railroad to Dartmouth College, at Hanover, New Hampshire. At this time I discovered near by, in the meadow, a dozen similar pieces, from 800 to 2,000 pounds in weight, more or less buried. These were subsequently numbered with paint and catalogued. On splitting mine, the brilliant surfaces were found filled with nodules of olivine, of all sizes up to 4 inches in diameter. Specimens were sent to various cabinets. The olivine was analyzed in the Sheffield Scientific School, at New Haven.[1]

One mass of 1,800 pounds is now in Columbia University, New York City; one of 1,200 or 1,400 pounds is at the United States Military Academy, at West Point; another is in the American Museum of Natural History, New York City. This last presents a mass of olivine 7 by 4 inches, pale yellow green, but only transparent in part. Smaller ones of 600 pounds and less are in the University of Chicago and in the New York State Museum at Albany, New York. In August, 1896, Mr. C. H. Richards discovered in Corinth, Vermont, 20 miles north of the locality, a dike in mica slate of similar composition, from 6 to 10 feet wide, and traced it for half a mile; this is the probable source of the bowlders. He obtained here crystals of olivine measuring 2.03 by 1.82 inches.[2]

ZIRCON.

Mr. T. K. Bruner, of Raleigh, North Carolina, mentions that zircons, large and richly colored in honey-red and brown shades, have been found in Iredell County, North Carolina, some of the crystals weighing as much as 2 ounces.

[1] See Dana's Mineralogy, 4th edition, p. 185.
[2] Nature, October 25, 1897, p. 632.

QUARTZ.

ROCK CRYSTAL.

CALIFORNIA.

Mention was made in this Report for 1897, p. 13, of a discovery of remarkably large quartz crystals in California, promising to yield material suitable for crystal balls and other handsome objects. Further accounts have been received during the last year and some of the crystals cut into fine spheres. The locality is at Mokelumne Hill, Calaveras County, and the specimens are found in the compacted filling of one of the old river channels that are so marked a feature of Californian geology. Mr. John E. Burton, who is engaged in taking out the crystals, describes them as lying irregularly in every sort of position in the old filling. Some are close to the rim rock or ancient river bed, embedded in coarse colored gravel and "cement," stained and discolored externally, but in some cases clear and brilliant within. Over the "rim rock" is a cream-colored clay and then a coarse, wet sand, much compacted, in which are found clean, handsome-looking crystals, though all are muddy and require thorough washing. Two little "stopes" or partly timbered drifts have been run into this deposit for several yards, and the sides, faces, and roofs are seen to be full of crystals. A large number have been taken out and much more is in sight. One crystal measures 19 by 15 by 14 inches, another 14 by 14 by 9 inches, etc.

A number of these specimens have been sent to New York, and special machinery for cutting them into balls has been put up. One ball has been finished. It is of flawless perfection and has a diameter of 5½ inches, and is one of the finest in the country; it is valued at $3,000. Other beautiful spheres have been cut from specimens from the same California locality. Two balls of 7⅕ inches in diameter were cut also, but these were not flawless.

This is an interesting and promising addition to American minerals available in the ornamental arts, as hitherto only occasional pieces of rock crystal possessing sufficient size and transparency to serve for any such purpose have been found in the United States. Japan, Brazil, Madagascar, and the Alps have heretofore been almost the only sources.

It will be an interesting geological problem to ascertain the place of origin of these grand crystals now strewn in the old channels. As they are not much rolled, and lie so thickly in a limited space, it seems that they can not be far removed from their point of occurrence, and the suggestion arises that some cavern or open vein lined with the crystals has been cut through by the ancient stream, and perhaps entirely obliterated, near the spot where they are now found.

PHANTOM QUARTZ.

Some very fine specimens of quartz crystals showing successive stages of growth—often called "phantom crystals"—have been obtained recently from Placerville, California. A large number of these have been sent to dealers and collectors, and others are found from time to time, though only a few out of many that occur are choice enough to be valuable. They are found embedded in clay, having apparently fallen from the walls of a mine or cavity in which they occur, the precise location of which has not been stated. The crystals vary from an inch to a foot in length and from 1 to 20 pounds in weight. Some are brilliant, clear rock crystal; others smoky; others dull and opaque, or coated with a thin layer of white silica on some of the sides. All show "phantoms" more or less numerous and marked.

Some extensive work was done in mining for amethyst in the quartz vein at Denmark, Maine, and some beautiful specimens were obtained, many of gem value. Among them was a faultless polished brilliant crystal of the most intense purple, 5 inches high, 3 inches wide, 4 inches thick and equal to any crystal ever found at any known locality.

OTHER VARIETIES.

At New Milford, Connecticut, according to Mr. S. C. Wilson, smoky quartz to the amount of 200 pounds, and worth $104, has been obtained during the year.

Mr. T. K. Bruner, of Raleigh, North Carolina, states that large amethysts of good color are still found in Lincoln County, together with smoky and lighter colored varieties. It is not possible, however, to give the value of the annual product.

In a list of local minerals furnished by the Peabody Academy of Science, at Salem, Massachusetts, the following are noted among the more interesting quartz varieties: Citrine and cairngorm stone, in the Rockport Company's granite quarry at Rockport, Massachusetts; smoky quartz and morion, in the Pomroy quarry at Gloucester; hornblende in quartz, on Salem Neck, and actinolite in quartz (Thetis's hair stone), at Bass Point, Nahant.

Very fine Thetis's hair stone is reported by Mr. R. G. Coates, of Los Angeles, California, as occurring in that vicinity.

Asteriated quartz is found occasionally in North Carolina, according to Mr. T. K. Bruner, of Raleigh, but no particulars are given as to locality.

Mr. M. Braverman, of Visalia, California, reports concerning the year's output of gold quartz in that State that the value of the material suitable for cutting was about $100, found mostly at White River, in Tulare County.

In a paper on "Petroleum inclusions in quartz crystals,"[1] Mr. Charles L. Reese describes specimens from Diamond post-office, near Guntersville, Marshall County, Alabama, not far from the Tennessee line. These are clear crystals of quartz, well formed, with triangular cavities parallel to the faces, wherein occurs a brown liquid around the walls and a circular space within, which move on turning the specimen about. In one crystal—the largest, about an inch by half an inch—the liquid at first formed a globule in the cavity, but on experimenting with heat this globule burst violently and its contents gathered about the walls. The liquid shows the fluorescent green of petroleum, and some small crystals from the same place, when crushed in filter paper, gave greasy spots thereon, which smelt and burnt like petroleum. This substance also occurs in the neighborhood of the locality.

CHRYSOPRASE.

Mr. M. Braverman, of Visalia, California, reports that a new location has been found about 1 mile east of Lindsay and 18 miles south of Visalia; 500 pounds have been taken out so far, but only a small quantity of gem material was found. Work is still going on at the claim.

Prof. N. H. Winchell, of Minneapolis, Minnesota, states that jasper (bloodstone) is common in the taconyte horizon of the Animikie, associated with "banded jaspers" in large pieces, many of which are beautiful when polished.

Mr. A. Bibbins, of Baltimore, Maryland, who has made much mineralogical exploration in that vicinity, reports the occurrence of carnelian, sard, and chalcedony at "Mine Old Field," in Harford County; of jasper at Soldiers' Delight, Baltimore County, and of silicified wood as common in the Potomac group of Maryland.

OPAL (AUSTRALIAN).

A paper read by Mr. F. G. de Gipps, before the Australian Institute of Mining Engineers, gives numerous details as to the mode of occurrence of the Australian opal in the White Cliff district, near Wilcannia, New South Wales, described in this report for 1896.[2] The point there referred to, as to the relations of this field to that of Queensland, is here stated to be that the Wilcannia region lies "near the southern edge of the Cretaceous basin of the interior of Queensland, New South Wales, and South Australia." The opal district, as far as explored, is about 15 miles long and from half a mile to 2 miles wide. The rocks are Cretaceous, of varied character, and Mr. de Gipps gives curious particulars as to the bands or "layers" of opal-bearing rock, referred to in the account above cited. He finds evidence that the opal must have been deposited during a long period of time, and in a peculiar way.

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[1] Jour. Am. Chemical Soc. for October, 1898, Vol. XX, No. 10.
[2] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 30, 31.

A good deal occurs in sandstone bowlders in the Cretaceous, which are worn, rounded, and often contain Devonian fossils, and have in some cases, after the introduction of opal, been broken and recemented with opal again. Another mode of occurrence is that in "nigger-heads" rounded silicious masses, varying from 1 to 100 pounds in weight, impregnated with opal. These appear to be concretionary, judging from Mr. de Gipps's acccount that they generally contain a central portion of opalized wood, with septaria-like cracks filled with opal. The bandstones, or opaliferous layers, are harder than the adjacent strata, and contain shells and belemnites more or less altered to opal, and cracks filled with it. He also refers to it as occurring in clay, kaolin, silicious beds, and in connection with gypsum (as mentioned at Milparinka, in the account before cited).[1] He describes it as peculiarly clear when in gypsum layers, especially when the latter is in crystals. Curious masses of mixed carbonate and sulphate of lead, in flattish concretions, occur throughout the same beds, but do not seem to have any connection with the opal.

Mr. de Gipps holds that all the facts indicate that the opal was deposited in a very fluid, gelatinous condition—e. g., the presence of included fragments and particles of clay, ironstone, wood, etc., in the clear opal; also a very general stratification of it, the varying bands of color being horizontal, parallel to flat seams and transverse to vertical ones, entirely unlike the usual character of banded veins of infiltration. "This," he says, "proves that the veins and cavities have not been subject to gradual deposition from silicious matter in a circulation of water, but filled by a gelatinous solution of silica, more or less pure, which had time to settle into zones, or horizontal bands." All of it, moreover, is cracked and fissured, as though from contraction, and often refilled as by subsequent deposit.

He gives further particulars as to grades and values. But little over 5 per cent of the opal found is "precious," or suitable for jewelry; for good material the prices vary widely, up to $120 an ounce, or rarely $125. Color and "pattern" are the chief conditions of price, those stones that show red fire being most esteemed, either alone or mingled with yellow, green, or blue. "Pattern" denotes the difference in size of color, "pin fire" being where the colors are in minute points or specks, "harlequin" where they are mingled in small patches or squares, and "flash fire" where there are broad gleams of color across the stone. These three grades shade into one another more or less; the second is the rarest, and when fine and uniform, the most valued.

During 1898 great quantities of gem material were found, a single find, it is said, having yielded £12,000 to £15,000.

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd.), p. 31.

PROSOPITE.

Two or three years ago attention was called to a beautiful light-green mineral from Utah, which was thought to be probably the same as utahlite, the massive or nodular variscite described by the present writer under the former name in this report for 1894, p. 602. The exact locality of this mineral has lately been ascertained and its character has been determined to be quite different. It was procured in 1895 by Mr. T. H. Beck, of Provo, Utah, in the Dugway mining district in Tooele County, in a low range of hills in a dry desert region, associated with fluorite, native silver, and decomposed auriferous pyrite. The rock is said to be trachytic, and "slate" is also reported. The mineral proves to be the rare species prosopite, a hydrous fluoride of aluminum and calcium, colored green by some copper compound, and mingled with quartz and perhaps fluorite. It is described by Mr. W. H. Hillebrand in the American Journal of Science for January, 1899, pp. 53, 54. The analyses were at first somewhat perplexing, but after eliminating probable small admixtures, and assuming some little fluorite as contained, a result was reached that comes very close to the two previous determinations of prosopite from Saxony and Colorado, as follows:

Analysis of prosopite from several localities.

Constituent.	Altenberg.	Pikes Peak.	Utah.
	Per cent.	*Per cent.*	*Per cent.*
Al	23.37	22.02	22.74
Ca	16.19	17.28	16.85
F	35.01	33.18	29.95
H_2O	12.41	13.46	16.12
O	12.58	13.41	14.34
	99.56	99.35	100.00

The view is taken by Mr. Hillebrand that the water is probably present as hydroxyl, and the analyses favor the idea of Penfield that hydroxyl in such cases replaces part of the fluorine.

Whether this rare mineral occurs here in quantity sufficient to be of use in the ornamental arts is not ascertained, but it is an interesting and beautiful addition to North American mineralogy.

THOMSONITE.

In regard to this mineral, which has to some extent been used as a semiprecious gem stone, and sold to tourists in the Lake Superior region, Prof. N. H. Winchell, of Minneapolis, says: "That reported for several years from Minnesota (near Grand Marais) is mesolite, though thomsonite also occurs. Lintonite is worthy of being classed with the gems. It is allied to the jacksonite of Whitney." He adds that none of these minerals has as yet any commercial value, except the mesolite, which, under the name of thomsonite, is sold to some extent as a gem

From this account, these closely similar minerals would belong strictly as follows: Thomsonite, so called, under mesolite; lintonite under thomsonite proper, and jacksonite under prehnite. All are related in composition and occurrence, being hydrous alumino-silicates, but differ in details of chemical and physical structure. They, as well as chlorastrolite and zonochlorite, are all found filling amygdules in the trap rocks of the Lake Superior region, and are weathered out therefrom and rolled on the beaches. Although resembling pebbles, they are not properly such, as only their surface polish and not their rounded form is due to the action of the waves.

CHLORASTROLITE.

During 1898 search was continued for chlorastrolite at Rock Harbor, Isle Royale, Lake Superior, with excellent result. Many thousand stones were found, some of them measuring an inch or more in length, and the value of the output was several thousand dollars.

Professor Winchell, in an article on chlorastrolite and zonochlorite,[1] discusses these two minerals at some length and comes to the conclusion that the former is probably a genuine species and the latter an impure or altered material. Chlorastrolite was first discovered by Dr. C. T. Jackson and analyzed by J. D. Whitney, in 1847; in 1875 it was again analyzed by Hawes, who concluded that it was not a homogeneous mineral, and referred it to an impure variety of prehnite. Lecroix, in 1888, referred it on optical grounds to thomsonite. Dana, in his last edition (1892), placed it among doubtful species in his "Appendix to zeolites."

It occurs on the beaches of the south shore of Isle Royale, as rolled, pebble-like amygdules, and also in the trap rock. Its green color and stellate radiated structure (whence the name), with its capacity of brilliant polish, have made it a favorite "local" gem stone. It has a higher index of refraction than thomsonite, and a distinct pleochroism (light green and colorless), and the fine, compact fibers vary in brightness in convergent light. as they expose to observation the acute or the obtuse angle. The mineral has a strong individuality, alike in structure, color, and constancy of optical orientation. Professor Winchell, therefore, thinks that the impurities noted by Hawes and Lecroix were accidental, and that when analyses are made with care to exclude foreign material "its chemical characteristics will be found as distinct as its physical." In this view he is sustained by the fact that in sections made of specimens of it for the Minnesota Survey the mineral is found to be quite pure, with only a few little spherules of delessite. He

[1] Am. Geologist, Vol. XXIII, No. 2, February, 1899.

believes, therefore, that small foreign inclusions of quartz, delessite, prehnite, or oxide of iron are amply sufficient to account for its supposed want of homogeneity of composition in former analyses.

Whitney's analysis is as follows:

Analyses of chlorastrolite from Lake Superior.

Constituent.	Per cent.
SiO_2	36.99
Al_2O_3	25.49
Fe_2O_3	6.48
CaO	19.90
Na_2O	3.70
K_2O	.40
H_2O	7.22
Total	100.18
H	5.5
G	3.155

Some of the nodules lack the characteristic stellate structure and present a dull green aspect, sometimes dark, sometimes verging toward a light green like that of lintonite, or into a white structureless substance of less hardness, or a pinkish zeolitic mineral, like mesolite. These are not true chlorastrolites, and Professor Winchell thinks, after examining a large number of such forms, that "the green structureless substance is a transition stage between chlorastrolite and mesolite, the iron element prevailing on one side and not on the other." He is disposed to identify this mineral with the zonochlorite of Foote (1873), though stating that he has not been able to examine the original material so named. Hawes reported it to be not a homogeneous substance (1875), but to contain green particles disseminated in a white mineral. It is but fair to the late Professor Foote, however, to recall that his zonochlorite was not "structureless," but was named from the fact that it presented concentric layers or zones of lighter and darker shades of green.

Professor Winchell develops an interesting point, however, in his view that this undefined greenish mineral of these Isle Royale amygdules grades into mesolite on one side and into chlorastrolite on the other, "the extremes only being identifiable," and that "these two minerals are closely allied in origin, structure, and composition, differing principally in the content of iron." They sometimes occur in the same amygdule, either clearly defined or passing into each other with more or less of the green amorphous material between.

The question as to the exact nature of zonochlorite probably remains to be decided by further analyses and by the examination of thin sections. It is evidently a closely related substance, but presents a characteristic structure different from chlorastrolite, and comes from a distinct locality, Nipigon Bay, on the north shore of Lake Superior.

A company has been formed, under a New Jersey charter, to work the tungsten ores of the Hubbard mines, at Trumbull, Fairfield County, Connecticut. It may be that interesting gem minerals will be found there, as the Trumbull locality has long been famous not only for the tungsten minerals, wolfram, and scheelite, but for topaz, and also for fluorspar and its variety, chlorophane.

Transparent and nearly colorless fluorspar in pieces of 2 inches square and over, if procurable in any quantity, would be valuable in the manufacture of some forms of optical goods. A demand exists for it that can not at present be readily met.

MOLDAVITE.

The question as to the origin of moldavite, whether the nodules in which it occurs are, as has been usually supposed, rounded and water-worn pieces from an ancient glass factory, or have a meteoric character, as lately urged by Dr. Suess, has attracted further discussion, which is not likely to cease until the interesting problem is definitely settled. Herr J. Bares has argued against the glass theory, and Professor Rzekak in favor of it, on various grounds, the former inclining to the view of Suess. In December last a paper was read before the Bokmische Kaiser Franz-Josephs Akademie, of Prague, by J. N. Woldrich, with photographs of numerous specimens, to illustrate the surface markings. He traces a likeness between these moldavite nodules, or pebbles (?), and certain obsidian bombs from Australia, some of the Bohemian specimens showing indications of a hollow-bomb structure, as well as peculiar "finger like" and radially furrowed external markings. Their occurrence, too, in sandy deposits both in northern and southern Bohemia, which are referred to late Tertiary or early Quaternary time, is a very peculiar feature. Herr Woldrich is led to favor the theory of their extra-terrestrial origin.

The writer has no question as to the possible worn-glass theory of moldavite, having studied many thousand pieces, and the prevalence of the round and elongated bubbles, so characteristic of glass, the so-called finger pittings being nothing but large bubble cavities that have been broken into by attrition.

AUVERGNE MINERALS.

In this Report for 1896[1] a sketch was given of the amethyst workings in the Auvergne district of central France, recently undertaken and carried on by M. Demarty. There has appeared within the last year a valuable pamphlet treating of the rocks, minerals, and precious stones of this celebrated region, prepared by M. Demarty for the use of tourists

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part V (cont'd), pp. 28, 29.

and scientific visitors.[1] The numerous precious and semiprecious stones of Auvergne are described as to their mode of occurrence, their degree of value and abundance, and their principal localities. The rocks are then treated of briefly, and a section is added on the frauds and imitations of gems and the manner of distinguishing them. The amethysts and their exploitation and working are described quite fully, much as summed up in this report above cited, and the other gem stones also there mentioned, although there is hardly any systematic working for any but the amethyst, unless on a small scale here and there. Some rare varieties of the quartz and chalcedony groups are noted, as a clear blue quartz, termed "saphir de France," occurring in small pebbles in certain stream beds, and fairly comparable in color with sapphire itself; also a red quartz, called "hyacinthe de compostelle," or Bohemian ruby, in small bipyramidal crystals in a trachyte of the Puy de la Tache. Agate is abundant and varied, and is treated artificially to enhance its colors, as in Germany. Resinite opal occurs at various points, employed in ornamental work, inlaying, etc. "It presents," says M. Demarty, "every color; brilliant white and dull white, pale brown, variegated watery green, black, yellow, chocolate, etc. At Sainte Nectaire la Haute, it is colored orange-yellow by arsenical sulphide—orpiment." The opal has been deposited from thermal waters, even quite recently, and at times has covered vegetable growths, such as branches of rose bushes, pieces of wood, etc.

Noble opal of great beauty, but in amounts too small for working, occurs at some points, and hyalite quite frequently. Opalized wood is rather abundant at several localities that are named, and is employed for cane heads, knife handles, and like objects.

Zircon appears in some of the stream gravels and in place in some of the feldspathic granites, and also in trachyte at Capucin, Mont Doré. It is sometimes of fine red color, and capable of use in jewelry.

Among inclusions aventurine quartz occurs occasionally in Auvergne and at other French localities, and some fine aventurine amethyst at Escout. M. Demarty gives a rather full account, also, of the manufacture of the artificial aventurine, with the formulas given by various experimenters. At St. Julien de Coppel occur remarkably fine dendritic inclusions in agates, giving beautiful examples of moss agates, "agates herborisées, arborisées," etc. Compact fibrolite is abundant and of much interest from its extensive use for implements by prehistoric man. It occurs at many points in place, and in streams as rolled pebbles which are not easily distinguished from quartz. M. Verniere, of Brioude, who is mentioned as possessing a remarkable collection of fibrolite specimens, gives as a distinction the fact that quartz pebbles become more translucent in water, while fibrolites, on the other hand, become more milky and opaque.

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[1] Les pierres d'Auvergne employées dans la jouillerie, la tabletterie, et les arts décoratifs; par J. Demarty, Membre de la Société française de Minéralogie, Paris, Paul Klincksieck, 52 Rue des Écoles, 1898, 8vo., pp. 64.

Chrysolite (peridot) is found in well-defined crystals at a few places, in volcanic tuffs, etc., and in the granular massive condition abundantly in the basaltic rocks throughout the Central Plateau.

Serpentine is widely present, especially in the Haute Loire. Obsidian, perlite, and retinite—volcanic glasses—are described and distinguished, as also iolite (cordierite), which abounds in the granites and gneisses, sometimes fine enough to be cut for gems (saphir d'eau).

Beryls are noted, and at two or three localities emeralds of some size, but not clear. These localities are Chanteloube, near Limoges, and Biauchaud, in Puy de Dôme.

Of the garnets only almandite and melanite appear in Auvergne, the former frequently, the latter rarely. The almandites are sometimes of gem quality. Many localities are given, the occurrences being generally in gneiss, mica-schist, granulite, or pegmatite, but in some cases apparently in trachytes and tuffs.

Tourmaline is frequent, but usually black. Green and red crystals, however, of 1.5 cm. in length, are found near St. Ilpize, in Haute Loire, and at one or two other localities.

Topaz occurs in some of the stream gravels, but rarely of a size or quality to render it of value.

Turquoise is mentioned (callaite) as found at one locality, not strictly in Auvergne, but near it, at Montebras, Creuse, where it is associated with amblygonite and montebrasite, which are worked for lithia. As no allusion is made to the working of the turquoise, it is presumably not of gem quality or in any valuable amount.

Corundum is not rare in Auvergne, and various forms of occurrence are noted—in the nepheline-dolerites of St. Sandoux, in the fibrolite in the vicinity of Brioude, in garnetiferous pegmatite near Fix, and in several stream beds as rolled crystals. The finest are found thus, together with olivine, augite, etc., and pebbles of the blue quartz, "saphir de France." Some of the corundums are fine blue and deep velvety red, and the red zircons and blue quartz are somewhat confounded with them.

Marbles, alabaster, and fluorspar are dealt with, the latter being a very frequent metalliferous vein material, and at some points named furnishing fine crystallized specimens.

RUSSIA.

The writer lately published an account of some of the principal localities of gems and precious stones in the region of the eastern Ural Mountains.[1] The paper describes the modes of access to the mining regions of the Ural, and gives the results of personal examination of many of the most interesting points, with historical matter, and

[1] A trip to Russia and the Ural Mountains; a lecture delivered by George F. Kunz before the Franklin Institute, Philadelphia, April 20, 1898. From the Journal of the Franklin Institute, September, 1898, 37 pp., 8°.

general observations on the people, the trade, and various physical peculiarities of the district. The visit was made several years ago, and the account is supplemented by interesting additions from the papers prepared by leading Russian geologists and mineralogists for the Ural excursion of the International Geological Congress in 1897. The gold and platinum workings are treated of at some length, especially the latter, with reference to the derivation of the metal from serpentine—itself an altered peridotite. The great iron works of Zlatoust and Kasli, their remarkable products, and the distribution thereof far into the interior of Asia, are described, as are also the copper mines of the Demidoff estate at Nijni Tagilsk, and the malachite there obtained that is so famous in Russian art. The gems proper are next dealt with; the phenacites and alexandrites; the emerald mines of Takowaja, abandoned years ago on account of the prohibitive rates charged by the Government for the right of working them; the splendid beryls and topazes of Alabashka; the rubellites of Sarapulka; and the "royal" amethysts found at several points in the government of Perm, in which all these and many other gem localities are comprised. The green demantoid garnets, or "Uralian emeralds" of jewelry, from Poldnewaja, in the Orenberg government, are described, also the rare gem euclase. The paper then takes up the ornamental or semiprecious stones—the malachite, lapis lazuli, labradorite, rhodonite, and the wonderfully beautiful varieties of jasper. These and the great establishments in Russia for cutting them and making elegant objects of art, from the most delicate to the most massive, are treated of somewhat fully. An account of the management of these imperial cutting works at St. Petersburg, Ekaterinburg in the Urals, and Kolivan in the Altai, together with their characteristic and remarkable products, occupies the remainder of the article, with the addition of some curious notes upon archæological researches in portions of the Ural district.

CARBORUNDUM AND THE CARBIDES.

The industrial importance of carborundum as an abrasive, next only to diamond, and the great interest of the discoveries and experiments of M. Moissan and others in the production of a numerous body of similar carbides, new to science, by means of the electric furnace, have led to a considerable literature on this subject, which has during the last year been collated and indexed by Mr. J. A. Mathews in a pamphlet published by the Smithsonian Institution.[1]

Over thirty carbides are noted in this paper, with their mode of preparation, leading properties, and bibliography. Reference will be made here only to a few that, owing to great hardness, present features of possible importance in ways similar to carborundum, though as yet no others appear to have been so utilized. A compound of

[1] Review and bibliography of the metallic carbides, by J. A. Mathews, Smithsonian Miscell. Collections, No. 1090, Washington, 1898, p. 32.

aluminum, boron, and carbon, expressed by $Al_3C_2B_{48}$, is referred to as possessing extreme hardness, between corundum and diamond, but the notice is brief and the substance is little known. The reference goes back to Hampe, in the American Chemist for 1876. Moissan has found a boron carbide (B_6C) in bright black crystals, harder than carborundum, with which faces may be cut upon diamond. Another boron carbide (BC, or B_2C_2) is not so hard, and fuses at a high heat. The chromium, uranium, vanadium, and zirconium carbides are all harder than quartz, and several others are spoken of as "very hard," but without specifications.

It is announced that the Carborundum Company, of Niagara Falls, New York, proposes to introduce its material in a new form—that of a carborundum paper and cloth—and to bring it forward in competition with the emery, sand, and garnet papers now so largely used. The carborundum, in fine grades, will be attached to cloth or paper, and from its great hardness would, no doubt, in this application find extensive and important use in many arts and industries. A new building for the manufacture of this preparation on a large scale is to be added to the company's works.

AMBEROID.

The utilization of small pieces and fragments of amber by compressing them with the aid of heat, and perhaps some partial solvent, into masses hardly distinguishable from natural amber, has been known and practiced for years past in North Germany, and, while effecting a large saving of material, has impaired the standing of real amber. Mr. E. L. Gaylord, of Bridgeport, Connecticut, claims to have invented a process of this kind superior to that of the Baltic manufacturers, and to be able to produce amber articles of any shape or size, perfect in aspect, highly polished, and transparent. Mr. Gaylord claims that his process utilizes not only the small pieces, as abroad, but the chips and fragments not heretofore saved. The method is said to lend itself especially to the making of articles inlaid with gold or silver, and to have many fine possibilities, but the details are not given, and its actual importance remains to be ascertained.

PRODUCTION.

In the following table is given a statement of the production of precious stones in the United States in 1896, 1897, and 1898:

Production of precious stones in the United States in 1896, 1897, and 1898.

Stone.	1896.	1897.	1898.
Diamond	None.	None.	None.
Sapphire	$10,000	$25,000	$5,000
Ruby	1,000	None.	2,000
Topaz	200	None.	100
Beryl (aquamarine, etc.)	700	1,500	2,200
Emerald	None.	25	50
Phenacite	None.	None.	None.
Tourmaline	3,000	9,125	4,000
Peridot	500	500	500
Quartz, crystal	7,000	12,000	17,000
Smoky quartz	2,500	1,000	1,000
Rose quartz	500	None.	100
Amethyst	500	200	250
Prase	100	None.	None.
Gold quartz	10,000	5,000	5,000
Rutilated quartz	500	None.	100
Dumortierite in quartz	50	None.	None.
Agate	1,000	1,000	1,000
Moss agate	1,000	1,000	1,000
Chrysoprase	600	None.	100
Silicified wood (silicified and opalized)	4,000	2,000	2,000
Opal	200	200	200
Garnet (almandite)	500	7,000	5,000
Garnet (pyrope)	2,000	2,000	2,000
Topazolite	100	None.	None.
Amazon stone	1,000	500	500
Oligoclase	500	25	10
Moonstone	250	None.	None.
Turquoise	40,000	55,000	50,000
Utahlite (compact variscite)	500	100	100
Chlorastrolite	500	500	5,000
Thomsonite	500	500	1,000
Prehnite	100	100	100
Diopside	200	100	None.
Epidote	250	None.	None.
Pyrite	1,000	1,000	1,000
Rutile	100	800	110
Anthracite	2,000	1,000	1,000
Catlinite (pipestone)	3,000	2,000	2,000
Fossil coral	1,000	500	500
Arrow points	1,000	1,000	1,000
Total	97,850	130,675	160,920

IMPORTS.

The following table shows the value of the diamonds and other precious stones imported into the United States from 1867 to 1898:

Value of diamonds and other precious stones imported and entered for consumption in the United States, 1867 to 1897, inclusive.

Year ending—	Diamonds.					Diamonds and other stones not set.	Set in gold or other metal.	Total.
	Glaziers'.	Dust.	Rough or uncut.	Set.	Unset.			
June 30, 1867	$906					$1,317,420	$291	$1,318,617
1868	484					1,060,544	1,465	1,062,493
1869	445	$140				1,997.282	23	1,997,890
1870	9,372	71				1,768,324	1,504	1,779,271
1871	976	17				2,349,482	256	2,350,731
1872	2,386	89,707				2,939,155	2,400	3,033,648
1873		40,424	$176,426			2,917,216	326	3,134,392
1874		68,621	144,629			2,158,172	114	2,371,536
1875		32,518	211,920			3,234,319		3,478,757
1876		20,678	186,404			2,409,516	45	2,616,643
1877		45,264	78,033			2,110,215	1,734	2,235,246
1878		36,409	63,270			2,970,469	1,025	3,071,173
1879		18,889	104,158			3,841,335	538	3,964,920
1880		49,360	129,207			6,690,912	765	6,870,244
1881		51,409	233,596			8,320,315	1,307	8,606,627
1882		92,853	449,513			8,377,200	3,205	8,922,771
1883		82,628	443,996			7,598,176	*g*2,801	8,126,881
1884	22,208	37,121	367,816			8,712,315		9,139,460
1885	11,526	30,426	371,679			5,628,916		6,042,547
Dec. 31, 1886	8,949	32,316	302,822			7,915,660		8,259.747
1887	9,027	33,498	262,357			10,526,998		10,831,880
1888	10,025	29,127	244,876			10,223,630		10,507,658
1889	8,156	68,746	196,294			11,704,808		11,978,004
1890	147,227	179,154	349,915			*e*12,429,395		13,105,691
1891	*a*565,623	125,688	(*c*)			*f*12,065,277		12,756,588
1892	532,246	144,487				*f*13,845,118		14,521,851
1893	357,939	74,255				*f*9,765,311		10,197,505
1894	82,081	53,691				*f*7,291,342		7,427,214
1895	107,463	135,558				*f*6,330,834		6,573,855
1896	78,990	65,690		(*d*)	(*d*)	*f*4,474,311		4,618,991
1897	*b*29,576	167,118	1,386,726	$330	$2,789,924	1,903,055		6,276,729
1898	8,058	240,665	2,513,800	6,622	5,743,026	1,650,770		10,162,941

a Including also engravers', not set, and jewels to be used in the manufacture of watches, from 1891 to 1894; from 1894 to 1896 miners' diamonds are also included.

b Including also miners' and engravers', not set.

c Included with diamonds and other stones from 1891 to 1896.

d Not specified prior to 1897.

e Includes stones set and not specially provided for since 1890.

f Including rough or uncut diamonds.

g Not specified since 1883.

PLATE I.

PLATE I.

AMERICAN GEMS.

A. Beryl; Topsham, Maine.
B. Prehnite; Paterson, New Jersey.
C. Turquoise; Grant County, New Mexico.
D. Turquoise; Santa Fe County, New Mexico.
E. Tourmaline; Haddam Neck, Connecticut.
F. Rose quartz; Albany, Maine.
G. Sapphire; Yogo Gulch, Fergus County, Montana.

ABRASIVE MATERIALS.

By Edward W. Parker.

BUHRSTONES.

PRODUCTION.

The use of buhrstones, or millstones, for flouring mills has almost entirely ceased. Mills for grinding the coarser cereals, paint ore, fertilizers, and cement rock continue to use the old-fashioned millstones, but this trade is comparatively limited, and the manufacture of millstones can hardly lay claim to existence as a separate industry. The value of the millstones produced in the United States has not amounted to $30,000 in any year since 1889, and has exceeded $25,000 only twice in that time—in 1897 and 1898—when the revival in other lines was reflected in a slight increase in the demand for millstones. The total value of the millstone production in 1898 amounted to $25,934, distributed among 17 producers, an average of about $1,500 each. Two of these producers in 1898 were in Virginia, 2 were in Pennsylvania, and 13 obtained their supply in Ulster County, New York. The stones are quarried from a quartz conglomerate rock, outcropping at several localities along the eastern slope of the Allegheny Mountains. The men engaged in the industry are generally individual and independent quarrymen who, upon receipt of an order for one or more stones, take one or two helpers, go to the hills and select a bowlder or blast out a piece of rock which will cut to the desired size. When finished, the stone or stones are hauled by wagon to the nearest rail or waterway shipping station, and no more work is done until other orders are received. The domestic product differs from the imported buhr, and when buhrstones were more generally used in flouring mills the imported French or Belgian buhr was considered superior to the domestic stone. For the coarser work now done by them the American stones seem to be as satisfactory as the foreign.

The millstone-making industry began to go down about twelve or fourteen years ago. Importations fell off very sharply in 1883 and 1884, and have amounted to as much as $40,000 in only one year since 1884. In the fifteen years from 1868 to 1882, inclusive, the value of the buhrstones, rough and manufactured, imported into the United States averaged $84,680 a year. In 1883 the value dropped to $73,685, and in the last fifteen years has averaged about $30,000. The records of domestic production extend back only as far as 1880. In the five years 1880 to 1884, inclusive, the domestic product was valued at an average of $170,000 a year. In the next five years, 1885 to 1889, it averaged only $91,000 a year, while in the last nine years the average has been but a little over $21,000 a year, that of 1898, $25,934, being the maximum.

The production since 1880 and imports since 1868 are shown in the following tables:

Value of buhrstones produced in the United States from 1880 to 1898.

Year.	Value.	Year.	Value.
1880	$200,000	1890	$23,720
1881	150,000	1891	16,587
1882	200,000	1892	23,417
1883	150,000	1893	16,639
1884	150,000	1894	13,887
1885	100,000	1895	22,542
1886	140,000	1896	22,567
1887	100,000	1897	25,932
1888	81,000	1898	25,934
1889	35,155		

IMPORTS.

The following table gives the value of buhrstones and millstones imported into the United States each year since 1868:

Value of buhrstones and millstones imported into the United States from 1868 to 1898.

Year ending—	Rough.	Made into millstones.	Total.
June 30, 1868	$74,224	....	$74,224
1869	57,942	$2,419	60,361
1870	58,601	2,297	60,898
1871	35,406	3,698	39,104
1872	69,062	5,967	75,029
1873	60,463	8,115	68,578
1874	36,540	43,170	79,710
1875	48,068	66,991	115,059
1876	37,759	46,328	84,087
1877	60,857	23,068	83,925

Value of buhrstones and millstones imported into the United States, etc.—Continued.

Year ending—	Rough.	Made into millstones.	Total.
June 30, 1878	$87,679	$1,928	$89,607
1879	101,484	5,088	106,572
1880	120,441	4,631	125,072
1881	100,417	3,495	103,912
1882	103,287	747	104,034
1883	73,413	272	73,685
1884	45,837	263	46,100
1885	35,022	455	35,477
Dec. 31, 1886	29,273	662	29,935
1887	23,816	191	24,007
1888	36,523	705	37,228
1889	40,432	452	40,884
1890	32,892	1,103	33,995
1891	23,997	42	24,039
1892	33,657	529	34,186
1893	29,532	729	30,261
1894			a 18,087
1895			20,316
1896			26,965
1897			22,956
1898			22,974

a Not separately classified after 1893.

CORUNDUM AND EMERY.

PRODUCTION.

The combined product of corundum and emery in 1898 amounted to 4,064 short tons, having a total value of $275,064. In both amount and value the product in 1898 was the largest ever obtained. As compared with 1897, the product increased 1,899 short tons, or 87.7 per cent. The largest previous production was in 1891, when 2,247 short tons were mined, compared with which the output in 1898 showed a gain of 1,817 tons, or 81 per cent. Owing to the difference between the prices of emery and corundum, and between the values of the different qualities of each, the total values from year to year vary greatly according to the production of the several grades, and an average price based upon the total product and value in each year would not be representative of any rise and fall in values. For instance, with a total product of 2,247 tons in 1891, the value was only $90,230, while in 1892 the product decreased 21 per cent, to 1,771 tons, and the value more than doubled.

It is not possible, however, to publish any more accurate details without violating the confidential nature of individual statistics. The aggregate value in 1898 was $168,490 or 158 per cent larger than it was in 1897, and more than 50 per cent greater than in 1892, when the previous largest value was reported. There was increased production in 1898 from all three sources of this class of abrasives. The production of corundum in North Carolina increased from 153 tons in 1897 to 535 tons in 1898, while to the product in the latter year was added 4 tons sold from stock mined several years ago, making the total marketed product in 1898, 539 short tons. The production in Chester County, Massachusetts was nearly two and one-fourth times larger than in 1897, and the shipments of emery from Westchester County, New York, increased from 949 short tons in 1897 to 1,130 tons in 1898.

The statistics of the production of emery and corundum since 1881 are presented in the following table:

Annual product of corundum and emery since 1881.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1881	500	$80,000	1890	1,970	$89,395
1882	500	80,000	1891	2,247	90,230
1883	550	100,000	1892	1,771	181,300
1884	600	108,000	1893	1,713	142,325
1885	600	108,000	1894	1,495	95,936
1886	645	116,190	1895	2,102	106,256
1887	600	108,000	1896	2,120	113,246
1888	589	91,620	1897	2,165	106,574
1889	2,245	105,567	1898	4,064	275,064

IMPORTS.

The corundum used in the United States is exclusively of domestic production. Emery is imported from Turkey and the island of Naxos, one of the Cyclades group in the Grecian Archipelago.

The following table shows the imports of emery from 1867 to 1898:

Emery imported into the United States from 1867 to 1898, inclusive.

Year ending—	Grains.		Ore or rock.		Pulverized or ground.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.	
June 30—	*Pounds.*		*Long tons.*		*Pounds.*			
1867..	....	....	428	$14, 373	924, 431	$38, 131	....	$52, 504
1868..	....	....	85	4, 531	834, 286	33, 549	....	38, 080
1869..	....	....	964	35, 205	924, 161	42, 711	....	77, 916
1870..	....	....	742	25, 335	644, 080	29, 531	....	54, 866
1871..	....	....	615	15, 870	613, 624	28, 941	....	44, 811
1872..	....	....	1, 641	41, 321	804, 977	36, 103	....	77, 424
1873..	610, 117	$29, 706	755	26, 065	343, 828	15, 041	$107	70, 919
1874..	331, 580	16, 216	1, 281	43, 886	69, 890	2, 167	97	62, 366
1875..	487, 725	23, 345	961	31, 972	85, 853	2, 990	20	58, 327
1876..	385, 246	18, 999	1, 395	40, 027	77, 382	2, 533	94	61, 653
1877..	343, 697	16, 615	852	21, 964	96, 351	3, 603	....	42, 182
1878..	334, 291	16, 359	1, 475	38, 454	65, 068	1, 754	34	56, 601
1879..	496, 633	24, 456	2, 478	58, 065	133, 556	4, 985	....	87, 506
1880..	411, 340	20, 066	3, 400	76, 481	223, 855	9, 202	145	105, 894
1881..	454, 790	22, 101	2, 884	67, 781	177, 174	7, 497	53	97, 432
1882..	520, 214	25, 314	2, 765	69, 432	117, 008	3, 708	241	98, 695
1883..	474, 105	22, 767	2, 447	59, 282	93, 010	3, 172	269	85, 490
1884..	143, 267	5, 802	4, 145	121, 719	513, 161	21, 181	188	148, 890
1885..	228, 329	9, 886	2, 445	55, 368	194, 314	8, 789	757	74, 800
Dec. 31—								
1886..	161, 297	6, 910	3, 782	88, 925	365, 947	24, 952	851	121, 638
1887..	367, 239	14, 290	2, 078	45, 033	a144, 380	6, 796	2, 090	68, 209
1888..	430, 397	16, 216	5, 175	93, 287	....	....	8, 743	118, 246
1889..	503, 347	18, 937	5, 234	88, 727	....	....	111, 302	218, 966
1890..	534, 968	20, 382	3, 867	97, 939	....	....	5, 046	123, 367
1891..	90, 658	3, 729	2, 530	67, 573	....	....	....	71, 302
1892..	566, 448	22, 586	5, 280	95, 625	....	....	2, 412	120, 623
1893..	516, 953	20, 073	5, 066	103, 875	....	....	3, 819	127, 767
1894..	597, 713	18, 645	2, 804	51, 487	....	....	1, 841	71, 973
1895..	678, 761	25, 066	6, 803	80, 386	....	....	27, 586	133, 038
1896..	755, 693	28, 493	6, 389	119, 738	....	....	....	148, 231
1897..	539, 176	20, 865	5, 213	107, 655	....	....	2, 211	130, 531
1898..	577, 655	23, 320	5, 547	106, 269	....	....	3, 810	133, 399

a To June 30 only; since classed with grains.

GARNET.

The varieties of garnet considered in this chapter include those only which are used for abrasive purposes. Ornamental or gem varieties are included in the chapter on precious stones, prepared by Mr. George F. Kunz. The localities from which abrasive garnet is obtained are: Litchfield County, Connecticut; Essex and Warren counties, New York, and Delaware County, Pennsylvania. The quality of the material from the several localities varies considerably, the price ranging, according to quality, from $20 to $45 per ton at the mines. The production as reported to the Survey for 1898 amounted to 2,967 short tons, valued at $86,850, against 2,554 short tons, worth $80,853 in 1897. The production since 1894, the first year for which statistics were obtained, has been as follows:

Production of abrasive garnet for five years.

Year.	Quantity.	Value.
	Short tons.	
1894	2,401	$90,660
1895	3,325	95,050
1896	2,686	68,877
1897	2,554	80,853
1898	2,967	86,850

GARNETS AS ENGRAVING TOOLS.

Dr. Frank Hamilton Cushing, of the Bureau of American Ethnology, has been making an investigation of the shell engraving practiced by the North American Indians. One of the results of his inquiries has been the establishment of the fact that the Indians employed tools consisting of garnet points attached to a wooden handle. In carrying on his investigation Dr. Cushing has endeavored to imitate the tools and work of the Indians, and in doing so has had the hearty cooperation of Messrs. H. H. Barton & Co., of Philadelphia; The North River Garnet Company, Ticonderoga, New York; The Union Sand Paper and Emery Wheel Company, East Walpole, Massachusetts, and Messrs. Herman Behr & Co., of New York, producers of abrasive garnets, who supplied him with garnet crystals for making the engraving tools. The results of Dr. Cushing's investigations will be published in the reports of the Bureau of Ethnology.

GRINDSTONES.

OCCURRENCE.

Grindstones of domestic manufacture are obtained from the sandstone deposits which extend along the shores of Lake Erie for some distance east and west of Cleveland, Ohio, and as far inland as Marietta, and on Lake Huron above Detroit, Michigan. In Mineral Resources for 1886 the methods of manufacture and use are given in detail, together with a tabular statement of the several varieties, foreign or domestic, that occur, with their special uses. Five varieties are produced in the United States—four in Ohio and one in Michigan. The four in Ohio are: (1) Berea, fine sharp grit, used specially for sharpening edge tools; (2) Amherst, soft loose grit, for edge tools and saws; (3) Independence, coarse sharp grit, for grinding springs and files and for dry grinding of castings; (4) Massillon, also coarse sharp grit, for large edge tools, springs, files, and dry castings. The Huron (Michigan) stone has a fine sharp grit, and is used for sharpening edge tools when a very fine edge is required.

PRODUCTION.

The value of the grindstones made in the United States in 1898 amounted to $489,769, about one-third more than that of 1897 and the highest figure reached in any year since 1885. The value of the grindstone production from 1880 to 1885 ranged from $500,000 to $700,000 per year. These figures were not obtained from a canvass of all the producers, but were largely estimates. The more accurate statements of subsequent years indicate that the estimated production from 1880 to 1885 was larger than that actually obtained, and it is probable that the grindstone production in 1898 was as large as that of any year in our history.

In making their reports of production to the Survey, some manufacturers use the ton as a unit of measurement and others state the number of grindstones made and sold, and until 1898 no separation of quantity was attempted. Last year the manufacturers who stated the number of grindstones sold reported a product aggregating 11,715 pieces, valued at $99,767. The product reported by weight amounted to 31,639 short tons, valued at $390,002. Reporting the imports of grindstones, the Bureau of Statistics of the Treasury Department also limits the statements to the value, no figures relating to quantities having been published since 1883. The value of the grindstones imported during the decade ending December 31, 1898, has averaged 15 per cent of the domestic product. During this period the greatest value for the domestic product was in 1898. The year of next largest production was in 1891, when a total of $476,113 was reported. The value of the imports reached the highest figure ($66,195) in 1896. The smallest domestic product was in 1895, the value in that year amounting to only $205,768, and the year of least value of the imports was in 1891, when it amounted to $21,028.

In the following table is shown the value of grindstones produced in the United States since 1880:

Value of grindstones produced in the United States, 1880 to 1898.

Year.	Value.	Year.	Value.
1880	$500,000	1890	$450,000
1881	500,000	1891	476,113
1882	700,000	1892	272,244
1883	600,000	1893	338,787
1884	570,000	1894	223,214
1885	500,000	1895	205,768
1886	250,000	1896	326,826
1887	224,400	1897	368,058
1888	281,800	1898	489,769
1889	439,587		

PULPSTONE.

The manufacture of paper from wood pulp has called for a stone suited to the grinding of wood pulp, resulting in the production in 1898 of 296 tons of "pulp" stones, valued at $10,619.

IMPORTS.

The amount and value of grindstones imported into the United States since 1868 are as follows:

Grindstones imported and entered for consumption in the United States, 1868 to 1898, inclusive.

Year ending—	Finished.		Unfinished or rough.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		
June 30, 1868		$25,640		$35,215	$60,855
1869		15,878		99,715	115,593
1870		29,161		96,444	125,605
1871	385	43,781	3,957.15	60,935	104,716
1872	1,202	13,453	10,774.80	100,494	113,947
1873	1,437	17,033	8,376.84	94,900	111,933
1874	1,443	18,485	7,721.44	87,525	106,010
1875	1,373	17,642	7,656.17	90,172	107,814
1876	1,681	20,262	6,079.34	69,927	90,189
1877	1,245	18,546	4,979.75	58,575	77,121
1878	1,463	21,688	3,669.41	46,441	68,129
1879	1,603	24,904	4,584.16	52,343	77,247
1880	1,573	24,375	4,578.59	51,899	76,274
1881	2,064	30,288	5,044.71	56,840	87,128
1882	1,705	30,286	5,945.61	66,939	97,225
1883	1,755	28,055	6,945.63	77,797	105,852
1884					*a* 86,286
1885					50,579
Dec. 31, 1886					39,149
1887					50,312
1888					51,755
1889					57,720
1890					45,115
1891					21,028
1892					61,052
1893					59,569
1894					52,688
1895					54,276
1896					66,195
1897					49,496
1898					62,973

a Since 1884 classed as finished or unfinished.

CANADIAN PRODUCTION.

The Geological Survey of Canada gives the following statement of the production of grindstones in the Dominion since 1886:

Production of grindstones in Canada since 1886.

Calendar year.	Quantity.	Value.
	Short tons.	
1886	4,000	$46,545
1887	5,292	64,008
1888	5,764	51,129
1889	3,404	30,863
1890	4,884	42,340
1891	4,479	42,587
1892	5,283	51,187
1893	4,600	38,379
1894	3,757	32,717
1895	3,475	31,932
1896	3,663	32,810
1897	4,572	42,340
1898	....	39,465

INFUSORIAL EARTH.

The abrasives included under this head consist of those porous siliceous earths of organic origin known as tripoli, diatomaceous earth, and infusorial earth. They are used to some extent in the manufacture of polishing powders and soaps, for which reason they are included among the abrasive materials. Their field is not limited to that use, however. Owing to the porous nature of infusorial earth it has been found to make an excellent absorbent for the manufacture of dynamite from nitroglycerine, and its nonconductivity to heat recommends it as a packing for boilers, steam pipes, and safes. The production in 1898 amounted to 2,733 short tons, which was 1,100 tons less than in 1897. The value of the product was $16,691, about 25 per cent less than that of the preceding year. The value of the product as given does not represent its final value in manufactured articles. Of the total product in 1898, the value of 2,528 tons is given for the material in its crude state, or without other preparation than drying and grinding, and the total value of this portion of the product was $9,691, an average of $3.73 per ton. The value of the other 205 short tons reported as refined and manufactured was $7,000, nearly $35 per ton.

The same conditions obtained in previous years, and the apparent fluctuations between quantities and values in the following table generally indicate the variations in value caused by marketing the product in different conditions.

The amount and value of the product of infusorial earth for the years they have been obtained since 1880 are shown in the following table:

Production of infusorial earth from 1880 to 1898.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	1,833	$45,660	1890	2,532	$50,240
1881	1,000	10,000	1891	....	21,988
1882	1,000	8,000	1892	....	43,655
1883	1,000	5,000	1893	....	22,582
1884	1,000	5,000	1894	2,584	11,718
1885	1,000	5,000	1895	4,954	20,514
1886	1,200	6,000	1896	3,846	26,792
1887	3,000	15,000	1897	3,833	22,385
1888	1,500	7,500	1898	2,733	16,691
1889	3,466	23,372			

OILSTONES AND WHETSTONES.

PRODUCTION.

The value of the production of this class of abrasives in 1898 was the largest ever recorded, amounting to $180,738, an increase of $30,768 over that of 1897, and $24,857 more than 1895, the year of previous maximum production. The product in 1898 consisted of 969,215 pounds of oilstones and water whetstones (against 846,000 pounds in 1897); 140,000 pounds of shoemakers and kitchen rubstones (a decrease from 240,000 pounds in 1897); 1,500 pounds of razor hones; 28,000 pounds of marble-cutters' rubstones; 150 gross of tablestones; and 25,242 gross of scythestones (an increase from 18,000 gross in 1897).

The rough material from which our oilstones, etc., are made is obtained from various localities in the United States. The finer grades of oilstones are made from two grades of novaculite quarried in the vicinity of Hot Springs, Arkansas, and known, respectfully, as "Arkansas" and "Washita" stone. Fine-grained sandstone, called "Hindostan" or "Orange" stone, from Orange County, Indiana; Lake Superior stone, quarried in Cuyahoga County, Ohio, and a similar material, known as Labrador stone, from Cortland County, New York, and chocolate stone, from Lisbon, New Hampshire, are used for whetstones. Scythestones and rubstones are made from Indian Pond and Lamoille stone, quarried in Grafton County, New Hampshire, and Orleans County, Vermont; from Berea, Ohio, grit (which also furnishes grindstones), and from some of the Indiana sandstone.

In the following table showing the value of the production of oilstones, whetstones, scythestones, etc., since 1891, the values given are for the finished stones, that being the first condition in which the product is marketed:

Value of oilstones, whetstones, etc., produced in the United States since 1891.

Year.	Value.
1891	$150,000
1892	146,730
1893	135,173
1894	136,873
1895	155,881
1896	127,098
1897	149,970
1898	180,486

From 1880 to 1890, inclusive, the product and value of the rough stone has been published in these reports, exception being made in the case of the output for 1890, when the value for the unfinished product was given for the novaculite of Arkansas, and in all other cases the value of the finished stones is quoted. The annual production from 1880 to 1890 was as follows:

Product of oilstones and whetstones from 1880 to 1890.

Year.	Quantity.	Value.
	Pounds.	
1880	420,000	$8,000
1881	500,000	8,580
1882	600,000	10,000
1883	600,000	10,000
1884	800,000	12,000
1885	1,000,000	15,000
1886	1,160,000	15,000
1887	1,200,000	16,000
1888	1,500,000	18,000
1889	5,982,000	32,980
1890	....	69,909

IMPORTS.

The following table shows the total value of all kinds of hones and whetstones imported since 1880:

Imports of hones and whetstones since 1880.

Year ending—	Value.	Year ending—	Value.
June 30, 1880	$14,185	Dec. 31, 1890	$37,454
1881	16,631	1891	35,344
1882	27,882	1892	33,420
1883	30,178	1893	25,301
1884	26,513	1894	26,671
1885	21,434	1895	32,439
Dec. 31, 1886	21,141	1896	50,588
1887	24,093	1897	34,485
1888	30,676	1898	30,856
1889	27,400		

PUMICE STONE.

The production of pumice stone from Nebraska and Utah in 1898 amounted to 600 short tons, valued at $13,200. The deposits from which this product was obtained were opened in 1897, with a product during that year of 158 short tons. These deposits were described in Mineral Resources for 1897.

QUARTZ CRYSTAL.

The product of quartz crystal for wood finishing amounted in 1898 to 8,312 short tons, valued, crude, at $23,990, against 7,500 short tons, worth $22,500, in 1897.

Production of quartz crystal since 1894.

Year.	Quantity.	Value.
	Short tons.	
1894	6,024	$18,054
1895	9,000	27,000
1896	6,000	18,000
1897	7,500	22,500
1898	8,312	23,990

CARBORUNDUM.

During the year 1898 there was produced in the United States 1,594,152 pounds of carborundum. This was all made by the Carborundum Company in their works at Niagara Falls, New York. This material went on to the market principally as carborundum, but there was an amount of 227,500 pounds that was sold in the form of fine powder, under the name of "carbide of silicon," to the steel manufacturers, to be used as a substitute for ferro-silicon, or aluminum, for the quieting of foaming steel in the production of solid castings.

The prices for carborundum were lowered during the year from those formerly in effect, and closed at 10 to 12 cents per pound for grains, 8 cents for powders, and 4 to 5 cents for carbide of silicon. The total valuation was approximately $150,000.

The year closed with the sales exceeding the production, and considerable reductions were made in the stock that was carried over from previous years.

Very decided progress was made in all of the older lines of uses for the product, in the perfecting of the articles as manufactured by the Carborundum Company, and in the consumption. The making of a wheel suitable for steel work, saw sharpening, etc., was one of the points of great advancement. In making this advancement advantage was taken of the reaction that occurs between carborundum and iron at high temperatures, and a small amount of oxide of iron was introduced into the porcelain bond which had heretofore been used in the making of wheels. During the process of vitrification this iron attacks the surface of the carborundum grains and causes a perfect union between the bond and carborundum.

A large amount of carborundum was exported to Scotland during the year, where it is now extensively used in finishing granite, having almost completely supplanted other agents for this work in that country.

Extensive additions were made to the factories of the Carborundum Company at Niagara Falls, the floor space having been doubled and now measuring over 80,000 square feet. The addition was made principally to provide space for the installation of a mill for spreading carborundum on paper and cloth. A small amount of carborundum paper and cloth had been manufactured during previous years by the makers of emery and garnet paper and cloth, and an effort was made to have the older manufacturers take up the new material, but failing to make satisfactory arrangements, the Carborundum Company installed its own plant, and claims to have met with decided success, the paper of their own manufacture proving to be superior to that formerly made. It is used extensively in the boot and shoe trade, where average results show an efficiency which, it is claimed, compares favorably with other agents.

The use of carbide of silicon in steel was taken up with a great deal of interest by the steel manufacturers, with the result of the consumption above stated. Experiments to a limited extent were made in the introduction of carbide of silicon in foundry work, but without any decided success, as in ordinary practice the metal as drawn from the cupola is of too low a temperature to cause the desired reaction between the carbide and the metal. It is probable that success may be met with by the introduction of the carbide in the form of briquettes in the cupola itself. Experiments are now being made in this line.

Another interesting use for carbide of silicon is in the manufacture of refractory linings or bricks for furnaces. Experimental work on this line has been encouraging, and the material will probably prove of value to the furnace men, as it is said to be much more refractory than magnesite or any other material heretofore used for furnace linings. For this purpose a noncrystalline variety of the carbide is used. This product is found in the furnace at a point outside of the crystalline carborundum, and where the temperature has not been sufficiently high to cause crystallization; and it has the special advantage of being not only extremely refractory, but also resists any chemical action by molten iron.

A small carborundum factory was erected during the year at Niagara Falls, Ontario. Two hundred electrical horsepower is used in this plant. The product is finished into grains and powder, and sold in this form to the granite and other lines of manufacture and for wheel making to the Hart Emery Wheel Company, of Hamilton, Ontario.

PHOSPHATE ROCK.

PRODUCTION.

The production of phosphate rock was without material change in the five years from 1893 to 1897, inclusive, the smallest output during that period being 930,779 long tons in 1896; the largest, 1,039,345 long tons in 1897. The annual average production for the five years was 989,398 long tons. The production in 1898 showed a notable increase, amounting to 1,308,885 long tons—269,540 long tons, or 26 per cent, more than the output in 1897, and 319,487 long tons, or 32 per cent, more than the average production during the preceding five years. The increased production was made up by a gain of a little over 48,500 long tons from Florida, an increase of about 42,000 tons from South Carolina, and of approximately 180,000 tons in Tennessee. The increase in Tennessee was nearly twice as much as that of Florida and South Carolina combined, and almost equal to the total production in the State for the three preceding years.

The value of the product in 1898, while more than that of 1896 or 1897, was less than that of any other year since 1891, with one exception (1892). In 1891 the product was only 45 per cent of the product of 1898, whereas the value of the product in the latter year was $200,000 less than that of 1891. The average price for rock in 1891 was about $6.20; in 1898 it was $2.65.

Prior to 1892, when the chief sources of supply were the land and river phosphate beds of South Carolina, prices were comparatively steady at from $5 to $6 per ton. In 1892 and 1893, with the large production from Florida, prices began to go down, and much of this decline was due rather to the inferior rock thrust upon the market as a result of speculative fever and "boomers" than the actual production. By the time the phosphate mining industry of Florida had settled down to a firmer and legitimate basis the Tennessee product became a factor in the market. The effect of the bringing in of this new supply is exhibited in the following table. The distance of the Tennessee deposits from the seaboard has doubtless prevented a still greater decline in prices.

Product of phosphate rock from 1891 to 1898.

State.	1891.		1892.		1893.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Florida:	*Long tons.*		*Long tons.*		*Long tons.*	
Hard rock	} 57,982	....	*a* 155,908	$859,276	215,685	$1,117,732
Soft rock			6,710	32,418	13,675	64,626
Land pebble			21,905	111,271	86,624	359,127
River pebble	54,500	....	*b* 102,820	415,453	122,820	437,571
Total	112,482	$703,013	287,343	1,418,418	438,804	1,979,056
South Carolina:						
Land rock	344,978	2,187,160	243,653	1,236,447	308,435	1,408,785
River rock	130,528	760,978	150,575	641,262	194,129	748,229
Total	475,506	2,948,138	394,228	1,877,709	502,564	2,157,014
Grand total	587,988	3,651,151	681,571	3,296,127	941,368	4,136,070

State.	1894.		1895.		1896.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Florida:	*Long tons.*		*Long tons.*		*Long tons.*	
Hard rock	326,461	$979,383	307,098	$1,302,096	296,811	$1,067,525
Soft rock	....	....	6,916	32,000	400	2,300
Land pebble	98,885	296,655	181,011	593,716	97,936	176,972
River pebble	102,307	390,775	73,036	185,090	100,052	300,556
Total	527,653	1,666,813	568,061	2,112,902	495,199	1,547,353
South Carolina:						
Land rock	307,305	1,252,768	270,560	898,787	267,072	792,457
River rock	142,803	492,808	161,415	512,245	135,351	389,192
Total	450,108	1,745,576	431,975	1,411,032	402,423	1,181,649
Tennessee	19,188	67,158	38,515	82,160	26,157	57,370
North Carolina	....	....	....	....	7,000	17,000
Grand total	996,949	3,479,547	1,038,551	3,606,094	930,779	2,803,372

a Includes 52,708 tons of hard rock carried over in stock from 1891.
b Includes 12,120 tons of river pebble carried over in stock from 1891.

Product of phosphate rock from 1891 to 1898—Continued.

State.	1897.		1898.	
	Quantity.	Value.	Quantity.	Value.
Florida:	*Long tons.*		*Long tons.*	
Hard rock	360,147	$1,063,713	366,810	$1,396,108
Soft rock	2,300	4,600		
Land pebble	92,132	180,794	155,084	293,688
River pebble	97,763	244,408	79,000	158,000
Total	552,342	1,493,515	600,894	1,847,796
South Carolina:				
Land rock	267,380	748,050	298,610	856,225
River rock	90,900	238,522	101,274	251,047
Total	358,280	986,572	399,884	1,107,272
Tennessee	128,723	193,115	308,107	498,392
North Carolina				
Grand total	1,039,345	2,673,202	1,308,885	3,453,460

Since 1880 the amount and value of the phosphate rock produced in the United States has been as follows:

Production and value of phosphate rock in United States since 1880.

Year.	Production.	Value.	Year.	Production.	Value.
	Long tons.			*Long tons.*	
1880	211,377	$1,123,823	1890	510,499	$3,213,795
1881	266,734	1,980,259	1891	587,988	3,651,150
1882	332,077	1,992,462	1892	681,571	3,296,227
1883	378,380	2,270,280	1893	941,368	4,136,070
1884	431,779	2,374,784	1894	996,949	3,479,547
1885	437,856	2,846,064	1895	1,038,551	3,606,094
1886	430,549	1,872,936	1896	930,779	2,803,372
1887	480,558	1,836,818	1897	1,039,345	2,673,202
1888	448,567	2,018,552	1898	1,308,885	3,453,460
1889	550,245	2,937,776			

FLORIDA.

The annual circular issued through the enterprise of Messrs. Auchincloss Brothers, of New York City, presents the statistics of high-grade hard-rock shipments from Florida, by months, and the countries and ports to which exported. How closely these records of shipments coincide with the statistics of hard-rock production, as shown in the preceding table, is noticeable and attests the correctness of each.

Total shipments of Florida hard-rock phosphate, by months, since 1894.

[Long tons.]

Months.	1894.	1895.	1896.	1897.	1898.
January	16,526	15,780	16,996	12,924	11,682
February	4,111	17,252	16,853	20,668	26,850
March	34,126	31,283	37,155	37,243	34,049
April	36,533	41,445	36,559	32,608	22,274
May	30,780	45,053	45,846	45,715	31,992
June	29,818	31,027	16,511	32,837	31,948
July	46,855	21,284	15,296	22,639	53,114
August	37,823	14,588	19,914	19,292	27,409
September	34,032	25,388	25,116	59,966	46,961
October	19,732	27,783	30,605	27,664	21,476
November	7,683	18,160	38,402	20,184	30,595
December	6,060	17,003	23,618	18,537	22,155
Total	304,079	306,046	322,871	350,277	360,505

The following is the record of shipments to each country for the last five years:

Shipments of hard-rock phosphate, by countries.

[Long tons.]

Country.	1894.	1895.	1896.	1897.	1898.
England	45,455	27,007	20,533	24,163	23,849
Scotland	8,144	3,054	1,038	5,957	6,000
Ireland	6,737	3,867	513	2,953	3,420
Germany	153,526	145,377	151,461	181,355	186,731
Belgium	....	7,033	27,214	22,954	38,903
Holland	47,465	52,724	47,235	53,039	64,309
Denmark	7,726	6,735	9,594	11,019	8,287
Norway and Sweden	7,940	9,304	12,534	7,442	9,378
France	12,101	23,534	6,986	13,931	....
Italy	13,810	21,615	32,999	16,931	11,040
Russia	....	....	1,607	3,613	....
Austria	700	3,871	2,494	4,505	4,946
United States, West Indies, Australia, etc	475	1,925	8,663	2,415	3,642
Total	304,079	306,046	322,871	350,277	360,505

A large proportion of the shipments to Rotterdam is forwarded to the interior of Germany.

The following are the details of all shipments to each port:

Destination of shipments of Florida hard-rock phosphate, by ports.

[Long tons.]

Port.	1894.	1895.	1896.	1897.	1898.
UNITED KINGDOM.					
London	13,970	7,071	6,382	9,058	3,694
Liverpool	3,053	6,475	8,423	11,295	15,878
Birkenhead	5,724	2,446	2,442		
Garston	16,987	4,706			
Hull			1,130		
Newcastle	5,721	4,363	2,156	2,316	4,277
Bo'ness	2,838				2,306
Glasgow	2,070	2,209		2,174	3,010
Aberdeen	836	845	1,038	1,495	684
Dublin	3,689	1,548	513	1,476	2,420
Cork	1,076	1,218		1,477	1,000
Belfast	1,972	1,101			
Leith	2,400			2,288	
Ipswich				1,494	
Felixstowe		850			
Silloth		1,096			
Total	60,336	33,928	22,084	33,073	33,269
BALTIC.					
Aarhuus	2,118	773	3,217	4,917	2,214
Kastrup	5,608	5,962	6,377	6,102	6,073
Landskrona	2,680	2,952	8,441	3,110	3,185
Gothenburg	2,630	3,927	2,771	1,285	4,025
Stockholm	2,630	2,425	1,322	3,047	
Stettin	46,380	55,016	60,977	63,437	71,047
Danzig	4,331	1,842	2,215		2,569
Memel	2,184	4,200	2,981	10,135	9,281
Frederichstadt		3,819			
Riga			1,607		
Libau				3,613	
Gaeddviken					2,168
Total	68,561	80,916	89,908	95,646	100,562

Destination of shipments of Florida hard-rock phosphates, by ports—Continued.

[Long tons.]

Port.	1894.	1895.	1896.	1897.	1898.
CONTINENTAL.					
Rotterdam	47,465	52,724	42,204	50,548	61,289
Antwerp		2,805	14,632	8,716	23,160
Ghent		1,818	12,582	14,238	15,743
Hamburg	61,712	62,975	58,772	82,765	75,798
Harburg	24,297	12,894	10,789	5,378	
Bremen		1,653	13,700	19,640	28,036
Geestemunde	14,622	2,978	2,027		
La Pallice		5,692		2,740	
Delfzyl			1,738		
Dordrecht			3,293		
Ostend		2,410			
Bordeaux	2,953				
Tounay Charente	1,025				
Zwyndrecht				2,491	3,020
Total	152,074	145,949	159,737	186,516	207,046
MEDITERRANEAN.					
Cette	1,132	6,055		7,746	
St. Louis du Rhone	6,991	9,159	3,207	2,354	
Marseilles		2,030		1,091	
Venice	2,181	7,888	10,272	5,310	1,800
Genoa	11,629	13,227	21,632	11,621	4,975
Galatz			2,494		2,754
Fiume	700	3,871		2,705	4,400
Port le Bouc			1,458		
Leghorn			3,416		2,057
Trieste				1,800	
Bone		1,098			
Total	22,633	43,328	42,479	32,627	15,986
DOMESTIC, UNITED STATES, ETC.					
Cartaret			2,950	2,415	1,935
Baltimore		1,920	292		
Elizabethport			1,920		
Philadelphia			3,001		
New York		5			
Barbados, W. I	475		500		
Australia					1,707
Total	475	1,925	8,663	2,415	3,642

Destination of shipments of Florida hard-rock phosphates, by ports—Continued.

RECAPITULATION.

[Long tons.]

Port.	1894.	1895.	1896.	1897.	1898.
To United Kingdom ports	60,336	33,928	22,084	33,073	33,269
To Baltic ports	68,561	80,916	89,908	95,646	100,562
To Continental ports	152,074	145,949	159,737	186,516	207,046
To Mediterranean ports	22,633	43,328	42,479	32,627	15,986
Total foreign shipments	303,604	304,121	314,208	347,862	356,863
Total domestic shipments	475	1,925	8,663	2,415	3,642
Total shipments	304,079	306,046	322,871	350,277	360,505

The substantial yearly increase in shipments shows that Florida high-grade rock continues in favor with the superphosphate manufacturers of Europe.

The following shows the uninterrupted increase in shipments since the commencement of the industry:

Total shipments of Florida hard-rock phosphates since 1890.

[Long tons.]

Year.	Tons.	Year.	Tons.	Year.	Tons.
1890	11,206	1893	220,216	1896	322,871
1891	71,682	1894	304,079	1897	350,277
1892	188,013	1895	306,046	1898	360,505

The above table shows that a total of 2,134,895 long tons of high-grade phosphate rock have been shipped to European manufacturers during the nine years of exploitation.

In commenting upon the condition of the industry in 1897, Messrs. Auchincloss Brothers stated that in their opinion the hard-rock industry was emerging from the unhealthy state which had prevailed for several years. This opinion seems to have been confirmed by the slow but sustained advance in prices, free on board, which began early in 1898, but which had only a moderate effect in increasing the output.

In addition to the growing European demand for high-grade rock, the situation in Florida has been considerably improved by the steady reduction of stocks on hand. The statistics of stocks carried forward at stated periods have been carefully compiled by Messrs. Auchincloss Brothers since 1896 and are presented in the following table:

Stocks of high-grade Florida phosphate rock at quarterly periods in 1896, 1897, and 1898.

[Long tons.]

Date.	1896.	1897.	1898.
January 1	159,051	135,494	86,064
April 1	158,918	133,714	85,182
July 1	136,639	94,514	65,632
October 1	158,134	64,694	43,579

The shipments of Florida hard rock during the same periods were as follows:

Shipments of high-grade Florida phosphate rock by quarterly periods in 1896, 1897, and 1898.

[Long tons.]

Date.	1896.	1897.	1898.
January 1 to April 1	71,004	70,835	72,581
April 1 to July 1	98,916	111,160	86,214
July 1 to October 1	60,326	101,897	127,484
October 1 to December 30	92,623	66,385	74,226
Total	322,869	350,277	360,505

From the above it is evident that in the hard-rock industry there has been, during the past three years, a yearly excess of shipments over production.

The exhaustion of small mining properties and the increasing difficulties of mining is placing the industry under the control of comparatively few concerns. Detailed figures in this connection were given in the report for 1897, and as no discoveries of importance have been made during 1898 (although prospecting forces have been continuously in the field), the exhaustion of such properties is naturally now more apparent than it was twelve months ago. The difficulties of mining are also increasing, as at the lower levels the removal of water greatly impedes operations and increases cost.

The miners who have survived the speculative era of the past few years, profiting by their experiences and appreciating more fully the growing value of their unworked lands, are now working more in harmony, and with a view of obtaining a fair profit. The indications are that the industry has passed the speculative period and is settling down into a legitimate business.

In the early days of the industry the unfortunate impression that the high-grade deposits of Florida were "practically inexhaustible" was created in the minds of both miners and manufacturers by the report of a well-known American statistician estimating the available deposits of high-grade rock in Florida at 133,000,000 tons. Experience and ascertained facts have proven this estimate to have been erroneous and misleading, for after nine years of exploitation and actual shipments of only 2,134,895 tons many supposedly "unlimited deposits" have been abandoned as exhausted, and miners are daily meeting with increasing difficulties in their work.

Miners and manufacturers have alike suffered severely from this impression, and are now to be congratulated on the healthier conditions of the industry—the surviving miners on obtaining a better price for their phosphate, and manufacturers on having the cost of their raw material on a more stable basis.

While the improved prices no doubt will stimulate production, it is probable that the prospective increase can not more than meet the growing demand of Europe and the increasing requirements of the new foreign and colonial markets.

It should also be clearly understood that the free-on-board market price of to-day no more than returns a reasonable remuneration to the miner for the increasing difficulties of mining, the cost and steady depreciation of plant, and the progressive exhaustion of mining property, and if the demand for Florida high-grade rock continues to increase at the average rate of the last three years the trend of prices will be toward a higher level.

The following statements in regard to the shipments of pebble phosphate are also furnished by Messrs. Auchincloss Brothers:

Shipments of Florida pebble phosphate from 1895 to 1898.

[Long tons.]

Port.	1895.	1896.	1897.	1898.
UNITED KINGDOM.				
London	7,860	1,138	....	2,904
Liverpool	....	3,972	....	....
Birkenhead	....	....	6,576	3,100
Garston	2,261	....	2,739	....
Glasgow	3,360	....	2,377	....
Aberdeen	2,186	1,582	1,000	....
Dublin	....	1,021	....	....
Belfast	3,873	2,576	3,158	....
Plymouth	8,921	4,623	7,408	2,920
Kingslynn	12,003	9,019	13,046	2,185
Newport	....	....	3,000	....
Falmouth	....	1,200	1,830	....
Swansea	....	819	1,250	....

Shipments of Florida pebble phosphate from 1895 to 1898—Continued.

[Long tons.]

Port.	1895.	1896.	1897.	1898.
UNITED KINGDOM—cont'd.				
Bristol	2,724	1,813	6,000	2,780
Ipswich	6,017	4,529		
Drogheda		2,694		
Exmouth	710			
Monmouth	2,574			
Harwich		2,045		
Padstow	436			
Felixstowe				3,000
Total	52,925	37,031	48,384	16,889
BALTIC.				
Gothenburg		2,020		
Stettin	7,704	2,760	5,309	5,780
Memel		1,500		
Riga	2,613	2,650		
Helsingborg	15,298	9,495	14,834	14,242
Muhlgraben			2,500	
Total	25,615	18,425	22,643	20,022
CONTINENTAL.				
Rotterdam	5,743			
Hamburg	18,877	4,876	6,176	
Harburg	6,532	5,501	6,405	2,910
Bremen		2,465		
La Pallice		2,180		2,106
Nantes	2,045	2,282	2,092	850
Bordeaux	1,611	5,040	2,753	
St. Nazaire		2,802		2,370
Honfleur				2,106
Total	34,808	25,146	17,426	10,342
MEDITERRANEAN.				
Cette	258			2,800
St. Louis du Rhone	5,298			1,425
Marseilles				1,425
Venice				3,339
Genoa	1,005		1,160	10,766
Port le Bouc		1,204		
Total	6,561	1,204	1,160	19,755

Shipments of Florida pebble phosphate from 1895 to 1898—Continued.

[Long tons.]

Port.	1895.	1896.	1897.	1898.
DOMESTIC, UNITED STATES, ETC.				
Cartaret	19,808	15,278	28,728	30,710
Baltimore	26,804	38,630	48,936	56,875
Elizabethport	....	....	827	1,015
Philadelphia	12,962	5,308	11,526	21,582
New York	3,731	5,113	....	....
Newtown Creek	....	....	618	....
Mantua Creek	....	2,473	1,752	865
Alexandria	....	969	6,668	3,727
Wilmington	800	6,620	6,855	6,591
Mobile	....	1,725	....	....
Savannah	575	....	....	....
Richmond	....	4,406	4,908	....
Norfolk	....	6,235	11,918	....
Pensacola	....	1,968	....	....
New Orleans	....	5,419	....	....
Yokohama	....	....	....	2,415
Total	64,680	94,144	122,736	123,780

RECAPITULATION.

To United Kingdom ports	52,925	37,031	48,384	16,889
To Baltic ports	25,615	18,425	22,643	20,022
To Continental ports	34,808	25,146	17,426	10,342
To Mediterranean ports	6,561	1,204	1,160	19,755
Total foreign shipments	119,909	81,806	89,613	67,008
Total domestic shipments	64,680	94,144	122,736	123,780
Total shipments	184,589	175,950	212,349	190,788
RIVER PEBBLE.				
Foreign shipments	67,694	45,552	46,575	24,238
Domestic shipments	8,798	29,289	60,329	44,715
Total shipments	76,492	74,841	106,904	68,953
LAND PEBBLE.				
Foreign shipments	52,215	36,254	43,038	42,770
Domestic shipments	55,882	64,855	62,407	79,065
Total shipments	108,097	101,109	105,445	121,835

SOUTH CAROLINA.

The total production of phosphate rock in South Carolina since 1867 and the distribution of the shipments according to sources (land or river) are shown in the following table:

Phosphate rock mined by the land and river mining companies of South Carolina.

[Long tons.]

Year ending—	Land companies.	River companies.	Total.
May 31, 1867	6		6
1868	12,262		12,262
1869	31,958		31,958
1870	63,252	1,989	65,241
1871	56,533	17,655	74,188
1872	36,258	22,502	58,760
1873	33,426	45,777	79,203
1874	51,624	57,716	109,340
1875	54,821	67,969	122,790
1876	50,566	81,912	132,478
1877	36,431	126,569	163,000
1878	112,622	97,700	210,322
1879	100,779	98,586	199,365
1880	125,601	65,162	190,763
1881	142,193	124,541	266,734
1882	191,305	140,772	332,077
1883	219,202	159,178	378,380
1884	250,297	181,482	431,779
1885	225,913	169,490	395,403
Dec. 31, 1885 *a*	149,400	128,389	277,789
1886	253,484	177,065	430,549
1887	261,658	218,900	480,558
1888	290,689	157,878	448,567
1889	329,543	212,102	541,645
1890	353,757	110,241	463,998
1891	344,978	130,538	475,516
1892	243,652	150,575	394,227
1893	308,425	194,129	502,564
1894	307,305	142,803	450,108
1895	270,560	161,415	431,975
1896	267,072	135,351	402,423
1897	267,380	90,900	358,280
1898	298,610	101,274	399,884
Total	5,741,572	3,570,560	9,312,132

a Seven months.

In the following tables will be found statements of the shipments of South Carolina phosphate rock since 1874, and the product of the State from 1867 to 1898:

Detailed statement of total foreign and coastwise shipments and local consumption of South Carolina rock since June 1, 1874.

[Long tons.]

Period.	Shipments and consumption.	Beaufort.	Charleston.	Total.	Total for each year.
	Foreign ports...	44,617	25,929	70,546	
June 1, 1874, to May 31, 1875..	Domestic ports .	7,000	25,560	32,560	122,790
	Consumed	....	19,684	19,684	
	Foreign ports...	50,384	25,431	75,815	
June 1, 1875, to May 31, 1876..	Domestic ports .	9,400	28,831	38,231	132,896
	Consumed	....	18,850	18,850	
	Foreign ports...	73,923	28,844	102,767	
June 1, 1876, to May 31, 1877..	Domestic ports .	6,285	40,768	47,053	163,220
	Consumed	....	13,400	13,400	
	Foreign ports...	100,619	21,123	121,742	
June 1, 1877, to May 31, 1878..	Domestic ports .	8,217	60,729	68,946	208,323
	Consumed	....	17,635	17,635	
	Foreign ports...	97,799	21,767	119,566	
June 1, 1878, to May 31, 1879..	Domestic ports .	8,618	52,281	60,899	199,365
	Consumed	....	18,900	18,900	
	Foreign ports...	47,157	14,218	61,375	
June 1, 1879, to May 31, 1880..	Domestic ports .	13,346	94,002	107,348	190,763
	Consumed	....	22,040	22,040	
	Foreign ports...	62,200	8,568	70,768	
June 1, 1880, to May 31, 1881..	Domestic ports .	65,895	91,929	157,824	266,734
	Consumed	....	38,142	38,142	
	Foreign ports...	89,581	22,905	112,486	
June 1, 1881, to May 31, 1882..	Domestic ports .	65,340	111,314	176,654	332,077
	Consumed	....	42,937	42,937	
	Foreign ports...	94,789	28,251	123,040	
June 1, 1882, to May 31, 1883..	Domestic ports .	62,175	150,545	212,720	378,380
	Consumed	....	42,620	42,620	
	Foreign ports...	132,114	20,539	152,653	
June 1, 1883, to May 31, 1884..	Domestic ports .	41,040	181,363	222,403	431,779
	Consumed	5,800	50,923	56,723	
	Foreign ports...	111,075	11,495	122,570	
June 1, 1884, to May 31, 1885..	Domestic ports .	44,130	161,700	205,833	395,403
	Consumed	12,000	55,000	67,000	
	Foreign ports...	105,761	8,581	114,342	
June 1, 1885, to Dec. 31, 1885..	Domestic ports .	16,321	112,126	128,447	277,789
	Consumed	5,000	30,000	35,000	
	Foreign ports...	153,443	5,926	159,369	
Jan. 1, 1886, to Dec. 31, 1886...	Domestic ports .	14,622	187,558	202,180	430,549
	Consumed	9,000	60,000	69,000	
	Foreign ports...	189,995	9,740	199,735	
Jan. 1, 1887, to Dec. 31, 1887...	Domestic ports .	15,905	181,918	197,823	480,558
	Consumed	13,000	70,000	83,000	
	Foreign ports...	124,474	3,611	128,085	
Jan. 1, 1888; to Dec. 31, 1888...	Domestic ports .	20,404	212,078	232,482	448,567
	Consumed	13,000	75,000	88,000	

Detailed statement of total foreign and coastwise shipments and total consumption of South Carolina rock since June 1, 1874—Continued.

[Long tons.]

Period.	Shipments and consumption.	Beaufort.	Charleston.	Total.	Total for each year.
Jan. 1, 1889, to Dec. 31, 1889	Foreign ports	137,102	5,900	143,002	541,645
	Domestic ports	60,000	248,643	308,643	
	Consumed	15,000	75,000	90,000	
Jan. 1, 1890, to Dec. 31, 1890	Foreign ports	72,241	55,000	127,241	463,998
	Domestic ports	15,000	213,757	228,757	
	Consumed	13,000	85,000	98,000	
Jan. 1, 1891, to Dec. 31, 1891	Foreign ports	94,528	4,655	99,183	475,516
	Domestic ports	22,000	252,083	274,083	
	Consumed	14,000	88,250	102,250	
Jan. 1, 1892, to Dec. 31, 1892	Foreign ports	105,150	5,052	110,202	394,227
	Domestic ports	30,425	148,600	179,025	
	Consumed	15,000	90,000	105,000	
Jan. 1, 1893, to Dec. 31, 1893	Foreign ports	156,257	175	156,432	502,564
	Domestic ports	22,872	160,942	183,814	
	Consumed	15,000	147,318	162,318	
Jan. 1, 1894, to Dec. 31, 1894	Foreign ports	114,155	12,417	126,572	450,108
	Domestic ports	21,000	154,853	175,853	
	Consumed	12,683	135,000	147,683	
Jan. 1, 1895, to Dec. 31, 1895	Foreign ports	114,430	10,090	124,520	431,975
	Domestic ports	9,500	155,855	165,355	
	Consumed	12,100	130,000	142,100	
Jan. 1, 1896, to Dec. 31, 1896	Foreign ports	80,960	1,290	82,250	402,423
	Domestic ports	44,391	140,782	185,173	
	Consumed	10,000	125,000	135,000	
Jan. 1, 1897, to Dec. 31, 1897	Foreign ports	65,828	....	65,828	358,280
	Domestic ports	11,072	143,211	154,283	
	Consumed	14,000	124,169	138,169	
Jan. 1, 1898, to Dec. 31, 1898	Foreign ports	60,925	....	60,925	399.884
	Domestic ports	25,349	148,610	173,959	
	Consumed	15,000	150,000	165,000	

TENNESSEE.

The production of phosphate rock in Tennessee since the beginning of mining in that State has been as follows:

Production of phosphate rock in Tennessee since 1894.

Year.	Quantity	Value.
	Long tons.	
1894	19,188	$67,158
1895	38,515	82,160
1896	26,157	57,370
1897	128,723	193,115
1898	308,107	498,392

A BRIEF RECONNAISSANCE OF THE TENNESSEE PHOSPHATE FIELDS.

By C. Willard Hayes.

The phosphate rock mined in Tennessee for commercial purposes may be divided into three distinct varieties, designated by the color of the material—blue rock, brown rock, and white rock. The blue-rock deposits, occurring principally in Hickman County, have been described in previous volumes of Mineral Resources. Mention has also been made of the white-rock deposits in Perry County, and the following brief notes are confined chiefly to the brown-rock deposits of Maury County, upon which a considerable amount of development work was done during 1898.

Mount Pleasant district.—A small district in the vicinity of Mount Pleasant, Maury County, contains the most extensive deposits of the brown phosphate thus far discovered. The limits of the area within which they occur have not yet been accurately determined, but the area is probably 5 or 6 miles in diameter. Only a small portion of this area, however, contains workable deposits, since the extent of the latter depends upon certain limiting topographic conditions. The Mount Pleasant district is near the southwestern margin of the central basin of Tennessee. The streams tributary to Duck River have cut back into the highland rim and formed rather broad valleys, which open out into the central basin and are separated from each other by narrow ridges or lines of hills, the remnants of the formerly more extensive highland rim. It is in one such valley that Mount Pleasant is located, with hills rising to the east, south, and west. The stream which has formed the valley flows in a shallow and rather broad channel. Above the stream channel from 50 to 100 feet are broad terraces, which extend to the steep slopes of the bordering hills. The terrace surfaces are somewhat undulating and are intersected by numerous narrow valleys of smaller tributaries. It is upon these terraces, lying between the stream channels and the steep hill slopes, that the brown phosphate occurs.

The immediate origin of these deposits of brown phosphate is manifest from the most casual examination. They are derived from the weathering of certain phosphatic layers in the Lower Silurian limestone which forms the basin of middle Tennessee. These phosphatic beds do not occupy an unvarying stratigraphic position, but occur at various horizons in the Lower Silurian.

The character of the limestone suggests the manner in which the phosphate was originally accumulated. The phosphatic beds generally show the effects of currents, sometimes in a very striking manner. Thus at the works of the Tennessee Phosphate Company, at Mount Pleasant, the limestone is cross bedded and contains coarse conglomerates, in which the pebbles are limestone, doubtless derived from the immediate vicinity. They are well rounded and embedded in a limestone matrix. The currents sufficiently strong to move pebbles several inches in diameter could have been present only in a comparatively shallow sea. From the evidence afforded by this conglomerate, and the fact that the Upper Silurian formations were never deposited over this region, it appears probable that the broad arch to which the central basin is due began to rise early in Silurian time. The sea was consequently shoaled and deposition was checked or entirely interrupted. The same conditions occurred at intervals nearly to the close of the Devonian, when there was a general submergence of the entire southern Appalachian region, with great uniformity of conditions over a very broad area. The conditions which prevailed in the region of the central basin during certain portions of Silurian and Devonian time were such that, while lime-secreting organisms were abundant, the accumulation of a corresponding thickness of limestone was prevented by the solution of the greater part of the lime carbonate in the sea water. The conditions were at the same time favorable for the growth of organisms secreting a considerable proportion of lime phosphate, such as Lingula and Cyclora. The phosphate, being relatively insoluble, remained, while the carbonate was removed. In this way the phosphate, which would normally have been disseminated through many hundred feet of limestone, is here locally concentrated in 10 or 12 feet.

The unweathered phosphatic limestone is composed of alternating layers, from a half inch to 3 inches in thickness, of blue crystalline limestone, often fossiliferous, but containing very little phosphate, and of gray, finely granular, nonfossiliferous, but highly phosphatic, limestone. On the weathering of the mass by the solution and removal of carbonate, the highly phosphatic layers remain with no diminution in their bulk, but more or less porous, depending on the original content of carbonate. These plates of phosphate are separated by thin seams of red clay, which represents the iron, alumina, and other insoluble constituents of the original blue limestone layers. At many points the phosphate plates can be traced continuously into the gray granular layers, while the clay parting is as clearly associated with the blue limestone.

While the above description applies to the greater part of these deposits, it does not apply to all. In some parts of the Mount Pleasant district, notably in the Central Phosphate Company's mines, there is a variety of phosphate which very closely resembles the blue Devonian rock of Hickman County. It is a dark, bluish-black rock, without distinct bedding, apparently nonfossiliferous, and with a fine granular structure. It weathers in concentric shells about a central core, first to a light bluish-gray, and then to a rusty brown. It appears to contain originally but a small proportion of lime carbonate, and the weathering is due chiefly to the oxidation of the carbonaceous matter.

The original extent of the highly phosphatic limestone is not known, though it was probably not much greater than the area within which workable deposits now occur. It may have extended some distance to the north, where it has been removed by erosion, but to the south and west it becomes so sandy that the leached residuum can not be utilized.

The present extent of the workable deposits depends on the coincidence of exactly the right stage of weathering and surface degradation in the region of an originally highly phosphatic limestone bed. The weathering has in general gone so far that the phosphatic bed is thoroughly leached, while the surface is degraded to such a point that the phosphatic horizon coincides very nearly with the broad rolling terraces on either side of the stream channels.

The abundant fragments of leached rocks on the edges of the terraces mark the outcrops of the phosphate bed. From its outcrop it follows somewhat closely the contour of the slightly rolling surface beneath a cover of red clay. The phosphate bed, or rather layer of loose plates, varies from 1 to 8 feet in thickness, and the clay cover from 1 to 20 feet. When the weathering has gone through the phosphatic bed and beyond, the phosphate is found resting upon a layer of red clay, the residuum from the underlying limestone. In numerous places the weathering has not gone so far and the phosphate rests upon a limestone floor, with unweathered masses of the phosphatic limestone protruding through the phosphate as "horses" or "chimneys." There appears to be a slight difference between the upper and lower portions of the phosphatic bed, particularly at the Tennessee Phosphate Company's mines, near the northern portion of the district. The upper portion is very generally weathered, yielding a layer of brown phosphate about 3 feet thick. The lower portion, about 3½ feet in thickness, is apparently more resistant, and in considerable areas which have been worked out it is less than half leached. It presents remarkable regularity in its leaching. The rock appears to have been first intersected by joints at right angles, cutting the mass into blocks from 20 to 50 feet in diameter. Weathering started from these joints and extended into the limestone blocks at a uniform rate. As a result, the workable phosphate occupies narrow strips which intersect at right angles, and when it is removed leaves narrow passages between rectangular blocks of unweathered phosphatic limestone.

Athough the phosphatic limestone was, before weathering, practically horizontal, the resulting phosphate is not correspondingly horizontal, but, as stated above, it follows somewhat closely the undulations of the terrace surfaces. As the process of weathering has gone on from the surface downward, the phosphate has simply remained with the other insoluble constituents, and as the bulk of the underlying limestone diminished, the regolith has accommodated itself mantlewise to the form of the underlying rock surface.

Swan Creek district.—The brown phosphate has recently been discovered in the valley of Swan Creek, Hickman County, where it is being thoroughly prospected under the supervision of Lucius P. Brown. In the Mount Pleasant district the interval between the phosphatic horizon and the Devonian is several hundred feet, while on Swan Creek it varies from nothing to 40 feet. In the lower portion of the valley the interval is the greatest, while it decreases southward, the Devonian and Silurian phosphates being in contact at the mouth of Falls Branch and also at the Mayfield place on the Upper Swan.

In general, the phosphatic limestone and the resulting brown phosphate present the same appearance as in the Mount Pleasant district. The lime carbonate, however, forms a somewhat larger proportion of the rock, and the phosphate is in thinner seams. Hence, in the leached product the plates of phosphate are comparatively thin and the clay partings are thick. There are also some beds of blue rock which resemble the Devonian blue phosphate, and, like it, weather to a rusty-brown porous residue.

The valley of Swan Creek is rather narrow, with steep hills on either side. The few terraces which lie a short distance above the creek bottoms do not generally coincide with the phosphate horizon. The latter crops out on the steep slopes, where the depth of the overburden increases very rapidly, being derived from the overlying Carboniferous chert. Also, as would naturally be anticipated from these topographic conditions, the area of leached rock is insignificant in comparison with that in the Mount Pleasant district. It generally forms a mere crust on the outcrops of the phosphatic limestone, which is encountered only a few feet from the surface. It is safe to say that the brown rock in this district, while a small amount will be taken out with profit, will never compete in importance with the blue rock in the same district.

Indian Creek district.—In the valley of Indian Creek, also in Hickman County, and a short distance west of Swan Creek, practically the same conditions prevail as on the latter. The valley is narrow, with steep sides, and the brown phosphate, which occurs immediately under the Devonian, forms a thin crust on the outcrops of the phosphatic limestone. The leaching has rarely gone more than 10 feet from the surface, and in many places the phosphate is removed by erosion as rapidly as it is leached out.

The phosphatic limestone in this district has the greatest thickness anywhere observed, reaching at least 18 feet. Its position, however, almost immediately below the resistant Carboniferous chert, where the outcrops are always on steep slopes, is unfavorable for extensive leaching, and therefore it is practically certain that no extensive areas of the leached rock will be found in this district. The west side of the valley is generally too steep for any leached rock to resist erosion. On the east side, where the slopes are somewhat less steep, the outcrop has been or may be worked for a considerable portion of the distance between Deans Siding and Centerville.

Some mining of brown rock has also been done in the valley of Defeated Creek, which joins Duck River from the north, opposite Indian Creek.

Sumner County district.—The Sumner County district lies about 5 or 6 miles northeast of Gallatin, in the valley of De Shea Creek. Its extent is not yet determined, but it is at least 2 miles, and possibly 3 or 4, in diameter. The region is very similar to the Mount Pleasant district, and its importance is only second to the latter. It is estimated that the productive area in the portion of the district thus far prospected is something over 300 acres, and that this area will produce at least 1,000,000 tons of phosphate. I am not prepared to vouch for this estimate, although it appears to be conservative. The factor which can not be determined until the field is well developed is the extent of the leaching. It is quite possible that some of the territory which has been estimated as productive may be found to contain so large a proportion of unleached limestone that the yield will be materially reduced. However, the phosphate in sight is amply sufficient to warrant the building of a railroad 4 miles to the field.

The interval between the phosphatic bed and the top of the Silurian is probably at least 150 feet, so that the Carboniferous chert is not abundant in the cover and does not protect the rock from extensive leaching. In general, the overburden appears to be somewhat lighter than at Mount Pleasant, which will render mining cheaper; but the terraces on the sides of the valley are narrower, and hence the productive area is not so large a proportion of the district. The largest areas are on the low spurs between the various branches of De Shea Creek, where the surface coincides approximately with the phosphatic horizon. At many points along the creek valley the hills rise so abruptly that there is no terrace, and the productive area will be confined to a narrow strip along the outcrop of the phosphatic bed. The length of such outcrop, however, is very considerable, and the aggregate yield would be large even if there were no terrace deposits.

Development.—The improved condition of the market for phosphate rock has caused a recent marked increase in production, particularly in the Mount Pleasant field. Improved plants are being installed by a number of companies, and the prospect is that the output will be largely increased in the near future. Owing, however, to the way in which the deposits are worked the production will be very much greater during the summer than the winter months.

In Hickman County the Duck River Phosphate Company is still mining the blue rock at Tottys Bend, and the Meridian Fertilizer Company is mining blue rock on Indian Creek. All the other companies have stopped work, and most of them are in the hands of receivers. A new company has been organized which is planning to work both blue and brown rock on Swan Creek.

A company is working on the white phosphate of Toms Creek in Perry County, and, it is said, has found large deposits of high-grade rock where the surface indications gave very little promise.

The Sumner County field has been taken up by a company which purposes to develop it at once.

With regard to the probability of finding other deposits of brown phosphate similar to those at Mount Pleasant and Gallatin, I should say they were good. As indicated above, the presence of workable deposits depends on the coincidence of conditions of sedimentation favorable for original accumulation and conditions of degradation favorable for the leaching and preservation of the phosphate. Such a coincidence may be looked for anywhere in the outer portion of the central basin or in the valleys which indent the highland rim. Indeed, it would be somewhat remarkable if the coincident favorable conditions were not found at other localities than those now known.

IMPORTS.

The following table shows the imports of fertilizers of all kinds into the United States from 1868 to 1898:

Fertilizers imported and entered for consumption in the United States, 1868 to 1898.

Year ending—	Guano.		Crude phosphates and other substances used for fertilizing purposes.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		
June 30, 1868...	99, 668	$1, 336, 761	....	$88, 864	$1, 425, 625
1869...	13, 480	217, 004	....	61, 529	278, 533
1870...	47, 747	1, 414, 872	....	90, 817	1, 505, 689
1871...	94, 344	3, 313, 914	....	105, 703	3, 419, 617
1872...	15, 279	423, 322	....	83, 342	506, 664
1873...	6, 755	167, 711	....	218, 110	385, 821
1874...	10, 767	261, 085	....	243, 467	504, 552
1875...	23, 925	539, 808	....	212, 118	751, 926
1876...	19, 384	710, 135	....	164, 849	874, 984
1877...	25, 580	873, 459	....	195, 875	1, 069, 334
1878...	23, 122	849, 607	....	285, 089	1, 134, 696
1879...	17, 704	634, 546	....	223, 283	857, 829
1880...	8, 619	108, 733	....	317, 068	425, 801
1881...	23, 452	399, 552	....	918, 835	1, 318, 387
1882...	46, 999	854, 463	133, 956	1, 437, 442	2, 291, 905
1883...	25, 187	537, 080	96, 586	798, 116	1, 335, 196
1884...	28, 090	588, 033	35, 119	406, 233	994, 266
1885...	20, 934	393, 039	40, 068	611, 284	1, 004, 323
Dec. 31, 1886...	13, 520	306, 584	82, 608	1, 179, 724	1, 486, 308
1887...	10, 195	252, 265	53, 100	644, 301	896, 566
1888...	7, 381	125, 112	36, 405	329, 013	454, 125
1889...	15, 991	313, 956	35, 661	403, 205	717, 161
1890...	4, 642	59, 580	31, 191	252, 787	312, 367
1891...	11, 937	199, 044	29, 743	214, 671	413, 715
1892...	3, 073	46, 014	92, 476	666, 061	712, 075
1893...	5, 856	97, 889	106, 549	718, 871	816, 760
1894...	5, 757	105, 991	126, 820	904, 247	1, 010, 238
1895...	4, 270	51, 642	80, 088	450, 379	502, 021
1896...	6, 532	79, 815	113, 955	639, 858	719, 673
1897...	4, 930	55, 715	200, 598	970, 836	1, 026, 551
1898...	4, 482	50, 783	139, 472	720, 053	770, 836

SULPHUR AND PYRITE.

By Edward W. Parker.

SULPHUR.

PRODUCTION.

The consumption of sulphur and the amount of iron pyrite burned for sulphur contents in the United States in 1898 exceeded to a considerable extent the domestic consumption during any similar period in our history. The amount of sulphur mined as such in this country, however, was less than in any year since 1894, and as compared with the imports and consumption has no appreciable effect upon the total. The product of 1,200 short tons, all of which was from Beaver County, Utah, represented less than one-third of 1 per cent of our total consumption, estimating the sulphur contents of domestic and imported pyrite ore at 45 per cent. Operations at Sulphur City, near Lake Charles, Louisiana, which were suspended in 1897, have not been resumed, but it is reported that experimental work is to be resumed there at an early date under a chemical process for recovering the sulphur, the Frasch process of liquefying the sulphur by superheated water not having proved the commercial success its promoters anticipated.

The deposits in El Paso County, Texas, which have been referred to in previous reports (Mineral Resources, 1896 and 1897) have not been thoroughly exploited and operations on a commercial scale have not been inaugurated. About 275 short tons were taken out, however, in 1898 for experimental purposes. This factor is not included in the statement of production.

Mr. Pattillo Higgins, of Beaumont, Texas, who is interested in the sulphur deposits about 4 miles from that city, states that operations will probably be commenced there before the close of 1899.

The following table shows the product of sulphur in the United States since 1880:

Sulphur product of the United States since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	600	$21,000	1890	....	....
1881	600	21,000	1891	1,200	$39,600
1882	600	21,000	1892	2,688	80,640
1883	1,000	27,000	1893	1,200	42,000
1884	500	12,000	1894	500	20,000
1885	715	17,875	1895	1,800	42,000
1886	2,500	75,000	1896	5,260	87,200
1887	3,000	100,000	1897	2,275	45,590
1888	....	....	1898	1,200	32,960
1889	450	7,850			

DOMESTIC CONSUMPTION.

The use of iron pyrite for the manufacture of sulphuric acid has during the past decade grown to be an important industry, and in considering the production and consumption of sulphur the sulphur contents of pyrite used for acid making must necessarily be included. It is only since 1891, however, that accurate statistics in regard to the importations of pyrite for acid making have been available. Prior to 1884 pyrite was included among other sulphur ores in the statistics compiled by the Bureau of Statistics of the Treasury Department. Pyrite was separately reported from 1884 to 1887, but the small quantities reported indicate that a considerable amount was imported either under the former classification as sulphur ore or as iron ore under which it was classed from 1887 to 1891, when the copper contents did not exceed 3.5 per cent. Reviewing the industry then since 1891, it is seen that in that year the amount of sulphur produced in the United States was 1,071 long tons, and the imports 117,187 long tons, a total of 118,258 long tons. The domestic production of pyrite in the same year was 106,536 long tons, and the importations 100,648 long tons, a total of 207,184 tons. Estimating the sulphur contents of both domestic and imported pyrite at 45 per cent, this total represented 93,233 long tons of sulphur, and added to the sulphur consumption makes the total for the year 211,491 long tons. It will be seen in the following table that this total has shown a steady and almost uniform increase until 1898, during which period there were only two years in which the sulphur imports showed a decrease (the domestic production being inconsiderable and having little influence on the total), and in each case this decrease was more than compensated for in the increased consumption of iron pyrite. In no instance has there been any decrease shown in the total pyrite consumption, any decline in domestic production being made up by larger imports, and vice versa. In 1898, notwithstanding the war between the United States and Spain, and sulphur contraband of war, the imports of sulphur into the United States showed an increase of 16 per cent. This was probably due to the increased demand for sulphur as one of the ingredients in powder manufacture, for which the sulphur contents of pyrite are not so readily available. The consumption of pyrite also showed an increase, all of which was made up of the domestic product, as there was a slight decrease in the imports. The total consumption in 1898 amounted to 366,337 long tons, of which 165,575 long tons were of sulphur and 200,762 long tons the sulphur contents of pyrite. The increase in the consumption of sulphur itself in 1898 as compared with 1891 was 47,316 long tons, or 40 per cent, while the amount of sulphur contained in iron pyrite consumed in 1898 was more than double that of 1891. In only two years since 1891 has the consumption of sulphur exceeded the sulphur contents of pyrite consumed. This was in 1894 and 1896, the latter being trifling and due to a somewhat larger domestic production.

The statistics of production, and imports of sulphur and the sulphur contents of domestic and imported pyrite exhibiting together the total domestic consumption, are presented in the following table:

Estimated consumption of sulphur in the United States from 1891 to 1898.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Sulphur:								
Domestic	1,071	2,400	1,071	446	1,607	4,696	2,031	1,071
Imported (*a*)	117,187	101,122	105,823	125,459	122,096	139,280	141,905	164,504
Sulphur contents of pyrite: (*b*)								
Domestic	47,941	49,405	34,100	47,673	44,697	51,968	64,440	87,014
Imported	45,292	68,561	87,715	74,596	85,796	90,076	116,796	113,748
Total domestic consumption	211,491	221,488	228,709	248,174	254,196	286,020	325,172	366,337

a Includes crude sulphur, flowers of sulphur, refined sulphur, and sulphur lac.
b Based on average sulphur contents of 45 per cent.

In the foregoing table the domestic production of sulphur has been reduced from short tons to long tons for the sake of uniformity.

CONDITION OF THE INDUSTRY.

The bulk of the sulphur product of the world is obtained from the island of Sicily, off the southern coast of Italy. Conditions, therefore, which affect the sulphur industry of Sicily influence the sulphur industry of the world.

The Anglo-Sicilian Sulphur Company, which was formed in 1896 for the purpose of controlling the production and marketing of Sicilian sulphur, has succeeded in its efforts, notwithstanding conditions which at one time threatened to break its hold. In the latter part of 1896, the operations of the syndicate were considerably disturbed by the independent producers, who took advantage of the rise in prices to increase their production to such an extent that prices showed a decline equivalent to about 50 per cent of the advance inaugurated by the syndicate, and values remained without material change throughout 1897. The war between Spain and the United States affected the prices in this country independent of the syndicate's operations. The syndicate in the meantime has secured a firmer hold upon the industry, having obtained direct control of about 80 per cent of the product, and has been able to hold in check the outside producers. The Oil, Paint, and Drug Reporter (January 22, 1899) states that the uniformity in spot prices quoted by the syndicate and outside producers leads to the surmise of an agreement to maintain prices. Indications point to advancing prices, as European demand has been active and there has been no unusual accumulation of stocks. The shipment of sulphur from Sicily in 1898 was the largest ever recorded, amounting, according to Mr. A. S. Malcomson, of New York, to 447,324 long tons, against 410,538 long tons in 1897. The United States is the largest consumer of Sicilian sulphur, an average of 30 per cent of the total shipments being to this country. The shipments to this country in 1898 amounted to 138,435 long tons, an increase of more than 20,000 long tons from 1897. The increase is attributed in part to the demand created by the war, but there has also been an augmented demand due to the requirements of the manufacturers of paper pulp. This increased consumption is remarkable, particularly when the increased consumption of iron pyrite for acid making is considered.

PRICES OF SICILIAN SULPHUR.

Mr. Alfred S. Malcomson has furnished the Survey with the following statement of the prices of Sicilian sulphur, best unmixed seconds, ex steamer at New York, for each month during 1896, 1897, and 1898. The wide variation between the extremes of prices in April and May, 1898, was due to the war with Spain. In each case the lower figure was for sulphur sold previously for April and May delivery. The higher prices were for spot sulphur after hostilities began and before the syndicate could make arrangements for shipping:

Spot prices for Sicilian sulphur, per long ton, ex steamer at New York.

Date.	1896.	1897.	1898.
January	$15.50	$20.00 @ $20.50	$20.50
February	15.50	19.75	20.50
March	15.00	20.00	21.50
April	15.50	19.25 @ 19.50	$21.50 @ 35.00
May	$15.50 @ 16.00	19.25 @ 19.50	21.75 @ 32.00
June	19.00	19.25	24.00
July	19.50	19.75	22.00
August	20.00 @ 21.00	20.00	21.00
September	22.50 @ 23.00	21.00	20.50 @ 21.00
October	24.00 @ 25.00	21.00	21.00 @ 22.00
November	22.00	21.00	21.00 @ 21.50
December	21.00	20.75	21.00

PRODUCTION OF SULPHUR IN ITALY.

In the following table the statistics of the production and value of sulphur in Italy, from 1860 to 1897 (practically all of which is obtained from the island of Sicily), are taken from the official report, Rivista del Servizio Minerario, metric tons having been converted into long tons and "lire" into United States values. The official statistics for 1898 are not available at the time this report goes to press and the figures are estimated. The estimate of production is based upon Mr. Malcomson's report of shipments and stocks on hand January 1 and December 31, 1898, and the values on the average advance in prices during the year. The table shows that, while the production in 1897 was the largest up to that time, the value was more than $300,000 less than that of 1882, when the product was 50,000 tons less than the output of 1897. The statement of shipments from Sicily, shown on a subsequent page, and which includes the shipments in 1898, indicates that the production of 1897 was surpassed by that of 1898 by about 40,000 tons. Shipments from Naples and Bologna are included in the table below, but they form an unimportant factor. Sicily contributes at least 95 per cent of the total in each year.

Production of sulphur in Italy from 1860 to 1897, inclusive.

Year.	Production.	Value.	Year.	Production.	Value.
	Long tons.			*Long tons.*	
1860	155, 067	$3, 693, 036	1880	353, 883	$7, 037, 859
1861	163, 217	3, 865, 950	1881	367, 163	8, 088, 237
1862	162, 825	3, 872, 376	1882	438, 751	9, 002, 010
1863	179, 637	4, 273, 992	1883	439, 332	8, 181, 887
1864	177, 707	4, 134, 870	1884	404, 431	7, 048, 751
1865	168, 829	3, 756, 507	1885	418, 708	6, 748, 077
1866	195, 019	4, 579, 547	1886	368, 327	5, 396, 720
1867	195, 873	4, 641, 046	1887	336, 715	4, 572, 979
1868	198, 097	4, 822, 158	1888	370, 486	4, 827, 512
1869	197, 493	5, 071, 715	1889	365, 524	4, 758, 005
1870	200, 597	4, 702, 716	1890	363, 305	5, 455, 201
1871	196, 518	4, 869, 515	1891	389, 171	8, 593, 413
1872	235, 323	5, 746, 251	1892	411, 828	7, 569, 781
1873	269, 794	6, 566, 050	1893	410, 958	5, 716, 018
1874	247, 221	6, 813, 675	1894	399, 260	4, 876, 715
1875	204, 086	5, 562, 575	1895	364, 807	3, 989, 877
1876	271, 605	6, 372, 385	1896	419, 501	5, 919, 554
1877	256, 141	5, 184, 313	1897	488, 676	8, 680, 800
1878	300, 238	5, 896, 665	1898	*a* 525, 000	9, 300, 000
1879	370, 268	7, 040, 165			

a Estimated on the basis of shipments and stocks. Domestic consumption is taken at the average for the previous five years.

EXPORTS OF SICILIAN SULPHUR.

Taken in connection with the foregoing statistics, the following table exhibiting the exports of sulphur from Sicily, together with the countries to which exported since 1883, is of interest. It will be observed that during the entire period the United States has been the most important customer. The decrease in shipments to Great Britain since 1890 as compared with the earlier years has been due, doubtless, to the supply furnished by the recovery of sulphur from alkali waste. This table is compiled from the annual statements published by Mr. Alfred S. Malcomson of New York. The shipments of 12,692 long tons to Canada included in the total to the United States, and the statement on a subsequent page that the United States imported 10,437 long tons from Canada indicate that this product came through some Canadian port in transit.

Total exports of sulphur from Sicily since 1883.

Country.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United States	96, 629	94, 929	99, 378	98, 590	89, 419	128, 265	109, 008	106, 656
France	63, 602	65, 098	58, 264	54, 280	56, 222	52, 083	67, 340	71, 790
Italy	66, 810	56, 292	49, 415	48, 658	48, 997	47, 664	43, 523	40, 231
United Kingdom	41, 788	40, 760	33, 402	30, 236	30, 007	35, 634	39, 203	26, 213
Greece	10, 494	7, 033	13, 664	19, 697	18, 370	5, 809	10, 158	18, 103
Portugal	15, 298	11, 018	17, 760	30, 943	16, 587	15, 851	16, 799	16, 695
Russia	10, 413	12, 831	13, 420	10, 570	13, 441	22, 043	17, 678	17, 158
Germany	7, 232	6, 622	6, 103	8, 689	9, 700	12, 402	15, 401	15, 703
Austria	4, 915	6, 037	5, 965	5, 800	6, 702	8, 942	8, 984	8, 746
Turkey	3, 043	1, 285	3, 077	4, 598	6, 238	1, 457	2, 231	4, 231
Spain	5, 242	3, 920	2, 243	5, 890	5, 873	3, 433	6, 586	5, 679
Belgium	7, 660	6, 793	9, 516	6, 580	5, 318	6, 951	7, 752	7, 279
Holland	1, 256	696	1, 237	2, 999	1, 747	2, 793	2, 424	....
Sweden	1, 010	744	328	1, 916	1, 169	3, 004	3, 899	3, 314
South America	....	....	....	....	710	95	23	....
Australia	....	....	....	....	600	885	....	400
Denmark	....	....	810	....	202	464	443	2, 565
Total	335, 392	314, 058	314, 582	329, 446	311, 302	347, 775	351, 451	344, 763

Total exports of sulphur from Sicily since 1883—Continued.

Country.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United States	97, 520	84, 450	83, 901	105, 773	99, 227	124, 923	118, 137	138, 435
France	56, 168	73, 176	89, 736	56, 932	69, 696	76, 739	84, 895	88, 657
Italy	42, 212	38, 711	54, 486	49, 895	49, 349	54, 009	73, 052	62, 652
United Kingdom	23, 408	24, 853	27, 453	22, 165	24, 043	21, 913	24, 520	26, 983
Greece and Turkey	11, 414	*a*14, 845	*a*13, 840	*a*16, 870	*a*16, 195	*a*18, 556	*a*13, 866	*a*24, 808
Portugal	11, 439	13, 490	14, 545	8, 670	14, 562	12, 001	7, 054	8, 257
Russia	11, 930	14, 178	19, 730	17, 977	17, 962	18, 752	17, 532	12, 285
Germany	10, 629	14, 326	16, 259	16, 437	15, 472	15, 680	19, 721	27, 048
Austria	10, 575	9, 096	10, 169	11, 494	12, 170	13, 799	15, 993	15, 796
Turkey	3, 000	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
Spain	3, 845	7, 382	3, 499	3, 445	5, 753	5, 910	4, 039	3, 233
Belgium	5, 089	5, 133	4, 358	5, 644	6, 410	7, 527	9, 253	8, 402
Holland	....	2, 183	2, 957	2, 365	3, 335	3, 834	3, 599	5, 646
Sweden	2, 252	4, 561	6, 579	7, 887	5, 730	14, 540	11, 226	12, 331
Australia	....	1, 200	....	....	....	....	....	....
Denmark	300	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Other countries	3, 542	3, 152	1, 680	3, 376	7, 732	8, 562	7, 651	12, 791
Total	293, 323	309, 536	349, 192	328, 930	347, 636	396, 745	410, 538	447, 324

a Exports to Greece and Turkey combined after 1892. *b* Included in exports to Sweden.

PORTS IN UNITED STATES RECEIVING SICILIAN SULPHUR.

The ports in the United States to which such shipments were made, together with the amount shipped to each since 1883, and the quality of the shipments since 1886, are shown in the following tables:

Ports in the United States receiving Sicilian sulphur and the amount received by each.

Port.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	41,238	46,460	50,814	49,952	45,979	60,706	55,939	37,390
Charleston	5,425	7,706	12,416	10,556	14,324	22,496	12,399	27,563
Philadelphia	23,123	19,234	12,153	15,662	11,764	11,793	14,334	11,094
Baltimore	16,175	13,986	16,435	15,680	10,306	17,330	15,316	16,700
Boston	5,864	4,723	4,200	3,800	3,300	6,300	4,950	2,500
Wilmington, N. C.					1,020	2,355	2,040	1,309
Savannah						3,545	3,240	5,920
Pensacola								1,390
Port Royal	600	610	680	660	1,000	600		600
Providence	650	1,140	1,370	1,180	630	1,250	590	650
San Francisco	1,884	500			296			
New Orleans	350	100	250		200	250	200	800
Woods Hole	650	470	1,060	1,100		1,160		
Mobile								740
Sundries	670				600	480		
Total	96,629	94,929	99,378	98,590	89,419	128,265	109,008	106,656

Ports of the United States receiving Sicilian sulphur, etc.—Continued.

Port.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	49,023	49,090	43,396	46,875	55,863	68,353	70,474	72,089
Charleston	21,646	4,510	13,525	15,296	9,150	7,700	5,130	2,100
Philadelphia	6,856	10,400	8,160	5,400	8,350	6,000	5,409	6,600
Baltimore	11,365	12,355	9,950	15,300	9,720	14,150	13,831	14,365
Boston	1,950	3,325	500	4,317	4,950	5,300	8,220	6,050
Wilmington, N. C.	2,600		1,140	1,890	650	2,660	1,550	1,700
Savannah	1,550	1,170	5,330	9,795	4,584	9,395	4,700	1,980
Pensacola								
Port Royal	700			800		660		
Providence				1,500	1,380			
San Francisco						3,125		2,539
New Orleans	1,200	2,000	1,900	2,400	1,700	2,100	3,340	2,500
Mobile				800	880			
Delaware Breakwater	630							
Portland, Me		2,000			1,300	2,550	4,343	13,750
Norfolk				1,400	700	2,930	1,140	
Portland, Ohio								2,070
Canada								12,692
Total	97,520	84,850	83,901	105,773	99,227	124,923	118,137	138,435

Quality of Sicilian sulphur received at the different ports of the United States since 1886.

Port.	1886.		1887.		1888.		1889.	
	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	36, 352	13, 600	29, 919	16, 060	35, 573	25, 133	32, 983	22, 956
Charleston	7, 506	3, 050	8, 875	5, 449	15, 485	7, 011	6, 325	6, 074
Philadelphia	4, 660	11, 002	2, 127	9, 637	3, 050	8, 743	2, 000	12, 334
Baltimore	7, 325	8, 355	4, 463	5, 843	11, 380	5, 950	7, 656	7, 660
Boston	600	3, 200	200	3, 100	700	5, 600	750	4, 200
Savannah	......	......	......	......	2, 130	1, 415	2, 790	1, 450
Wilmington, N. C	......	......	1, 020	......	2, 355	......	2, 040	......
Other ports	1, 180	1, 760	106	2, 620	1, 500	2, 240	200	590
Total	57, 623	40, 967	46, 710	42, 709	72, 173	56, 092	53, 744	55, 264

Port.	1890.		1891.		1892.		1893.	
	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	20, 801	16, 589	29, 358	19, 665	34, 390	14, 700	29, 146	14, 250
Charleston	20, 873	6, 690	17, 196	4, 450	4, 010	500	11, 665	1, 860
Philadelphia	1, 000	10, 094	450	6, 406	3, 600	6, 800	1, 900	6, 260
Baltimore	5, 930	10, 770	4, 510	6, 855	900	11, 455	2, 050	7, 900
Boston	200	2, 300	1, 300	650	1, 825	1, 500	500	......
Savannah	2, 750	3, 170	850	700	600	570	3, 450	1, 880
Wilmington, N. C	1, 309	......	1, 900	700	......	......	......	1, 140
New Orleans	......	......	......	......	......	......	1, 900	......
Other ports	1, 540	2, 640	1, 200	1, 330	4, 000	......	......	......
Total	54, 403	52, 253	56, 764	40, 756	49, 325	35, 525	50, 611	33, 290

Port.	1894.		1895.		1896.		1897.		1898.	
	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	33, 150	13, 725	35, 888	19, 975	50, 557	17, 796	57, 174	13, 300	49, 614	22, 475
Charleston	3, 273	12, 023	700	8, 450	2, 330	5, 370	1, 500	3, 630	500	1, 600
Philadelphia	350	5, 050	1, 200	7, 150	500	5, 500	199	5, 210	1, 200	5, 400
Baltimore	600	14, 700	1, 100	8, 620	3, 650	10, 500	3, 798	10, 033	2, 350	12, 015
Boston	1, 017	3, 300	2, 350	2, 600	4, 600	700	7, 220	1, 000	4, 500	1, 550
Savannah	5, 695	4, 100	3, 784	800	8, 370	1, 025	4, 700	......	1, 980	......
Wilmington, N. C	......	1, 890	......	650	1, 260	1, 400	......	1, 550	500	1, 200
New Orleans	2, 400	......	1, 700	......	2, 100	......	3, 340	......	500	2, 000
Other ports	800	3, 700	1, 880	2, 380	7, 975	1, 290	4, 883	600	27, 851	3, 200
Total	47, 285	58, 488	48, 602	50. 625	81, 342	43, 381	82, 814	35. 323	88, 995	49, 440

IMPORTS.

The following statements, showing the amount and value of sulphur imported into the United States for a series of years, are obtained from the Bureau of Statistics of the Treasury Department:

Sulphur imported and entered for consumption in the United States, 1867 to 1898.

Year ending—	Crude.		Flowers of sulphur.		Refined.		All other. (a)		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		*Long tons.*		*Long tons.*		
June 30, 1867...	24,544	$620,373	110	$5,509	251	$10,915	....	....	$636,797
1868...	18,151	446,547	16	948	65	2,721	....	....	450,216
1869...	23,590	678,642	97	4,576	645	27,149	....	....	710,367
1870...	27,380	819,408	76	3,927	157	6,528	....	$1,269	831,132
1871...	36,131	1,212,448	66	3,514	92	4,328	....	754	1,221,044
1872...	25,380	764,798	36	1,822	57	2,492	....	....	769,112
1873...	45,533	1,301,000	55	2,924	36	1,497	....	....	1,305,421
1874...	40,990	1,260,491	51	2,694	57	2,403	....	....	1,265,588
1875...	39,683	1,259,472	18	891	....	....	....	....	1,260,363
1876...	46,435	1,475,250	41	2,114	44	1,927	....	....	1,479,291
1877...	42,963	1,242,888	116	5,873	1,171	36,962	....	....	1,285,723
1878...	48,102	1,179,769	159	7,628	150	5,935	....	....	1,193,332
1879...	70,370	1,575,533	138	6,509	69	2,392	....	....	1,584,434
1880...	87,837	2,024,121	124	5,516	158	5,262	....	....	2,034,899
1881...	105,097	2,713,485	98	4,226	71	2,555	....	....	2,720,266
1882...	97,504	2,627,402	159	6,926	59	2,196	....	....	2,636,524
1883...	94,540	2,288,946	79	3,262	115	4,487	....	....	2,296,695
1884...	105,112	2,242,697	178	7,869	126	4,765	....	....	2,255,331
1885...	96,839	1,941,943	121	5,351	114	4,060	....	....	1,951,354
1886...	117,538	2,237,989	213	8,739	116	3,877	....	....	2,250,605
1887...	96,882	1,688,360	279	9,980	84	2,383	....	....	1,700,723
Dec. 31, 1888...	98,252	1,581,583	128	4,202	27	734	....	....	1,586,519
1889...	135,933	2,068,208	15	1,954	10	299	....	....	2,070,461
1890...	162,674	2,762,953	12	1,718	103	3,060	....	....	2,767,731
1891...	116,971	2,675,192	206	6,782	10	1,997	....	....	2,683,971
1892...	100,938	2,189,481	158	5,439	26	4,106	....	....	2,199,026
1893...	105,539	1,903,198	241	5,746	43	1,017	....	....	1,909,961
1894...	125,241	1,703,265	173	4,145	45	1,207	....	....	1,708,617
1895...	121,286	1,546,481	581	12,888	229	4,379	....	50,006	1,613,754
1896...	138,168	1,967,454	665	13,266	447	8,226	....	183,683	2,172,569
1897...	136,563	2,395,436	....	....	....	....	5,342	58,637	2,454,073
1898...	151,225	2,891,767	507	14,548	163	4,396	12,609	159,213	3,069,924

a Includes sulphur lac and other grades not otherwise provided for, but not pyrite.

Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1895 to 1898.

Countries whence exported and customs districts through which imported.	1895.		1896.	
	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*	
England	17,332	$272,807	15,640	$248,498
Italy	96,162	1,296,989	125,850	1,586,551
Japan	14,241	130,988	8,997	95,244
Total	127,735	1,700,784	150,487	1,930,293
DISTRICTS.				
Baltimore, Md	10,706	150,129	13,759	169,666
Beaufort, S. C	800	11,669	660	8,250
Boston and Charlestown, Mass	19,683	301,749	19,564	304,374
Charleston, S. C	11,576	143,915	9,730	118,885
Mobile, Ala	880	13,027	....	....
New Orleans, La	1,260	17,179	2,139	28,711
New York, N. Y	55,484	702,998	74,281	914,504
Norfolk and Portsmouth, Va	700	8,368	2,400	31,970
Philadelphia, Pa	8,216	110,841	9,085	122,195
Portland, Me	....	....	1,600	21,435
Providence, R. I	1,604	21,779	580	7,276
Puget Sound, Wash	....	....	458	5,710
San Francisco, Cal	6,356	64,758	6,370	66,934
Savannah, Ga	8,965	135,816	7,764	102,905
Willamette, Oreg	885	9,423	47	720
Wilmington, N. C	620	9,133	2,050	26,758
Total	127,735	1,700,784	150,487	1,930,293

Countries whence exported and customs districts through which imported.	1897.		1898.	
	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*	
Canada	....	....	10,437	$265,969
England	10,298	$194,992	7,359	157,747
Italy	108,908	1,821,056	146,596	2,613,394
Japan	9,446	140,426	7,489	146,813
Other countries	1,481	27,133	508	9,605
Total	130,133	2,183,607	172,389	3,193,528

Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1895 to 1898—Continued.

Countries whence exported and customs districts through which imported.	1897.		1898.	
	Quantity.	Value.	Quantity.	Value.
DISTRICTS.	*Long tons.*		*Long tons.*	
Baltimore, Md	10,139	$161,524	16,938	$296,073
Boston and Charlestown, Mass	14,088	259,559	15,866	308,092
Champlain, N. Y			5,678	144,216
Charleston, S. C	6,370	109,186	7,230	123,871
Mobile, Ala			299	9,256
New Orleans, La	3,050	53,041	2,300	35,690
New York, N. Y	61,151	1,035,786	86,761	1,539,858
Norfolk and Portsmouth, Va	1,153	17,650	406	9,868
Philadelphia, Pa	6,726	111,725	6,585	116,264
Portland, Me	5,400	94,279	10,100	191,065
Puget Sound, Wash	32	1,275		
San Francisco, Cal	9,973	134,565	6,338	121,050
Savannah, Ga	7,295	129,747	4,780	89,928
Vermont, Vt			2,675	72,121
Willamette, Oreg	2,696	42,020	1,653	37,804
Wilmington, N. C	2,060	33,250	2,450	45,063
All other			2,330	53,309
Total	130,133	2,183,607	172,389	3,193,528

PYRITE.

PRODUCTION.

The production of iron pyrite for acid making in 1898 experienced a noteworthy impetus and resulted in a marketed product of 193,364 long tons, an increase of 35 per cent over the output in 1897, and of 67.5 per cent over that of 1896, in each of which years the production was the largest up to that time. The increased production in 1898 was attended with an advance in values, for in sympathy with the rise in the price of Sicilian sulphur the average price received for pyrite advanced from $2.73 per long ton in 1897 to $3.07 per ton in 1898. The total value of the pyrite product in 1898 was $593,801 against $391,541 in 1897, an increase of $202,260, or 51.7 per cent as compared with a 35 per cent increase in product.

The actual amount of pyrite mined in 1898 was 204,452 long tons, of which 193,364 tons were marketed, leaving about 11,000 tons of stock on hand January 1, 1899. The marketed product only is considered in this report. The increase in the production of pyrite in 1898 may be attributed, like the increased imports and consumption of sulphur, to the demand for sulphur for powder manufactured in consequence of the war with Spain. There was a slight falling off in the amount of pyrite imported into this country in 1898 as compared with 1897, but this decrease was insignificant as compared with the increase in the domestic production.

About 70 per cent of the pyrite product in 1898 was from Virginia, 22 per cent was from Massachusetts, and the other 8 per cent was contributed by California, Colorado, New York, North Carolina, Ohio, and Tennessee.

The amount and value of pyrite mined for sulphur contents in the United States since 1882 have been as follows:

Production of pyrite in the United States from 1882 to 1898.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1882	12,000	$72,000	1891	106,536	$338,880
1883	25,000	137,500	1892	109,788	305,191
1884	35,000	175,000	1893	75,777	256,552
1885	49,000	220,500	1894	105,940	363,134
1886	55,000	220,000	1895	99,549	322,845
1887	52,000	210,000	1896	115,483	320,163
1888	54,331	167,658	1897	143,201	391,541
1889	93,705	202,119	1898	193,364	593,801
1890	99,854	273,745			

IMPORTS.

The following table shows the imports of pyrite containing not more than 3.5 per cent of copper from 1884 to 1898:

Imports of pyrite containing not more than 3.5 per cent of copper from 1884 to 1898. (a)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1884	16,710	$50,632	1893	194,934	$721,699
1885	6,078	18,577	1894	163,546	590,905
1886	1,605	9,771	1895	190,435	673,812
1887	16,578	49,661	1896	200,168	648,396
1891	100,648	392,141	1897	259,546	747,419
1892	152,359	587,980	1898	252,773	717,813

a Previous to 1884, classed among sulphur ores; 1887 to 1891, classed among other iron ores; since 1891, includes iron pyrite containing 25 per cent and more of sulphur.

CONSUMPTION.

As the imports of iron pyrite for use in the manufacture of sulphuric acid were not stated separately by the Bureau of Statistics of the Treasury Department prior to 1891, a comparison with the preceding years can not be made. The following table shows the amount of pyrite mined and imported for the past five years, and as no exports are reported by the Treasury Department, these figures may be accepted as representing the domestic consumption. The table also shows the estimated amount of sulphur displaced each year on a basis of 45 per cent of sulphur contents.

Amount of pyrite consumed in the United States, and estimated sulphur displaced, from 1891 to 1898.

Source.	1891.	1892.	1893.	1894.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
Domestic product	106,536	109,788	75,777	105,940
Imports	100,648	152,359	194,934	163,546
Domestic consumption	207,184	262,147	270,711	269,486
Sulphur displaced estimated on basis of 45 per cent contents	93,233	117,966	121,815	121,269

Source.	1895.	1896.	1897.	1898.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
Domestic product	99,549	115,483	143,201	193,364
Imports	190,435	200,168	259,546	252,773
Domestic consumption	289,984	315,651	402,747	446,137
Sulphur displaced estimated on basis of 45 per cent contents	130,493	142,097	181,236	200,672

CANADIAN PRODUCTION.

While the production and consumption of pyrite in the United States have been steadily increasing, production in Canada has been steadily declining for several years, the production in 1898 being less than half of what it was in 1891 and about 45 per cent of the product in 1889. There was a slight reaction in 1897, but the output in 1898 was the smallest in thirteen years. It will be observed, however, that there was in Canada, as in the United States, a notable advance in price. Since 1886 the production of pyrite in Canada has been as follows:

Annual production and value of pyrite in Canada since 1886.

Calendar year.	Tons of 2,000 lbs.	Value.
1886	42, 906	$193, 077
1887	38, 043	171, 194
1888	63, 479	285, 656
1889	72, 225	307, 292
1890	49, 227	123, 067
1891	67, 731	203, 193
1892	59, 770	179, 310
1893	58, 542	175, 626
1894	40, 527	121, 581
1895	34, 198	102, 594
1896	33, 715	101, 155
1897	38, 910	116, 730
1898	32, 218	128, 872

WORLD'S PRODUCTION.

The following table has been compiled, chiefly from official sources, to show the pyrite production in the principal producing countries and to exhibit to what an extent pyrite has supplanted sulphur for acid making. In the case of Spain the exports are taken instead of the production for such years as they are available. The published figures of pyrite production in Spain show an output in each year averaging from 20 to 25 per cent of the exports. As the export figures are probably taken from the custom-house records they are considered more reliable.

World's product of iron pyrite and amount of sulphur displaced. (a)

Country.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Spain (*b*)	279, 161	435, 906	393, 453	511, 769	480, 255	....	217, 545
France	243, 030	226, 304	227, 288	278 452	248, 934	295, 325	298, 571
United States	106, 536	109, 788	75, 777	105, 940	99, 549	115, 483	143, 201
Italy	....	....	....	....	....	....	57, 383
Canada	60, 474	53, 372	52, 270	36, 185	30, 534	30, 103	34, 471
United Kingdom	....	....	....	....	....	....	10, 583
Total	689, 211	1, 005, 370	748, 788	932, 346	859, 272	....	761, 754
Sulphur displaced (*a*)	310, 145	452, 416	336, 955	419, 556	386, 672	....	342, 789

a Based on estimated 45 per cent of sulphur contents. *b* Exports only.

GYPSUM.

By Edward W. Parker.

PRODUCTION.

The production of gypsum in the United States during 1898 amounted to 291,638 short tons, valued at $755,280. In 1897 the amount was 288,982 short tons, valued at $755,864. These figures show an increase of 2,656 short tons in the amount of the product and a decrease of $584 in the value. The production in 1898 was the largest ever recorded, as was the output in 1897 to that date. The value in 1898 was less than that of any year since 1893, with the exception of 1896, when the product was only 224,254 short tons.

The principal gypsum-producing States are Iowa, Kansas, Michigan, New York, Ohio, and Texas, each of which produces over 20,000 short tons of crude gypsum a year. Other producing States are Arizona, California, Colorado, Montana, Oklahoma, Oregon, Utah, Virginia, and Wyoming, none of which produced in 1898 as much as 10,000 short tons. The gypsum producers of Iowa object to the publication of the production in that State, as all of the three mills are located at one place (Fort Dodge), and such publication would, they claim, give information to competitors. Consequently the production of Iowa is included with that of Kansas. The aggregate output of these two States in 1898 was 83,913 short tons, against 83,783 short tons in 1897. The value declined from $255,129 to $237,208. The production in Michigan decreased from 94,874 short tons in 1897 to 93,181 tons in 1898, while the value increased slightly, from $193,576 to $204,310, the increase in value being due to increased sales of land plaster and stucco, or plaster of paris, and a decrease in the sales of crude gypsum. Increased sales of land plaster and an advance in price of this material in New York caused a slight increase in the total value of that State, in spite of a decrease in the total product and a decrease in the value of the calcined plaster produced. Ohio's total production increased from 18,592 short tons to 21,303 short tons, Texas's from 24,454 short tons to 34,215 short tons, and Virginia's from 6,374 short tons to 8,378 short tons. The production of plaster of paris in Texas during 1898 was nearly 40 per cent in excess of that of 1897, and in Virginia the output of calcined plaster was nearly two and one-half times as much as it was in 1897.

The details of production by States during the last two years are shown in the following tables:

Product of gypsum in the United States in 1897, by States.

State.	Total product.	Sold crude.		Ground into land plaster.		Calcined into plaster of paris.			Total value.
		Quantity.	Value.	Quantity.	Value.	Before calcining.	After calcining.	Value.	
	Short tons.	*Short tons.*		*Short tons.*		*Short tons.*	*Short tons.*		
Colorado and Indian Territory	12,309	......	......	1	$5	12,308	9,300	$50,350	$50,355
Iowa, Kansas	83,783	589	$1,151	500	400	82,694	62,657	253,028	254,579
Michigan	94,874	16,001	20,004	7,193	9,662	71,680	59,340	163,910	193,576
New York	33,440	5,394	3,516	15,826	34,368	12,220	9,200	40,800	78,684
South Dakota	8,350	......	......	......	......	8,350	6,280	19,240	19,240
Texas	24,454	......	......	......	......	24,454	16,412	65,651	65,651
Virginia	6,374	160	257	5,504	14,804	710	592	1,838	16,899
Other States (*a*)	25,398	1,020	2,092	2,538	7,844	21,840	17,154	66,944	76,880
Total	288,982	23,164	27,020	31,562	67,083	234,256	180,935	661,761	755,864

a Includes the product of Arizona, 30 tons; California, 351 tons; Montana, 425 tons; Ohio, 18,592 tons; Utah, 2,700 tons, and Wyoming, 3,300 tons.

Product of gypsum in the United States in 1898, by States.

State.	Total product.	Sold crude.		Ground into land plaster.		Calcined into plaster of paris.			Total value.
		Quantity.	Value.	Quantity.	Value.	Before calcining.	After calcining.	Value.	
	Short tons.	*Short tons.*		*Short tons.*		*Short tons.*	*Short tons.*		
California	3,800	215	$1,297	710	$4,600	2,875	2,220	$19,080	$24,977
Colorado and Wyoming	5,390	......	......	......	......	5,390	4,263	23,712	23,712
Iowa and Kansas	83,913	101	202	1,026	1,505	82,786	64,477	235,501	237,208
Michigan	93,181	1,984	1,984	13,345	20,493	77,852	63,005	181,833	204,310
New York	31,655	2,243	1,353	17,112	40,066	12,300	9,275	40,550	81,969
Virginia	8,378	320	676	6,258	17,464	1,800	1,447	5,248	23,388
Other States (*a*)	65,321	895	1,688	2,478	6,649	61,948	45,396	151,379	159,716
Total	291,638	5,758	7,200	40,929	90,777	244,951	190,083	657,303	755,280

a Includes the product of Arizona, 30 tons; Montana, 1,123 tons; Ohio, 21,303 tons; Oklahoma, 3,150 tons; Oregon, 150 tons; South Dakota, 2,740 tons; Texas, 34,215 tons, and Utah, 2,610 tons.

In the report for 1897 comment was made upon the increase shown in the manufacture of plaster of paris by the producers of gypsum. In 1889, when the first attempt was made at separating the production according to its condition when first sold, the total output was 267,769 short tons, of which only 85,755 short tons, or about one-third, was made into "stucco" or calcined plaster (plaster of paris). In 1898, nine years later, the amount of gypsum calcined was 244,951 short tons, 84 per cent of the total product of 291,638 tons, and nearly three times the amount so used in 1889. The amount of calcined plaster produced in 1889 was 64,711 short tons; in 1898 this product amounted to 190,083 tons, each year from 1889 to 1898 showing an increase over the preceding year, with the single exception of 1896. The production in 1897, however, was more than 20,000 tons over that in 1895, and if the production for 1896 and for 1895 had been reversed, the steady ratio of increase would have been maintained. In considering the value of the stucco or plaster of paris produced, a different aspect is presented, for while the output in nine years has increased practically 200 per cent, the value of the product has increased less than 50 per cent and the price has been cut exactly in half, declining from $6.92 per ton in 1889 to $3.46 in 1898. The decrease in average price has been almost as steady and persistent as the increase in production, as shown in the following table:

The quantities sold crude or as land plaster show much more variation from year to year than the amount of calcined plaster made and sold. The most of the gypsum sold crude is afterwards ground and used as land plaster, the demand for which varies according to whether the season be wet or dry. Land plaster is used principally in dry seasons, and does not show the same regularity of production as exhibited in the statistics of calcined plaster. It will be observed also, that the value of crude gypsum per ton has varied during ten years from $1.02 to $1.68 per ton, the lower figure being reached in 1890 and the higher in 1893. The price of land plaster has also varied somewhat, but not so much as that of crude gypsum. The lowest average price per ton for this product during the last ten years was $2.11 per ton in 1893, the year of highest price for crude gypsum, and the highest price for land plaster was $2.53 per ton in 1890, the year in which crude gypsum brought the lowest price. It must be remembered, however, that these variations are not necessarily fluctuations or the results thereof. Much of the difference in average price is due to variations in the quantity of higher or lower grade of material which is included in the amount sold, and also to the producing locality. The same quantity of the same quality of plaster would show a higher value in California than in New York.

The average prices for crude gypsum and for land plaster in 1898 were slightly higher than in either 1896 or 1897, as shown in the following table:

Distribution of the gypsum product of the United States since 1889.

Year.	Total amount produced.	Sold crude.			Ground into land plaster.		
		Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
	Short tons.	*Short tons.*			*Short tons.*		
1889	267,769	73,243	$82,704	$1.13	108,771	$233,307	$2.14
1890	182,995	18,742	19,148	1.02	56,525	143,014	2.53
1891	208,126	18,574	28,690	1.54	51,700	117,356	2.27
1892	256,259	58,080	80,797	1.39	47,668	106,247	2.23
1893	253,615	42,808	71,860	1.68	50,408	106,365	2.11
1894	239,312	34,702	56,149	1.62	41,996	95,944	2.28
1895	265,503	26,624	37,837	1.42	35,079	85,355	2.43
1896	224,254	17,302	19,134	1.11	27,354	59,749	2.18
1897	288,982	23,164	27,020	1.17	31,563	67,083	2.13
1898	291,638	5,758	7,200	1.25	40,929	90,777	2.22

Year.	Calcined into plaster of paris.				Total value.
	Weight before calcining.	Calcined plaster produced.	Value.	Average price per ton.	
	Short tons.	*Short tons.*			
1889	85,755	64,711	$448,107	$6.92	$764,118
1890	107,728	79,257	412,361	5.20	574,523
1891	137,852	110,006	482,005	4.38	628,051
1892	150,511	106,141	508,448	4.79	695,492
1893	160,399	122,937	518,390	4.22	696,615
1894	162,614	127,158	609,626	4.79	761,719
1895	203,800	150,801	674,255	4.47	797,447
1896	179,598	137,505	494,461	3.60	573,344
1897	234,256	180,935	661,761	3.66	755,864
1898	244,951	190,083	657,303	3.46	755,280

The total production and value, by States, for the same period were as follows:

Comparative statistics of gypsum production for ten years.

State.	1889.		1890.		1891.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Colorado	7, 700	$28, 940	4, 580	$22, 050	....	....
Iowa	21, 781	55, 250	20, 900	47, 350	31, 385	$58, 095
Kansas	17, 332	94, 235	20, 250	72, 457	40, 217	161, 322
Michigan	131, 767	373, 740	74, 877	192, 099	79, 700	223, 725
New York	52. 608	79, 476	32, 903	73, 093	30, 135	58, 571
South Dakota	320	2, 650	2, 900	7, 750	3, 615	9, 618
Virginia	6, 838	20, 336	6, 350	20, 782	5, 959	22, 574
Other States	29, 420	109, 491	20, 235	138, 942	17, 115	94, 146
Total	267, 769	764, 118	182, 995	574, 523	208, 126	628, 051

State.	1892.		1893.		1894.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Iowa	(*a*)	(*a*)	21, 447	$55, 538	17, 906	$44, 700
Kansas	46, 016	$195, 197	43, 631	181, 599	64, 889	301, 884
Michigan	139, 557	306, 527	124, 590	303, 921	79, 958	189, 620
New York	32, 394	61, 100	36, 126	65, 392	31, 798	60, 262
Ohio	(*a*)	(*a*)	(*a*)	(*a*)	20, 827	69, 597
South Dakota	....	....	5, 150	12, 550	4, 295	16, 050
Texas	....	....	....	....	6, 925	27, 300
Virginia	6, 991	28, 207	7, 014	24, 359	8, 106	24, 431
Other States	31, 301	104, 461	15, 657	53, 256	4, 608	27, 875
Total	256, 259	695, 492	253, 615	696, 615	239, 312	761, 719

State.	1895.		1896.		1897.		1898.	
	Product.	Value.	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
California	5, 158	$51, 014	1, 452	$11, 738	(*a*)	(*a*)	3, 800	$24, 977
Colorado	1, 371	8, 281	1, 600	10, 547	*b* 12, 309	$50, 355	*c* 5, 390	23, 712
Iowa	25, 700	36, 600	18, 631	34, 020	83, 783	255, 129	83, 913	237, 208
Kansas	72, 947	272, 531	49, 435	148, 371				
Michigan	66, 519	174, 007	67, 634	146, 424	94, 874	193, 576	93, 181	204, 310
New York	33, 587	59, 321	23, 325	32, 812	33, 440	78, 684	31, 655	81, 969
Ohio	21, 662	71, 204	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
South Dakota	6, 400	20, 600	(*a*)	(*a*)	8, 350	19, 240	(*a*)	(*a*)
Texas	10, 750	36, 511	(*a*)	(*a*)	24, 454	65, 651	34, 215	58, 130
Virginia	5, 800	17, 369	5, 955	17, 264	6, 374	16, 899	8, 378	23, 388
Other States	15, 609	50, 009	56, 222	172, 168	25, 398	76, 880	31, 106	101, 586
Total	265, 503	797, 447	224, 254	573, 344	288, 982	755, 864	291, 638	755, 280

a Included in other States. *b* Including Indian Territory. *c* Includes Wyoming.

The following table shows the annual production of gypsum in the United States since 1880. It will be noticed that the largest production prior to 1897 was in 1889, though the value of the product in both these years was less than that of 1895:

Production of gypsum in the United States since 1880.

Year.	Product.	Value.	Year.	Product.	Value.
	Short tons.			*Short tons.*	
1880	90, 000	$400, 000	1890	182, 995	$574, 523
1881	85, 000	350, 000	1891	208, 126	628, 051
1882	100, 000	450, 000	1892	256, 259	695, 492
1883	90, 000	420, 000	1893	253, 615	696, 615
1884	90, 000	390, 000	1894	239, 312	761, 719
1885	90, 405	405, 000	1895	265, 503	797, 447
1886	95, 250	428, 625	1896	224, 254	573, 344
1887	95, 000	425, 000	1897	288, 982	755, 864
1888	110, 000	550, 000	1898	291, 638	755, 280
1889	267, 769	764, 118			

GYPSUM IN FLORIDA.

An occurrence of gypsum has been observed about 6 miles west of Panasoffkee, Florida. The deposit has been examined by Dr. David T. Day, Chief of the Division of Mineral Resources, who reports that the gypsum occurs in a low-lying area of hummock land known as Bear Island. Near the marsh which surrounds the so-called island it is covered with cypress trees, and, farther in, by rather unusually large palmetto trees and the usual mixture of live oak and magnolia, with occasional low spots where nothing but cypress will grow. In the southern and southwestern portion of this so called island the gypsum reaches the surface, with no covering whatever, except an inch or two of vegetable mold. By striking a hoe into this the gypsum is dug up in a very soft state like clay, but soon hardens on exposure to dry air. It is greenish while wet and turns quite white on drying. Where the gypsum is at the surface the land is usually in the form of knolls from 10 to 50 feet square, 3 to 6 feet higher than the adjoining land, but the gypsum is found almost everywhere by slight excavation. Two pits, sunk through it, have shown it to be 6½ feet in one place and 7 feet in the other, with the usual light Florida sand underneath it. Mixed through it are bowlders of very impure limestone, with occasional hard, flinty bowlders. Fifteen different samples were taken from deposits and numbered stakes left at each place. Analyses and determinations of these 15 samples will be made. As a rule, the topography of the country will admit of digging 6 or 8 feet through the gypsum without encountering any considerable amount of water, except in the wet season.

The quality of the gypsum is almost uniform in all the places from which specimens were taken. The quantity is evidently sufficient for a large supply. The mining should be extremely easy except for the considerable work of clearing off the heavy growth of timber, about half of which will be of some value. The only difficulty anticipated in the mining would be the fact that the lumps of limestone would be encountered at irregular intervals, and their character makes it evident that they are residual lumps from limestone which has been dissolved by the action of the rain water, as in many other parts of the State. This leaves it probable that the floor of the deposit will frequently be a bed of limestone, very irregular in its surface, so that it will be difficult to dig all the gypsum from it by cheap means. This, however, should be a slight objection only, on account of the apparently large amount of material available. The land is owned by Messrs. H. A. Batchelor and his son. Mr. H. A. Batchelor is president of the Cypress Lumber Company, who have a large sawmill at Panasoffkee. They are now cutting cypress from the northeast side of Lake Panasoffkee and bringing it by logging trains by rail to the mill, a distance as great as or slightly greater than will be necessary in reaching Bear Island by the same means. They propose to cut the timber from the large body of cypress trees immediately west of Bear Island, and would cross Bear Island in this work. Transportation cost would therefore be reduced to the minimum.

The following analysis represents the approximate composition of the Bear Island gypsum:

Analysis of gypsum from Bear Island, near Panasoffkee, Florida.

Constituent.	Per cent.
Silica	0.07
Iron oxide	0.01
Sulphuric acid	45.76
Lime	32.32
Water	21.39
Total	99.55

IMPORTS.

The imports of gypsum are chiefly from Canada, the product from the Dominion being very pure and well adapted for the manufacture of plaster of paris. The following table exhibits the total amount and value of gypsum imported into the United States since 1867:

Gypsum imported into the United States from 1867 to 1898.

Year ending—	Ground or calcined.		Unground.		Value of manufactured plaster of paris.	Total value.
	Quantity.	Value.	Quantity.	Value.		
	Long tons.		*Long tons.*			
June 30, 1867....	....	$29, 895	97, 951	$95, 386	....	$125, 281
1868....	....	33, 988	87, 694	80, 362	....	114, 350
1869....	....	52, 238	137, 039	133, 430	$844	186, 512
1870....	....	46, 872	107, 237	100, 416	1, 432	148, 720
1871....	....	64, 465	100, 400	88, 256	1, 292	154, 013
1872....	....	66, 418	95, 339	99, 902	2, 553	168, 873
1873....	....	35, 628	118, 926	122, 495	7, 336	165, 459
1874....	....	36, 410	123, 717	130, 172	4, 319	170, 901
1875....	....	52, 155	93, 772	115, 664	3, 277	171, 096
1876....	....	47, 588	139, 713	127, 084	4, 398	179, 070
1877....	....	49, 445	97, 656	105, 629	7, 843	162, 917
1878....	....	33, 496	89, 239	100, 102	6, 989	140, 587
1879....	....	18, 339	96, 963	99, 027	8, 176	125, 542
1880....	....	17, 074	120, 327	120, 642	12, 693	150, 409
1881....	....	24, 915	128, 607	128, 107	18, 702	171, 724
1882....	5, 737	53, 478	128, 382	127, 067	20, 377	200, 922
1883....	4, 291	44, 118	157, 851	152, 982	*a* 21, 869	218, 969
1884....	4, 996	42, 904	166, 310	168, 000	....	210, 904
1885....	6, 418	54, 208	117, 161	119, 544	....	173, 752
1886....	5, 911	37, 642	122, 270	115, 696	....	153, 338
1887....	4, 814	37, 736	146, 708	162, 154	....	199, 890
Dec. 31, 1888....	3, 340	20, 764	156, 697	170, 023	....	190, 787
1889....	5, 466	40, 291	170, 965	179, 849	....	220, 140
1890....	7, 568	55, 250	171, 289	174, 609	....	229, 859
1891....	9, 560	97, 316	110, 257	129, 003	....	226, 319
1892....	6, 882	75, 608	181, 104	232, 403	....	308, 011
1893....	3, 363	31, 670	164, 300	180, 254	....	211, 924
1894....	2, 027	16, 823	162, 500	179, 237	....	196, 060
1895....	3, 295	21, 526	192, 549	215, 705	10, 352	247, 583
1896....	3, 292	21, 982	180, 269	193, 544	11, 722	227, 248
1897....	2, 664	17, 028	163, 201	178, 686	16, 715	212, 429
1898....	2, 973	18, 501	166, 066	181, 364	40, 979	240, 844

a Not specified from 1883 to 1894.

CANADIAN PRODUCTION AND EXPORTS.

As the imports of gypsum into the United States are principally from the Provinces of Ontario, New Brunswick, and Nova Scotia, in the Dominion of Canada, the following table, showing the production in and the exports from the Dominion, will be found interesting:

Production and exports of Canadian gypsum since 1886.

Year.	Production.		Exports.	
	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*	
1886	162,000	$178,742	142,833	$155,213
1887	154,008	157,277	132,724	146,542
1888	175,887	179,393	125,508	121,389
1889	213,273	205,108	178,182	194,404
1890	226,509	194,033	175,691	192,254
1891	203,605	206,251	171,311	181,795
1892	241,048	241,127	189,860	201,086
1893	192,568	196,150	*a* 162,192	159,262
1894	223,631	202,031	160,412	158,124
1895	226,178	202,608	*a* 189,486	193,244
1896	207,032	178,061	181,277	186,589
1897	239,691	244,531	189,206	197,150
1898	219,256	230,440	....	....

a Entire exports went to the United States.

WORLD'S PRODUCTION.

The United States is the second country in the world as a producer of gypsum. France leads with more than one-half the entire world's production. Canada follows the United States in importance, though in one year (1896) the output of Great Britain exceeded that of Canada.

The following table exhibits, in short tons, the amount of gypsum produced by the principal countries of the world in each year, for which statistics are available, since 1893:

The world's production of gypsum since 1893.

Year.	United States.		Great Britain.		Canada.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
1893	253,615	$696,615	158,122	$287,940	192,568	$196,150
1894	239,312	761,719	169,102	321,822	223,631	202,031
1895	265,503	797,447	196,037	348,400	226,178	202,608
1896	224,254	573,344	213,028	361,509	207,032	178,061
1897	288,982	755,864	203,151	325,513	239,691	244,531

The world's production of gypsum since 1893—Continued.

Year.	France.		German Empire.		India.		Cyprus.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
1893	....	....	......	....	......	......	2, 357	$6, 625
1894	1, 693, 831	$2, 891, 365	......	....	3, 548	$1, 566	3, 104	9, 006
1895	2, 175, 448	3, 392, 768	23, 994	$11, 040	7, 511	2, 987	2, 093	5, 252
1896	1, 866, 498	2, 661, 200	31, 736	14, 598	8, 248	3, 130	1, 050	2, 590
1897	1, 845, 874	2, 673, 033	28, 821	13, 228	9, 025	3, 333	......	......

SALT.

By Edward W. Parker.

PRODUCTION.

Salt production in the United States during 1898 kept pace with the increased activity displayed in other lines of industry, and, following a year of unprecedented output, added over 1,600,000 barrels to the production of 1897, which was 2,000,000 barrels ahead of 1896. The combined output of brine and rock salt, and the salt contents of brine used in making soda ash, reduced to a common unit, amounted in 1898 to 17,612,634 barrels of 280 pounds, as compared with 15,973,202 barrels in 1897, and 13,850,726 barrels in 1896. These three years are the culmination of fifteen years in which the salt production of the United States has, with one exception, steadily increased. The single exception was in 1889, when the production was about 50,000 barrels (0.6 per cent) less than that of 1888. The salt-producing industry has shown a remarkable development during the period covered by this series of reports. In 1880 the total salt production of the United States was 5,961,060 barrels, a little more than one-third the product of 1898. Compared with 1888, the production in 1898 shows an increase of over 100 per cent. There are only five other important mining industries that have shown the same ratio of increase during the last decade. These are copper, zinc, aluminum, petroleum, and phosphate rock, and one of these, aluminum, has been developed altogether within the last ten years.

The increased production in 1898 was accompanied by an advance of 15 per cent in price, which brought the total value up to $6,212,554, an increase of $1,238,534 over 1897, and of $2,117,715, or more than 50 per cent, over that of 1896. Taking into consideration all the various qualities of salt produced, from fancy table and dairy grades to cheap "coarse solar" and unprepared rock salt, the average price obtained in 1898 was 35.3 cents net per barrel. By "net" is meant the value of the salt alone, and exclusive of the cost of package, such as cartons, bags, barrels, etc., which in many cases is equal to the price obtained for the salt. The average net price obtained by producers in 1897 was 30.8 cents per barrel, against 29.2 cents in 1896, 32 cents in 1895, and

36½ cents in 1894. It will be seen from this that the price brought in 1898 was the best since 1894. There was no decided increase in the production of the higher priced grades. On the other hand, there was an actual decrease of about 356,000 barrels in the output of table and dairy brands, which would have a tendency toward lowering the average price. The improvement in values may be taken as an evidence of a healthful recovery from the depression of the three preceding years. A further and more conclusive evidence of this is presented in the following figures, showing the average prices for common fine salt in some of the leading producing States. Michigan produces the largest amount of common fine salt, 4,552,908 barrels out of a total product of 5,263,564 barrels in 1898 being of that grade. The average price in 1897 for this quality in Michigan was 26.95 cents, and in 1898, 27¼ cents. In New York the average price was 29.4 cents in 1897, and 32.4 cents in 1898. In Ohio the price declined from 36 cents to 35 cents. In Kansas it advanced from 27.7 cents to 29 cents. These figures are not shown in the accompanying tables, but are averages compiled from individual reports to the Survey. Common fine salt may be considered as the most popular grade, as about 50 per cent of the total product is of this quality. The quantity of this grade of salt exceeds that of any other grade in all the producing States except in New York, California, and Utah. The last is unimportant. California's principal product is "coarse solar," made in ponds along the shores of San Francisco Bay, in Alameda County. New York produced about equal amounts of table and dairy and common fine salt in 1898, nearly as much of rock salt, while the production of coarse solar salt in the Onondaga district and at Geddes (the salt in brine used for making soda ash being included with the coarse solar) was a little more than the combined output of table, dairy, and common fine salts in that State.

The retail prices of salt are not apt to be affected by any moderate advance in the price at first hands. The prices obtained by producers in 1896, 1897, and 1898 were equivalent, respectively, to 10.4 cents, 11.2 cents, and 12.6 cents per 100 pounds. Ordinary table salt retails at about 2 cents per pound in 2½ to 5 pound sacks, equivalent to $2 per 100 pounds, so that there is a wide margin to divide between the transportation companies and the middlemen. Much of the salt retailed for table and dairy use leaves the producer as "common fine."

Mr. Horace Arthur, with Austin, Nichols & Co., wholesale grocers, of New York City, states that the wholesale prices for salt at New York are, for table, $1.90 per barrel; common fine, $1.75 per barrel; common coarse, 1-bushel bags (56 pounds), 40 cents per bag; coarse solar, 1-bushel bags, 45 cents per bag. All of these retail at about 2 cents per pound. Table and dairy salts in 5 and 10 pound sacks sell at wholesale at 4 and 7 cents, respectively, per bag.

Outside of the increased production in 1898, the interesting features which characterized the salt industry during the year were (1) preliminary steps looking to the formation of an association among the producers in the Warsaw district of New York, and which was consummated in the spring of 1899, for self-protection and for putting an end to the ruinous competition which has for several years made the salt industry an unprofitable, if not a losing one; (2) the increased development of the salt resources of Louisiana.

Prior to 1898 the only active operations prosecuted in Louisiana were on Avery Island, near New Iberia, although other large deposits were known to exist. All the production up to the close of 1898 was from the Avery Island mines. In August of last year Messrs. Myles & Co., of New Orleans, who had been operating the Avery Island, or "Petite Anse" mines for several years, surrendered their lease. Since that time the mines have been operated by the Avery Rock Salt Mining Company. Messrs. Myles & Co. have, since surrendering their lease at Avery Island, developed mines on the extensive salt beds underlying Weeks Island, and their production for 1899 will be from this locality. In addition to these, a company formed in Chicago has been engaged for several months in sinking a shaft, constructing buildings, and installing machinery on Belle Isle, and will contribute to the salt production in 1899. Mr. A. F. Lucas, M. E., formerly with Myles & Co., has done some prospecting work on Jefferson Island, owned by Mr. Joseph Jefferson. Mr. Lucas's work was confined entirely to drilling for the purpose of ascertaining the extent of the deposit under Jefferson Island. Salt was found at a depth of 260 feet. Work was continued until the drill had passed through over 1,800 feet of salt without reaching the bottom. At this point Mr. Jefferson expressed himself as satisfied with the amount of salt in sight, and work was suspended. No further progress in the way of developing this property has been made.

PRODUCTION BY STATES.

In considering the production in 1898 by States it will be observed that New York continues to hold first place, which was attained in 1893. There was a slight decrease in 1898. Michigan's product increased from 3,993,225 barrels in 1897 to 5,263,564 barrels in 1898, a gain of 1,270,339 barrels, or about 32 per cent. Until 1893, when it was supplanted by New York, Michigan was the largest salt producer. Since 1893 Michigan has held second place. New York and Michigan together produced a little more than two-thirds of the total output of salt in 1898, New York contributing 38 per cent and Michigan 30 per cent. Kansas regained third place, supplanting Ohio, which fell back to fourth place, these two States resuming the positions held between 1889, when Kansas appeared as an important source of supply, and 1895, when the large production at Cleveland pushed Ohio ahead.

The following tables exhibit the details of production in 1897 and 1898 by States and grades.

Production of salt in 1897, by States and grades.

State.	Number of works.	Table and dairy.	Common fine.	Common coarse.	Packers'.	Coarse solar.	Rock.	Other grades.	Total product.	Total value.
		Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	
California	27	69,313	5,000	45,000	12,921	315,014	15,716	7,929	470,893	$162,654
Kansas	9	64,266	796,340	....	533,135	....	111,814	32,772	1,538,327	488,022
Michigan	53	173,441	3,298,350	190,794	6,660	320,986	....	2,994	3,993,225	1,253,403
New York:										
Brine salt	41	1,358,298	994,949	143,796	40,233	2,839,777	....	95,622	5,472,675	1,948,759 (Brine salt and Rock salt together)
Rock salt	2	....	....	....	....	....	1,333,179	....	1,333,179	
Ohio	11	401,494	1,081,983	87,616	....	....	....	4,321	1,575,414	421,757
Pennsylvania	3	471	144,863	18,953	....	....	....	....	164,287	45,107
Utah	6	162,214	65,143	11,286	16,429	131,571	2,679	15,857	405,179	196,056
West Virginia	4	303,400	137,693	800	....	....	....	....	441,893	160,129
Illinois, Louisiana, Oklahoma, Texas, and Virginia	5	22,381	344,477	17,898	....	7,143	186,071	160	578,130	244,133
Total	161	2,555,278	6,868,798	516,143	609,378	3,614,491	1,649,459	159,655	15,973,202	4,920,020

Production of salt in 1898, by States and grades.

State.	Table and dairy.	Common fine.	Common coarse.	Packers'.	Coarse solar.	Rock.	Milling.	Other grades.	Total product.	Total value.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	
California	61, 430	7, 143	46, 786	10, 000	505, 507	21, 429	....	714	653, 009	$185, 848
Kansas	90, 104	918, 213	122, 393	334, 983	1, 364	414, 943	....	329	1, 882, 329	616, 591
Michigan	208, 050	4, 552, 908	466, 466	10, 375	21, 997	....	....	3, 768	5, 263, 564	1, 628, 081
New York	1, 254, 854	1, 240, 325	169, 811	23, 777	2, 493, 285	1, 556, 300	....	53, 446	6, 791, 798	2, 369, 323
Ohio	400, 035	1, 154, 964	26, 548	500	....	....	....	100, 200	1, 682, 247	826, 868
Pennsylvania	....	140, 000	14, 287	....	....	....	....	....	154, 287	46, 000
Texas	33, 000	198, 570	10, 000	....	10, 714	....	....	2, 000	254, 284	119, 700
Utah	55, 714	4, 086	....	....	42, 014	7, 857	156, 579	....	266, 250	103, 778
West Virginia	90, 000	140, 501	17, 167	....	....	....	....	....	247, 668	88, 462
Other States	5, 152	226, 418	213	....	2, 143	183, 272	....	....	417, 198	227, 903
Total	2, 198, 339	8, 583, 128	873, 671	379, 635	3, 077, 024	2, 183, 801	156, 579	160, 457	17, 612, 634	6, 212, 554

In the following table is presented the distribution of the total salt product of the United States, by grades, during the past six years. It will be observed that the production of common fine salt has approximated 50 per cent of the total output during this period.

Production of salt in the United States, 1893 to 1898, inclusive, by grades.

Year.	Table and dairy.	Common fine.	Common coarse.	Packers'.	Solar.	Rock.	Milling.	Other grades.	Total product.	Total value.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	
1893	1, 791, 577	5, 478, 054	444, 498	96, 657	2, 110, 287	1, 884, 145	5, 141	6, 413	11, 816, 772	$4, 054, 668
1894	2, 839, 140	5, 281, 754	438, 074	103, 041	587, 305	2, 266, 606	95, 621	1, 356, 876	12, 968, 417	4, 739, 285
1895	2, 173, 123	6, 099, 480	280, 284	118, 801	983, 870	2, 089, 763	40, 107	1, 884, 221	13, 669, 649	4, 423, 084
1896	2, 230, 409	6, 598, 733	300, 365	163, 035	2, 531, 086	1, 783, 886	133, 271	109, 941	13, 850, 726	4, 040, 839
1897	2, 555, 278	6, 868, 798	516, 143	609, 378	3, 614, 491	1, 649, 459	....	159, 655	15, 973, 202	4, 920, 020
1898	2, 198, 339	8, 583, 128	873, 671	379, 635	3, 077, 024	2, 183, 801	156, 579	160, 457	17, 612, 634	6, 212, 554

PRODUCTION IN PREVIOUS YEARS.

In the following statement is shown the salt production of the United States, distributed by States, during a period of nineteen years. Within this period the salt product of the United States has trebled. A study of the statistics of production and importations clearly demonstrates the fact that in addition to supplying the increased demand created by the development of our enormous packing industries, the salt of domestic production has been steadily replacing foreign, particularly English, salt in our home markets. This has been accomplished only after a hard and persistent struggle. Until the last few years there was a prevailing opinion among the larger consumers of this necessary article of commerce that no salt of domestic production could compete in quality with English salt, and in order to find a market for the contents the packages had to bear the name of "ground Ashton," "Liverpool ground," or other known English brand. Some producers resorted to the practice of imitating the brands and style of packages, as they had imitated successfully the grain and quality of the product. This is no longer necessary, as American producers have demonstrated their ability to make the highest quality of salt for dairy, table, and packers' use, and it is now sold on its merits, the question of price acting as the most potent factor in determining the buyer's choice.

Turning to the tables of imports shown on a subsequent page, it is seen that while the domestic product in 1898 was nearly three times that of 1880, the amount of salt imported in 1898 was only a little more than one-third what it was in 1880. In fact, the imports have decreased in the last nineteen years in about the same ratio as the domestic production has increased, and the amount imported in 1898 was, with one exception, the smallest shown in the reports of the Bureau of Statistics of the Treasury Department since 1867.

The greater portion of the increased production since 1880 has been in the last six years. From 1880 to 1891 the increased production was about 4,000,000 barrels. The product in 1898 was nearly 7,650,000 barrels more than that of 1891, or almost double the difference between 1880 and 1891.

In reporting production some operators use the bushel as a unit of measurement, some adopt the short ton, some the barrel, and others state their production in pounds. For the sake of convenience, as well as on account of the necessity for a uniform unit in tabulation, the product of each State has been reduced to barrels. A barrel of salt contains 280 pounds, and is equal to 5 bushels of 56 pounds. A short ton contains $7\frac{1}{7}$ barrels.

Comparative table of production of salt by States and Territories from 1880 to 1898.

State or Territory.	1880.		1882.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	2, 485, 177	$2, 271, 913	3, 037, 317	$2, 126, 122
New York	1, 749, 641	1, 107, 760	1, 668, 036	834, 018
Ohio	530, 060	363, 791	400, 000	280, 000
West Virginia	535, 888	380, 369	400, 000	300, 000
Louisiana	62, 400	56, 160	....	....
California	176, 949	120, 650	214, 200	150, 000
Utah	96, 760	60, 280	92, 820	130, 000
Other States and Territories	324, 185	467, 643	600, 000	500, 000
Total	5, 961, 060	4, 828, 566	6, 412, 373	4, 320, 140

State or Territory.	1883.		1884.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	2, 894, 672	$2, 344, 684	3, 161, 806	$2, 392, 536
New York	1, 619, 486	680, 638	1, 788, 454	705, 978
Ohio	350, 000	231, 000	320, 000	201, 600
West Virginia	320, 000	211, 000	310, 000	195, 000
Louisiana	265, 215	141, 125	223, 964	125, 677
California	214, 286	150, 000	178, 571	120, 000
Utah	107, 143	100, 000	114, 285	80, 000
Nevada	21, 429	15, 000	17, 857	12, 500
Illinois, Indiana, Virginia, Tennessee, Kentucky, and other States and Territories	400, 000	377, 595	400, 000	364, 443
Total	6, 192, 231	4, 251, 042	6, 514, 937	4, 197, 734

Comparative table of production of salt by States and Territories, etc.—Continued.

State or Territory.	1885.		1886.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3, 297, 403	$2, 967, 663	3, 677, 257	$2, 426, 689
New York	2, 304, 787	874, 258	2, 431, 563	1, 243, 721
Ohio	306, 847	199, 450	400, 000	260, 000
West Virginia	223, 184	145, 070	250, 000	162, 500
Louisiana	299, 271	139, 911	299, 691	108, 372
California	221, 428	160, 000	214, 285	150, 000
Utah	107, 140	75, 000	164, 285	100, 000
Nevada	28, 593	20, 000	30, 000	21, 000
Illinois, Indiana, Virginia, Tennessee, Kentucky, and other States and Territories	250, 000	243, 993	240, 000	352, 763
Total	7, 038, 653	4, 825, 345	7, 707, 081	4, 825, 345

State or Territory.	1887.		1888.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3, 944, 309	$2, 291, 842	3, 866, 228	$2, 261, 743
New York	2, 353, 560	936, 894	2, 318, 483	1, 130, 409
Ohio	365, 000	219, 000	380, 000	247, 000
West Virginia	225, 000	135, 000	220, 000	143, 000
Louisiana	341, 093	118, 735	394, 385	134, 652
California	200, 000	140, 000	220, 000	92, 400
Utah	325, 000	102, 375	151, 785	32, 000
Kansas	....	....	155, 000	189, 000
Other States and Territories	250, 000	150, 000	350, 000	143, 999
Total	8, 003, 962	4, 093, 846	8, 055, 881	4, 374, 203

Comparative table of production of salt by States and Territories, etc.—Continued.

State or Territory.	1889.		1890.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3, 856, 929	$2, 088, 909	3, 837, 632	$2, 302, 579
New York	2, 273, 007	1, 136, 503	2, 532, 036	1, 266, 018
Ohio	250, 000	162, 500	231, 303	136, 617
West Virginia	200, 000	130, 000	229, 938	134, 688
Louisiana	325, 629	152, 000	273, 553	132, 000
California	150, 000	63, 000	162, 363	57, 085
Utah	200, 000	60, 000	427, 500	126, 100
Kansas	450, 000	202, 500	882, 666	397, 199
Other States and Territories	300, 000	200, 000	300, 000	200, 000
Total	8, 005, 565	4, 195, 412	8, 876, 991	4, 752, 286

State or Territory.	1891.		1892.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3, 966, 784	$2, 037, 289	3, 829, 478	$2, 046, 963
New York	2, 839, 544	1, 340, 036	3, 472, 073	1, 662, 816
Ohio	(*a*)	(*a*)	899, 244 (Ohio and West Virginia)	394, 720
West Virginia	(*a*)	(*a*)		
Louisiana	173, 714	102, 375	200, 000	100, 000
California	200, 949	90, 303	235, 774	104, 938
Utah	969, 000	265, 350	1, 292, 471	340, 442
Nevada	60, 799	39, 898	22, 929	22, 806
Kansas	855, 536	304, 775	1, 480, 100	773, 989
Illinois	39, 670	34, 909	60, 000	48, 000
Virginia	70, 442	70, 425	60, 000	50, 000
Pennsylvania			25, 571	10, 741
Texas			121, 250	99, 500
Other States and Territories	811, 507	430, 761		
Total	9, 987, 945	4, 716, 121	11, 698, 890	5, 654, 915

a Included in "Other States."

Comparative table of production of salt by States and Territories, etc.—Continued.

State or Territory.	1893.		1894.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
New York	5, 662, 074	$1, 870, 084	6, 270, 588	$1, 999, 146
Michigan	3, 057, 898	888, 837	3, 341, 425	1, 243, 619
Kansas	1, 277, 180	471, 543	1, 382, 409	529, 392
Ohio	543, 963	209, 393	528, 996	187, 432
West Virginia	210, 736	68, 222	194, 532	51, 947
Louisiana	191, 430	97, 200	186, 050	86, 134
California	292, 858	137, 962	332, 246	172, 678
Utah	189, 006	130, 075	268, 186	209, 077
Nevada	6, 559	4, 481	3, 670	4, 030
Illinois	59, 161	30, 168	50, 000	27, 500
Virginia	....	....	64, 222	43, 580
Pennsylvania	280, 343	136, 436	203, 236	83, 750
Texas	126, 000	110, 267	142, 857	101, 000
Total	11, 897, 208	4, 154, 668	12, 968, 417	4, 739, 285

State or Territory.	1895.		1896.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
New York	6, 832, 331	$1, 943, 398	6, 069, 040	$1, 896, 681
Michigan	3, 343, 395	1, 048, 251	3, 164, 238	718, 408
Kansas	1, 341, 617	483, 701	1, 408, 607	397, 296
Ohio	781, 033	326, 520	1, 662, 358	432, 877
West Virginia	176, 720	63, 041	176, 921	50, 717
Louisiana	159, 771	78, 169	(*a*)	(*a*)
California	318, 935	158, 683	430, 121	198, 963
Utah	294, 485	121, 762	279, 800	96, 550
Nevada	7, 000	5, 600	(*a*)	(*a*)
Illinois	67, 119	31, 548	(*a*)	(*a*)
Virginia	65, 000	40, 000	(*a*)	(*a*)
Pennsylvania	157, 243	67, 411	198, 596	56, 717
Texas	125, 000	55, 000	(*a*)	(*a*)
Other States	....	....	461, 045	192, 630
Total	13, 669, 649	4, 423, 084	13, 850, 726	4, 040, 839

a Included in "Other States."

Comparative table of production of salt by States and Territories, etc.—Continued.

State or Territory.	1897.		1898.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
New York	6,805,854	$1,948,759	6,791,798	$2,369,323
Michigan	3,993,225	1,253,403	5,263,564	1,628,081
Ohio	1,575,414	421,757	1,682,247	826,868
Kansas	1,538,327	488,022	1,882,329	616,591
California	470,893	162,654	653,009	185,848
West Virginia	441,893	160,129	247,668	88,462
Utah	405,179	196,056	266,250	103,778
Pennsylvania	164,287	45,107	154,287	46,000
Louisiana, Illinois, Virginia, Oklahoma, and Texas	578,130	244,133	671,482	347,603
Total	15,973,202	4,920,020	17,612,634	6,212,554

DOMESTIC CONSUMPTION.

In the following table is presented a statement showing approximately the amount of salt consumed in the United States each year since 1880. In order to make the statement absolutely correct it would be necessary to know the amount of stocks on hand at the first of each year. These figures are not obtainable, but as they would probably show comparatively little variation, the statement may be accepted as fairly representing the domestic consumption. The table shows that the yearly domestic consumption has increased from 9,384,263 barrels in 1880 to 18,920,606 barrels in 1898. There were five years in which the figures indicated a decrease in the consumption.

One of the interesting facts exhibited in the statement is the steadily decreasing proportion of foreign salt entering into domestic consumption. In 1880 the amount of salt imported was equivalent to 36.5 per cent of the entire consumption. This percentage was increased to 39.1 in 1881, since when, with a few unimportant exceptions, the percentage of foreign salt has steadily decreased, until in 1898 salt of foreign production represented only 7 per cent of the total consumption. The principal exception to the decreasing tendency occurred in 1894 and 1895, when salt was, by the tariff act of 1894, entered free of duty, and the imports increased from 348,519,173 pounds in 1893 to 434,155,708 pounds in 1894, and again to 559,161,669 pounds in 1895, an increase of over 210,000,000 pounds, or about 66⅔ per cent, in two years. Imports in 1896 fell off slightly, and in 1897, when salt was returned to the dutiable list, they dropped to 418,049,214 pounds, and still further in 1898 to 371,059,452 pounds. Domestic production continued to increase during this period, but not enough to prevent the imported salt showing an increased percentage. The effects of the large importations in 1894, 1895, and 1896 are shown in the decline in prices, previously discussed.

The following table presents the production, imports, exports, and consumption since 1880:

Supply of salt for domestic consumption from 1880 to 1898.

Source.	1880.	1881.	1882.	1883.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
Domestic production	5,961,060	a 6,000,000	6,412,373	6,192,231
Imports	3,427,639	3,839,994	3,085,168	3,099,698
Total	9,388,699	9,839,994	9,497,541	9,291,929
Exports	4,436	9,091	8,417	10,829
Domestic consumption	9,384,263	9,830,903	9,489,124	9,281,100
Increase over preceding year	....	446,640	b 341,779	b 208,024
Percentage of imports to total consumption	36.5	39.1	32.5	33.4
Source.	**1884.**	**1885.**	**1886.**	**1887.**
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
Domestic production	6,514,937	7,038,653	7,707,081	8,003,962
Imports	3,246,349	3,227,380	2,818,623	2,587,745
Total	9,761,286	10,266,033	10,525,704	10,591,707
Exports	14,003	14,649	17,246	16,732
Domestic consumption	9,747,283	10,251,384	10,508,458	10,574,975
Increase over preceding year	466,183	504,101	257,074	66,517
Percentage of imports to total consumption	33.3	31.5	26.8	24.5
Source.	**1888.**	**1889.**	**1890.**	**1891.**
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
Domestic production	8,055,881	8,005,565	8,876,991	9,987,945
Imports	2,232,253	1,833,452	1,838,024	1,694,048
Total	10,288,134	9,839,017	10,715,015	11,681,993
Exports	19,140	19,209	17,597	15,889
Domestic consumption	10,268,994	9,819,808	10,697,418	11,666,104
Increase over preceding year	b 305,981	b 449,186	877,610	968,686
Percentage of imports to total consumption	21.7	18.7	17.2	14.5

a Estimated. b Decrease.

Supply of salt for domestic consumption from 1880 to 1898—Continued.

Source.	1892.	1893.	1894.	1895.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
Domestic production	11, 698, 890	11, 897, 208	12, 968, 417	13, 669, 649
Imports	1, 633, 419	1, 244, 711	1, 550, 555	1, 996, 970
Total	13, 332, 309	13, 141, 919	14, 518, 972	15, 666, 619
Exports	18, 603	20, 686	38, 763	36, 855
Domestic consumption	13, 313, 706	13, 121, 233	14, 480, 209	15, 629, 764
Increase over preceding year	1, 647, 602	*a* 192, 473	1, 358, 976	1, 149, 555
Percentage of imports to total consumption	12. 3	9. 49	10. 71	12. 78

Source.	1896.	1897.	1898.
	Barrels.	*Barrels.*	*Barrels.*
Domestic production	13, 850, 726	15, 973, 202	17, 612, 634
Imports	1, 858, 614	1, 493, 033	1, 325, 212
Total	15, 709, 340	17, 466, 235	18, 937, 846
Exports	63, 391	54, 195	17, 240
Domestic consumption	15, 645, 949	17, 412, 040	18, 920, 606
Increase over preceding year	16, 185	1, 766, 091	1, 508, 566
Percentage of imports to total consumption	11. 88	8. 57	7. 00

a Decrease.

IMPORTS AND EXPORTS.

The imports of salt into the United States as reported by the Bureau of Statistics of the Treasury Department show that from 1867 to 1881 there was a persistent increasing tendency from 483,775,185 pounds in the former year to 1,075,198,397 pounds in 1881. From 1881 the imports decreased almost as steadily until 1893. The decrease was largely in the imports of fine salt, due to the successful efforts of American manufacturers to produce table, dairy, and other special grades of salt equal, if not superior, in quality and price to the imported article. The tariff act of 1894 placed salt upon the free list, and importations increased from 348,519,173 pounds in 1893 to 434,155,708 pounds in 1894, and to nearly 560,000,000 pounds in 1895. In 1896 the imports of foreign salt amounted to 520,411,822 pounds. The tariff act of 1897 returned salt to the dutiable list. Salt in bags, barrels, or other packages is now subjected to a duty of 12 cents per 100 pounds (33.6 cents per barrel), and salt in bulk is taxed at the rate of 8 cents per 100 pounds, or 22.4 cents per barrel. The duty on imported salt in bond used in curing fish taken by vessels licensed to engage in the fisheries and in curing fish on the navigable waters of the United States, or on salt used in curing meats for export, may be remitted. The quantity of salt imported in 1897 was nearly 20 per cent less than in 1896, the total amounting to 418,049,214 pounds, while in 1898 the imports fell off to 371,059,452 pounds, with one exception the smallest amount reported in 32 years. Since 1867 the imports have been as follows:

Salt imported and entered for consumption in the United States, 1867 to 1898, inclusive.

Year ending—	In bags, barrels, and other packages.		In bulk.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
June 30, 1867	254,470,862	$696,570	229,304,323	$336,302
1868	308,446,080	915,546	219,975,096	365,458
1869	297,382,750	895,272	256,765,240	351,168
1870	288,479,187	797,194	349,776,433	507,874
1871	283,993,799	800,454	274,730,573	355,318
1872	258,232,807	788,893	257,637,230	312,569
1873	239,494,117	1,254,818	388,012,132	525,585
1874	358,375,496	1,452,161	427,294,209	649,838
1875	318,673,091	1,200,541	401,270,315	549,111
1876	331,266,140	1,153,480	379,478,218	462,106
1877	359,005,742	1,059,941	444,044,370	532,831
1878	352,109,963	1,062,995	414,813,516	483,909
1879	375,286,472	1,150,018	434,760,132	532,706
1880	400,970,531	1,180,082	449,743,872	548,425
1881	412,442,291	1,242,543	529,361,041	658,068
1882	329,969,300	1,086,932	399,100,228	474,200
1883	312,911,360	1,035,946	412,938,686	451,001
1884	340,759,010	1,093,628	441,613,517	433,827
1885	351,276,969	1,030,029	412,322,341	386,858
Dec. 31, 1886	319,232,750	966,993	366,621,223	371,000
1887	275,774,571	850,069	343,216,331	328,201
1888	238,921,421	620,425	272,650,231	246,022
1889	180,906,293	627,134	234,499,635	249,232
1890	172,611,041	575,260	243,756,044	252,848
1891	150,033,182	492,144	220,309,985	224,569
1892	150,799,014	488,108	201,366,103	196,371
1893	98,037,648	358,575	146,945,390	63,404
1894	60,793,685	206,229	101,525,281	86,718
1895	601,086	1,723	1,874,644	1,874
1896	350,620	814	1,627,030	1,640
1897	36,801,048	114,072	50,775,105	46,412
1898	114,573,146	361,366	178,458,117	165,784

Salt imported and entered for consumption in the United States, etc.—Continued.

Year ending—	For the purpose of curing fish.		Not elsewhere specified.		Total quantity.	Total value.
	Quantity.	Value.	Quantity.	Value.		
June 30—	*Pounds.*		*Pounds.*		*Pounds.*	
1867					483, 775, 185	$1, 032, 872
1868					528, 421, 176	1, 281, 004
1869					554, 147, 990	1, 246, 440
1870	68, 597, 023	$87, 048			706, 852, 643	1, 392, 116
1871	64, 671, 139	66, 008			623, 395, 511	1, 221, 780
1872	57, 830, 929	60, 155			773, 700, 966	1, 161, 617
1873	86, 756, 628	86, 193			714, 262, 877	1, 866, 596
1874	105, 613, 913	126, 896			891, 283, 618	2, 228, 895
1875	110, 294, 440	119, 607			830, 237, 846	1, 869, 259
1876	118, 760, 638	126, 276			829, 504, 996	1, 741, 862
1877	132, 433, 972	140, 787			935, 484, 084	1, 733, 559
1878	100, 794, 611	96, 898			867, 718, 090	1, 643, 802
1879	94, 060, 114	95, 841			904, 106, 718	1, 778, 565
1880	109, 024, 446	119, 667			959, 738, 849	1, 848, 174
1881	133, 395, 065	144, 347			1, 075, 198, 397	2, 044, 958
1882	134, 777, 569	147, 058			863, 847, 097	1, 708, 190
1883	142, 065, 557	154, 671			867, 915, 603	1, 641, 618
1884	126, 605, 276	122, 463			908, 977, 803	1, 649, 918
1885	140, 067, 018	121, 429			903, 666, 328	1, 538, 316
Dec. 31—						
1886	103, 360, 362	94, 721			789, 214, 335	1, 432, 714
1887	105, 577, 947	107, 089			724, 568, 849	1, 285, 359
1888	113, 459, 083	111, 120			625, 030, 735	977, 577
1889	97, 960, 624	100, 123			513, 366, 552	976, 489
1890	98, 279, 719	96, 648			514, 646, 804	924, 756
1891	103, 990, 324	89, 196			474, 333, 491	805, 909
1892	105, 192, 086	90, 327			457, 357, 203	774, 806
1893	103, 536, 135	87, 749			348, 519, 173	509, 728
1894	93, 723, 885	79, 482	178, 112, 857	$263, 707	434, 155, 708	636, 136
1895	8, 668, 490	12, 195	548, 007, 449	739, 122	559, 151, 669	754, 914
1896	8, 351, 913	11, 814	510, 082, 259	687, 890	520, 411, 822	702, 158
1897	32, 961, 953	33, 962	297, 511, 108	370, 592	418, 049, 214	565, 038
1898	78, 028, 189	61, 503			371, 059, 452	588, 653

Salt of domestic production exported from the United States from 1790 to 1898, inclusive.

Year ending—	Quantity.	Value.	Year ending—	Quantity.	Value.
	Bushels.			*Bushels.*	
Sept. 30, 1790..	31, 935	$8, 236	June 30, 1864..	635, 519	$296, 088
1791..	4, 208	1, 052	1865..	589, 537	358, 109
1830..	47, 488	22, 978	1866..	70, 644	300, 980
1831..	45, 847	26, 848	1867..	605, 825	304, 030
1832..	45, 072	27, 914	1868..	624, 970	289, 936
1833..	25, 069	18, 211	1869..	442, 947	190, 076
1834..	89, 064	54, 007	1870..	298, 142	119, 582
1835..	126, 230	46, 483	1871..	120, 156	47, 115
1836..	49, 917	31, 943	1872..	42, 603	19, 978
1837..	99, 133	58, 472	1873..	73, 323	43, 777
1838..	114, 155	67, 707	1874..	31, 657	15, 701
1839..	264, 337	64, 272	1875..	47, 094	16, 273
1840..	92, 145	42, 246	1876..	51, 014	18, 378
1841..	215, 084	62, 765	1877..	65, 771	20, 133
1842..	110, 400	39, 064	1878..	72, 427	24, 968
June 30, 1843*a*.	40, 678	10, 262	1879..	43, 710	13, 612
1844..	157, 529	47, 755	1880..	22, 179	6, 613
1845..	131, 500	45, 151	1881..	45, 455	14, 752
1846..	117, 627	30, 520	1882..	42, 085	18, 265
1847..	202, 244	42, 333	1883..	54, 147	17, 321
1848..	219, 145	73, 274	1884..	70, 014	26, 007
1849..	312, 063	82, 972	1885..	*b*4, 101, 587	26, 488
1850..	319, 175	75, 103	Dec. 31, 1886..	4, 828, 863	29, 580
1851..	344, 061	61, 424	1887..	4, 685, 080	27, 177
1852..	1, 467, 676	89, 316	1888..	5, 359, 237	32, 986
1853..	515, 857	119, 729	1889..	5, 378, 450	31, 405
1854..	548, 185	159, 026	1890..	4, 927, 022	30, 079
1855..	536, 073	156, 879	1891..	4, 448, 846	23, 771
1856..	698, 458	311, 495	1892..	5, 208, 935	28, 399
1857..	576, 151	190, 699	1893..	5, 792, 207	38, 375
1858..	533, 100	162, 650	1894..	10, 853, 759	46, 780
1859..	717, 257	212, 710	1895..	7, 203, 024	30, 939
1860..	475, 445	129, 717	1896..	10, 711, 314	43, 202
1861..	537, 401	144, 046	1897..	11, 593, 321	52, 320
1862..	397, 506	228, 109	1898..	4, 827, 288	4, 751
1863..	584, 901	277, 838			

a Nine months. *b* Pounds from 1885.

In connection with the above tables it is interesting to note the sources from which our imported salt is obtained and the markets supplied by our exports of domestic salt. For this purpose the following tables, showing the countries from which we import, the amount and value of the salt received from each, and also the amount and value of the salt exported to each country, are given for the three fiscal years ending June 30, 1896, 1897, and 1898. It will be observed that Great Britain is the principal exporter of salt to the United States, the amount imported from the United Kingdom averaging somewhat over 50 per cent of the total imports. Next in importance are the West Indian Islands (chiefly British), and after these comes Italy. The amount received from other countries is comparatively small.

The principal exports are through the port of San Francisco, and to the Central American States, Mexico, the Hawaiian Islands, Japan, and Asiatic Russia. About 25 per cent, or a little more, goes across the Great Lakes to the Dominion of Canada.

The imports and exports for the past three fiscal years, with the countries from which imported and to which exported, have been as follows:

Imports of salt during the fiscal years ending June 30, 1896, 1897, and 1898.

Country from which exported.	Free.		Dutiable. (a)	
	Quantity.	Value.	Quantity.	Value.
Year ending June 30, 1896:	*Pounds.*		*Pounds.*	
United Kingdom	329,381,449	$552,794	184	$3
Italy	78,768,053	50,511		
Canada	190,667	282	4,336,260	10,484
West Indies	136,396,990	134,589		
Other countries	2,016,022	7,567	2,189,875	3,466
Total	546,753,181	745,743	6,526,319	13,953
Year ending June 30, 1897:				
United Kingdom	312,975,950	507,972	1,120,000	1,217
Italy	82,373,539	53,306		
Canada	461,440	1,194	3,453,447	8,164
West Indies	187,323,130	172,242		
Other countries	460	5	10,650,390	9,798
Total	583,134,519	734,719	15,223,837	19,179
Year ending June 30, 1898:				
United Kingdom	13,011,441	23,117	163,796,501	362,913
Italy	3,413,600	2,138	59,803,075	38,478
Canada			5,054,777	12,506
West Indies	9,628,849	8,913	78,294,591	69,170
Other countries			9,251,272	7,424
Total	26,053,890	34,168	316,200,216	490,491

a The tariff act of 1894 provided that salt should be free of duty, but when in bags or other packages the coverings should pay duty as if imported separately, and salt imported from countries imposing a duty on salt exported from the United States should pay the rate of duty imposed prior to the act of 1894. Under the tariff act of 1897 salt in bulk is subject to a duty of 8 cents per 100 pounds; salt in packages, 12 cents per 100 pounds, with duty remitted on salt used in curing meats for export, or in curing fish on the navigable waters of the United States.

Exports of salt during the fiscal years ending June 30, 1896, 1897, and 1898.

Country to which exported.	Year ending June 30, 1896.		Year ending June 30, 1897.		Year ending June 30, 1898.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*	
United Kingdom	....	......	95,000	$1,945	570,507	$4,554
Bermuda	20,375	$205	118,989	1,136	181,806	1,466
British Honduras	21,615	97	7,330	89	28,150	241
Dominion of Canada:						
Nova Scotia, New Brunswick, etc	20,093	211	20,070	366	114,452	1,261
Quebec, Ontario, etc.	1,393,105	3,042	1,667,317	4,349	2,247,640	7,090
British Columbia	373,874	2,690	425,257	3,529	1,119,949	5,663
Newfoundland and Labrador	18,150	151	51,870	497	109,700	1,226
Central American States:						
Costa Rica	33,635	427	45,466	370	111,820	864
Guatemala	129,102	1,152	476,194	2,967	207,470	982
Honduras	859,190	4,490	41,330	540	101,310	1,006
Nicaragua	183,105	1,603	180,451	1,715	266,240	2,481
Salvador	66,100	341	99,000	468	251,640	1,005
Mexico	1,064,276	8,871	480,559	4,529	1,210,258	8,367
West Indies:						
British	20,467	210	124,104	649	235,263	924
Danish	....	......	....	......	1,700	17
Dutch and French	....	......	2,295	26	7,455	82
Haiti	1,200	13	7,560	96	10,298	115
Santo Domingo	18,325	190	75,274	868	56,364	662
Cuba	300	4	52,000	560	17,372	118
Colombia	....	......	33,749	275	48,783	407
Japan	125,600	409	250,000	1,181	240,000	804
China	8,500	25	....	......	150,000	1,500
Russia, Asiatic	4,608,640	12,134	5,206,180	12,444	8,883,000	20,745
French Oceanica	143,400	728	102,600	517	107,110	450
British Australasia	24,500	245	52,927	272	86,830	893
Hawaiian Islands	632,000	3,304	462,700	2,223	613,500	2,776
British Africa	....	......	14,000	125	15,855	148
Other countries	....	......	5,990	60	78,742	504
Total	9,765,552	40,542	10,100,712	41,832	17,073,214	66,151

WORLD'S PRODUCTION.[1]

With the exception of the production of the United States and Canada, the latest statistics available for the countries contributing to the world's supply of salt are for the calendar year 1897. The subsequent table, accordingly, brings the output for these countries down to that year only. It shows that the United States, which since 1892 has held second place among the countries of the world, became the leader in 1897, ranking Great Britain by about 5 per cent. It further shows that while the production in the United States has increased steadily since 1890, the output of Great Britain has exhibited an annual decrease since 1894. Another fact presented by the table is that the United States contributed 20 per cent of the world's supply in 1897; Great Britain, 19 per cent; Russia, 15 per cent; Germany, 12 per cent, and France and India each, about 9 per cent. None of the other salt-producing countries averages as much as 5 per cent of the total a year.

Austria-Hungary, whose product is less than 5 per cent of the world's total, furnishes nearly 50 per cent of the value. In this case the salt-producing industry is a government monopoly and one of its principal sources of revenue. The production of Austria-Hungary amounts to a little more than one-fourth of that of the United States, but the value of the product in that country was about three and one-fourth times that of the United States in 1897 and was about five times that of Great Britain in the last three years. The first cost of salt to the consumer in the United States is about $2 per ton; in Austria-Hungary it is over $30 per ton. Under such conditions the small production is readily accounted for. Cheapness has increased the consumption of salt in the United States and developed many industries dependent upon it. The high prices charged for it by the Government of Austria-Hungary have restricted its production and consumption, and it is safe to assume that little salt is wasted by the people of that country.

[1] For sake of convenience the production of salt in all countries has been reduced in this paragraph to short tons.

The production of salt in Turkey is also a government monopoly and no statistics are published. The following table shows the production, in short tons, of salt by the principal countries of the world for such years as the figures are obtainable since 1890:

The world's salt production.

Year.	United States.		Great Britain.		France. (a)	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
1890	1, 242, 778	$4, 752, 286	2, 403, 462	$5, 354, 400	955, 434	$3, 458, 174
1891	1, 398, 312	4, 040, 839	2, 288, 800	4, 737, 596	932, 292	2, 868, 945
1892	1, 637, 845	5, 654, 915	2, 191, 307	4, 177, 795	1, 100, 898	3, 318, 366
1893	1, 665, 609	4, 154, 668	2, 154, 912	3, 565, 827	1, 248, 566	3, 291, 422
1894	1, 815, 438	4, 739, 285	2, 504, 221	3, 703, 601	1, 001, 498	2, 762, 216
1895	1, 913, 751	4, 423, 084	2, 434, 043	3, 442, 292	988, 273	2, 421, 378
1896	1, 939, 102	4, 040, 839	2, 265, 040	3, 233, 073	1, 178, 038	2, 492, 402
1897	2, 236, 248	4, 920, 020	2, 131, 912	3, 017, 564	1, 070, 290	2, 236, 755

Year.	German Empire.		Italy.		Austria-Hungary. (b)	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
1890	1, 156, 769	$3, 750, 642	524, 552	$999, 933	515, 736	$17, 863, 887
1891	1, 289, 560	3, 903, 438	492, 144	927, 812	508, 022	17, 436, 392
1892	1, 286, 365	3, 968, 650	461, 738	857, 692	490, 390	16, 069, 952
1893	1, 293, 748	4, 016, 909	466, 146	990, 283	524, 552	16, 475, 059
1894	1, 386, 316	4, 143, 710	477, 166	912, 118	565, 326	17, 256, 516
1895	1, 347, 014	4, 131, 945	526, 370	1, 030, 350	530, 062	17, 075, 675
1896	1, 436, 258	4, 204, 910	497, 915	935, 466	538, 951	15, 497, 873
1897	1, 306, 684	3, 730, 950	507, 778	968, 031	554, 078	15, 725, 518

Year.	Russia.		Spain.		India.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
1890	1, 531, 736	$2, 613, 611	678, 531	$1, 750, 444	1, 159, 395	$1, 948, 104
1891	1, 489, 008	4, 978, 589	642, 292	1, 687, 300	1, 139, 468	1, 690, 294
1892	1, 608, 595	4, 627, 700	750, 059	2, 505, 855	1, 008, 330	1, 750, 317
1893	1, 489, 687	4, 281, 970	166, 913	82, 076	940, 547	1, 546, 597
1894	1, 493, 572	3, 317, 160	227, 645	85, 786	1, 452, 654	2, 538, 121
1895	1, 705, 896	3, 887, 090	359, 604	918, 775	1, 282, 522	2, 058, 678
1896	1, 484, 782	4, 917, 250	574, 970	1, 113, 494	1, 131, 472	1, 753, 371
1897	1, 682, 337	4, 357, 253	560, 484	1, 118, 720	1, 033, 601	1, 560, 415

a Includes product of Algeria.

b Government monopoly.

The world's salt production—Continued.

Year.	Canada.		Other countries.		The world.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
1890	43, 754	$198, 857			10, 212, 147	$42, 690, 338
1891	45, 021	161, 179			10, 224, 919	42, 432, 384
1892	45, 486	162, 041			10, 581, 013	43, 093, 283
1893	62, 324	195, 926			10, 013, 004	38, 600, 737
1894	57, 199	170, 687	*a* 2, 772	$9, 515	10, 983, 807	39, 638, 715
1895	52, 376	160, 455	*b* 159, 129	1, 155, 738	11, 299, 040	40, 605, 460
1896	43, 960	169, 693	*c* 128, 959	408, 111	11, 219, 447	38, 766, 482
1897	51, 348	225, 730	*c* 35, 373	204, 468	11, 170, 133	38, 065, 424

a Cape Colony and Ceylon.
b Cape Colony, Ceylon, Greece, Bosnia, and Herzegovina.
c Cape Colony, Greece, Bosnia, and Herzegovina.

MICA.

PRODUCTION.

The mica production in the United States during 1898 amounted to 129,520 pounds of sheet mica valued at $103,534, and 3,999 tons of scrap mica valued at $27,564, giving a total value for the product of $131,098. This is an increase of 46,850 pounds of sheet mica and 3,259 tons of scrap mica over the production of 1897. This also shows the production of sheet mica in 1898 to be greater than for any year since 1884.

The following table shows the annual production of mica in the United States since 1880:

Production of mica since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1880	81,669	$127,825	1891	75,000	$100,000
1881	100,000	250,000	1892	75,000	100,000
1882	100,000	250,000	1893		88,929
1883	114,000	285,000	1894		52,388
1884	147,410	368,525	1895		55,831
1885	92,000	161,000	1896 Sheet		65,441
1886	40,000	70,000	1896 Scrap		1,750
1887	70,000	142,250	1897 Sheet	82,676	80,774
1888	48,000	70,000	1897 Scrap	*a* 740	14,452
1889	49,500	50,000	1898 Sheet	129,520	103,534
1890	60,000	75,000	1898 Scrap	*a* 3,999	27,564

a Tons.

The production of mica during 1898, by States, was as follows:

Production of mica in 1898, by States.

State.	Sheet mica.	Scrap mica.
	Pounds.	*Tons.*
New Hampshire	43,843	2,977
North Carolina	84,687	1,022
South Dakota	990	
Total	129,520	3,999

IMPORTS.

The following table shows the imports of unmanufactured mica from 1869 to 1896:

Unmanufactured mica imported and entered for consumption in the United States, 1869 to to 1896, inclusive.

Year ending—	Value.	Year ending—	Value.
June 30, 1869	$1,165	June 30, 1883	$9,884
1870	226	1884	28,284
1871	1,460	1885	28,685
1872	1,002	Dec. 31, 1886	a 56,354
1873	498	1887	a 49,085
1874	1,204	1888	a 57,541
1875	....	1889	a 97,351
1876	569	1890	a 207,375
1877	13,085	1891	95,242
1878	7,930	1892	218,938
1879	9,274	1893	147,927
1880	12,562	1894	126,184
1881	5,839	1895	174,886
1882	5,175	1896	169,085

a Including mica waste.

Under the new classification, made necessary by the Dingley tariff bill, in effect from and after July 24, 1897, mica is designated as "unmanufactured" and "cut or trimmed." A specific import duty of 6 cents per pound is imposed upon the former, and 12 cents per pound upon the latter, with an additional 20 per cent ad valorem duty upon each. The imports during 1897, before and after the new classification took effect, and for the year 1898, were as follows:

Mica imported and entered for consumption in 1897 and 1898.

Year.	Quantity.	Value.
1897.	*Pounds.*	
Prior to July 24	656,118	$140,353
After July 24:		
Unmanufactured	66,821	10,981
Cut or trimmed	226,771	41,068
Total	949,710	192,402
1898.		
Unmanufactured	877,930	115,930
Cut or trimmed	78,567	34,152
Total	956,497	150,082

MICA DEPOSITS IN THE UNITED STATES.

By J. A. Holmes.

MODE OF OCCURRENCE.

Muscovite, the name of the mineral species to which all of the commercial mica found in the United States belongs, is in its different forms quite widely distributed. In many of the crystalline rocks, such as granite and gneiss, it is widely disseminated in the form of scales, and often in the mica-schists it is in this form the dominant mineral. In the various sedimentary rocks, such as sandstone in many of the shales, and also in the soils resulting from these various rocks, small scales of this form of mica are found, often quite abundant and widespread in these sedimentary rocks, in the granites and schists and also in the resulting soils the small mica scales are often black in color and belong to a different species of mica, known as biotite.

Muscovite mica has a commercial value only when it occurs in blocks or masses which can be split into sheets several inches in diameter, and in this form its distribution is far more limited. Thus, in the Appalachian region it has been mined extensively in New Hampshire, Virginia, and North Carolina; and west of the Mississippi it has been mined in the Black Hills region of South Dakota, in the Cribbensville district of New Mexico, in Colorado, and in the Moscow district of western Idaho. Additional and promising deposits have also been found in Maine, New Jersey, Maryland, South Carolina, and Alabama of the Eastern States, and in Wyoming, Nevada, California and several other of the States west of the Mississippi.

The distribution of these bodies of commercial mica is more easily understood when considered in connection with the distribution of the crystalline rocks in which they occur. Thus the mica in the United States is found in coarse pegmatite dikes or veins, and these in turn occur in the granitic or gneissic rocks and the hornblende and mica-schists. These crystalline rocks form the backbone of the Appalachian system of mountains from Maine to Alabama, and appear at the surface in greater or smaller areas in the Black Hills, the Rockies, and other mountain districts of the far West. In the recently deposited clays, sands, and loams of the south Atlantic and Gulf coast, in the limestones, sandstones, and shales of the great Mississippi Valley, and in the sedimentary rocks of the western plateau region and of thè Pacific slope deposits of commercial mica are entirely wanting, for the reason that these are sedimentary rocks which have never undergone changes and alterations such as influence and accompany the formation of the pegmatite dikes.

NATURE OF THE DEPOSITS.

In the United States, as just suggested, masses of commercial mica occur in pegmatite "veins" or dikes. These pegmatite dikes are of common occurrence in the granites, gneisses, and micaceous and hornblendic schists. They are made up largely of two minerals, quartz and feldspar, in often nearly equal but varying proportions, and with the feldspar in a coarsely semicrystalline condition. In places the quartz is also in a semicrystalline state, but the larger part of it is more generally in massive form, like quartz in many metalliferous veins of this region. The feldspar in places crystallizes out in fairly distinctive forms of large size, these crystals weighing sometimes a thousand pounds and more. One from the Burnet mica mine, Buncombe County, North Carolina, now in the State Museum at Raleigh, weighs 800 pounds. As a third common mineral in these dikes, though one rarely exceeding 10 per cent of the total mass, muscovite mica is found, generally disseminated through this quartz-feldspar in small scales and crystals, and also at times in large irregular crystalline blocks or "books," from a few inches to 3 feet in size.

Owing to the preponderance of the quartz and feldspar, these dikes are usually white in color, and hence are easily observed in the darker rock masses. In size they vary from a few inches to several hundred feet in thickness, and their outcrops along the surface may be traced for from a few feet to several hundred yards. They are always more or less irregular in outline, and frequently have short, irregular branches or arms extending out on the sides into the adjacent country rock. Some of them are parallel to the "bedding" or lamination of the gneiss and schist and in some cases they lie nearly horizontal, while in other cases they break across these at varying angles, as is the case with true fissure veins. Often the same dike will be for a portion of its course parallel to the schistosity of the country rock, and at other places it has broken across at varying angles with this. As a rule, these dikes are more irregular in their courses and size than are the true fissure veins.

The great majority of these pegmatite dikes do not appear to contain mica in masses large enough to be of commercial value. And hence, while the dikes themselves are common in many portions of the country where these crystalline rocks occur, yet only a small number of them have been mined for mica. Thus a large dike near Webster, North Carolina, which has a width of more than 250 feet, and the outcrop of which has been traced along the surface for more than half a mile, has been mined for kaolin along its exposed surface for a number of years, and has yielded thus far, the writer is informed, not a single block of mica large enough for commercial purposes, although there are scattered through the quartz and feldspar (the latter of which has, near the surface, been altered to kaolin) numerous small scales of muscovite mica. Also along the coast region of Maine and in Connecticut some of these large dikes, which have been extensively quarried for feldspar, have yielded little or no commercial mica. In many of these dikes quartz and feldspar are somewhat uniformly disseminated and intermixed, while in others they are fairly well separated or segregated, and the one or the other may dominate as to quantity. In the dikes just referred to the feldspar is sufficiently abundant and well separated from the quartz to permit of its being quarried for pottery purposes, and in many of these dikes in the southern Appalachians, as in the case mentioned at Webster, the segregated feldspar from fifty to a hundred feet and more below the surface has been altered to kaolin, which is also being mined for pottery purposes.

QUANTITY AND DISTRIBUTION OF MICA.

As stated above, the vast majority of pegmatite dikes appear to contain no commercial mica, and in such cases there may be observed only the numerous small scales and irregular crystals of muscovite scattered through the pegmatite mass. No one has yet been able to suggest how, from the appearance of the dike at the surface, it may be determined with any degree of certainty whether or not the pegmatite at greater depths contains blocks of mica large enough for commercial purposes, except that the size and number of the blocks and scales of mica in the exposed surface of the pegmatite is usually considered a fair indication as to what one may expect to find below. Even in those dikes which are considered as mica bearing, the quantity of commercial mica present in proportion to the quantity of quartz and feldspar varies considerably. In portions of the New York mine in the Black Hills it has been estimated that the mica constituted at least 10 per cent of the weight of the pegmatite mass, while in other portions of the same dike the mica would probably constitute not more than 1 per cent of the total. In several mica mines in western North Carolina, in the Black Hills region, and also in New Mexico mica has been estimated to constitute much less than 1 per cent and in some cases even less than one-tenth of 1 per cent of the mass of the dike.

Occasionally, though rarely, the blocks of mica assume a nearly perfect crystalline form of the monoclinic system, the crystals being rhombic or hexagonal in outline, with plain angles of either 60 or 120 degrees. As a rule they are quite irregular and incomplete and flattened or tabular in habit. The majority of these flattened "blocks" of mica, as they are frequently called in the eastern States, or "books," as they are more generally called farther west, in an ordinary mica mine range from 3 inches to 12 or 15 inches in width and from 1 to 6 inches in thickness. Occasionally, however, blocks are found the greatest diameter of which is as much as 4 feet, and of lesser diameter from 1 to 2 feet. One of the North Carolina mica mines is reported to have yielded a block of mica that was estimated to weigh 2,000 pounds.

Several blocks both from the North Carolina and the New Hampshire mines have been reported as weighing from 200 to 300 pounds. The conditions which influence the size of the mica blocks are not clearly understood. There is certainly no definite relation between the sizes of the blocks and the size of the dike. It is sometimes the case that the greatest diameter of the block will be nearly equal to the width of the dike. Nor does there appear to be any relation between the size of the block and the completeness of its crystallization, as at the Hawk mine, in Mitchell County, North Carolina, a considerable portion of the mica mined was fairly well crystallized and the majority of these well-crystallized blocks were small. In some other mines blocks weighing as much as 200 pounds have been obtained which were fairly well crystallized, while other and smaller blocks from the same mine were much more flattened and irregular.

The distribution of these blocks of mica through the mass of the dike is, as a rule, quite irregular, and in this, as in other mining operations, a large amount of gangue must be removed from the mine in order to secure the commercial product. In some cases the blocks of mica are scattered through the entire mass of the dike with a suggestion of regularity. In other cases, as at the California mine, in the Cribbensville district, New Mexico, the mica appears to be near the walls of the dike, the central mass of the latter being apparently quite barren. In the majority of cases the blocks are distributed with considerable irregularity, in some places near the center, at other places near the hanging or foot wall, while in still other places several blocks of varying sizes may be clustered or segregated into bunches so as to almost touch one another, while in still other portions of the dike there may be an entire absence of mica blocks for a distance of 5, 10, or 20 feet. The irregular stringers or arms of various sizes, which extend out from the main dike for sometimes many feet, often contain fairly good-sized blocks of mica, even near their outer ends.

This condition of things makes mica mining even more uncertain than ordinary vein mining, for the reason that in the former there is no streak or true lead to follow; and while many mica miners will claim to be able to recognize certain conditions of the pegmatite as indicating the occurrence of mica blocks near by, and will follow with varying success what they call a "lead," yet this so-called lead is, as a rule, sufficiently indefinite to give rise to considerable differences of opinion among the miners themselves as to its nature and value.

QUALITY AND VALUE OF THE MICA.

There is a considerable variation in the quality of this muscovite mica from the different mines. The qualities which are most highly prized in cut mica are the uniform and nearly transparent white color, the freedom from spots or other stains and flaws, and the size of the sheets; and for electrical purposes also the flexibility and softness or toughness. Its color ranges from a nearly transparent and white mica (that which is most highly valued) to a wine-colored, cloudy, and nearly black or smoky mica.

The size of the sheets into which mica can be cut varies primarily with the size of the blocks taken from the mine. After these blocks have been brought to the surface and split up into sheets along the lines of cleavage planes, these sheets are, of course, to be cut into definite forms, which are usually rectangular, and the size of these rectangular patterns necessarily depends upon the size of the sheets taken from the mica blocks. These sheets should always be free from flaws and, as far as possible, from specks. In the mica brought from some mines, as from the Hawk and Flat Rock mines in Mitchell County, North Carolina, there is, as a rule, little waste, except such as may be necessary in trimming the somewhat hexagonal sheets into these rectangular forms. It is said that a block of mica from this latter mine weighing 100 pounds gave 75 pounds of cut mica. As a rule, however, the amount of waste in transforming the blocks of mica into these thin, rectangular sheets is much larger than this; indeed, it may be said that of the total quantity of mica brought out of the better mines not more than 10 per cent of it can be cut into merchantable sheets, though in many cases from selected blocks the yield is often as high as 30 or 40 per cent, and rarely as high as 75 per cent, as in the case just mentioned. In some of the mines in the Black Hills and in the Cribbensville district the yield of cut mica will hardly exceed 2 or 3 per cent of the total product of the mine.

In explanation of this large waste several characteristics of mica blocks may be mentioned:

First, it must be borne in mind that the shapes of many of the mica blocks are quite irregular.

Second, that the individual sheets of mica composing the blocks are also irregular. This is particularly the case in what is called the "wedge" or wedge-shaped mica, in which the block is thicker at one side or one end than the other, so that the majority of the individual sheets do not extend entirely across the cleavage surface. But even where the blocks are approximately the same thickness on all sides many of the cleavage sheets are imperfect, owing perhaps to disturbed conditions existing during the time of the original crystallization of the mica.

Third, in what is called "A" mica, where the sheets are more or less striated on two adjacent edges, the striæ forming the letter A or rather the letter V, the striated portions of these sheets must be left out in cutting the rectangular forms.

Fourth, the "ruling" of mica frequently destroys in a large measure its value by reducing the size of the sheets into which it can be trimmed. In some mines many blocks of mica are cut entirely or partially through along lines parallel to the faces of the crystals. The block of mica presents the appearance of having been cut through its entire mass along lines parallel to one another and to one of the crystal axes, by some sharp instrument. The resemblance is made still more striking by the fact that there often remain along the cut or ruled edges thin filaments or strings of mica left adhering to these edges. In some cases there will be found several of these cuts parallel to one another, leaving between them narrow strips or ribbons of mica from one-fourth of an inch to 2 inches in width, and destroying almost the entire value of the block. In many cases these rulings will be found parallel to two of the axes of the block, thus cutting the latter in two different directions. The conditions under which this ruling has taken place are not understood, but the extent to which it reduces the value of the mica output of certain mines is very striking, in some cases more than 75 per cent of the mica being rendered valueless thereby, except for grinding purposes. The ruling is more common in some deposits than others of the same region, and it is also more common in some portions of a given mine than in others.

The "specked" condition of mica also reduces its value. This is particularly the case in mica used for electrical purposes, for the reason that there is a tendency on the part of the electric current to penetrate the thin mica laminæ at points where these specks (which are usually of magnetic iron oxide) occur. These specks are not always uniformly distributed throughout the block of mica, sometimes being confined to one side, so that small sheets of clear mica may be cut from one side of the block, while only the second or third grade of specked mica may be taken from the other. The time and manner in which these iron specks were formed between the sheets of mica is still in a measure an unsettled problem. In many cases the material is very abundant and in crystallizing from a supersaturated solution it has assumed the form of a double system of rough parallel and intersecting lines parallel to the axes or lateral faces of the block or crystal, or to what are called the percussion lines. The indications are that some disturbance subsequent to the formation of the mica crystals either separated the laminæ of the crystal or weakened the bond between them to such an extent that under the accompanying pressure a solution of the oxide of iron or iron and manganese penetrated between these laminæ and resulted in leaving there the semicrystallized iron oxide, the accompanying liquid being taken up by the adjacent minerals. The presence of any considerable quantity of this iron also decreases the value of this mica for use as scrap mica, especially when it is sufficiently abundant to discolor the ground product.

The preparation of mica for market is a comparatively simple process, yet one which requires a considerable amount of skill and judgment. The blocks, as they are brought from the mine, are sent to the storage or stripping room, where all foreign matter is removed from them. By means of wedges and heavy knives these blocks are then split into sheets of varying thicknesses, which in turn are roughly trimmed and classified. These sheets are then turned over to the "scribers" or cutters. They are again split by means of knives, if necessary, and they are then cut into the largest sizes possible of which the various sheets will permit. The cutters are supplied with patterns, made of cardboard, tin, or sheet iron, representing the different sizes and shapes for which there is a demand. Some mica houses contain from 100 to 200 different patterns. The cutter places one of these patterns on the sheet of mica, and, holding the two together with the fingers of one hand, usually trims the sheet of mica to fit the pattern by means of a large pair of shears made, for this special purpose, one handle of which is stationary and the other is manipulated by the cutter. Occasionally, as a substitute for shears, a machine is made somewhat on the principle of a printing-office paper trimmer, the blade being operated either by hand or by the foot and pedal below. The forms with rounded surfaces, such as the rings, etc., for electrical purposes, are usually stamped out of the corners and smaller sheets.

As the mica is being cut it is still further graded, and then the different sizes of the same grade are wrapped together in packages of one or more pounds each. The packages are wrapped in strong paper and packed for shipment. The price of cut mica may be said to vary, according to the size and quality of the sheet, from 15 cents to $8 per pound. The larger part of the mica sold, however, ranges in price from 20 cents to $2 per pound. The use of this cut mica for stove purposes during the last decade has decreased to a considerable extent—perhaps more than 75 per cent—but its use for electrical purposes has increased during the same period in a much larger degree.

Assuming, then, that not exceeding 10 per cent of the mica taken from the mines is as a rule suitable to be considered as cut or sheet mica, it will be seen that by far the larger proportion (averaging 90 per cent) of this product, which was formerly considered as waste material, is now called scrap mica. Many of the more perfect scraps and small sheets produced in the trimming and cutting of the blocks and sheets are rearranged and cemented into larger sheets, which in turn are cut into various sizes and shapes, this product being known as micanite. By far the larger part of this scrap mica, however, is ground into a finely pulverized material, and is used in this form for lubricating and other purposes.

MINERALS OF THE MICA DIKES.

The three common minerals of the mica dikes—namely, quartz, feldspar, and muscovite mica—make up as a rule probably 99 per cent of the total mass. Nevertheless they have in certain regions associated with them a number of other minerals of greater or less rarity, while in other regions, as at Cribbensville, New Mexico, but few such associated minerals have been found. Even in the same district the number and abundance of these associated minerals varies greatly. Thus in western North Carolina the mica dikes of Mitchell and Yancey counties have yielded between 45 and 50 minerals, a few individual mines yielding as many as 20, while in a majority of these dikes in Jackson and Macon counties but few of these have been found. Some of the accessory minerals in North Carolina have proved of economic value. Thus the sales of gems, mainly beryl, from the mines of Mitchell and Yancey counties, have been estimated to yield not less than $20,000 in a single year. Other of these minerals, such as samarskite, columbite, etc., have proved of value on account of the rare metals which they contain.

The following may be considered a fairly complete list of the minerals which have been found in the mica-bearing pegmatite dikes of North Carolina:

- Quartz (massive, crystallized, and smoky).
- Albite, Microcline, Oligoclase, Orthoclase, Kaolin } Feldspars.
- Beryl { Emerald, yellow and aquamarine.
- Muscovite, Biotite } Micas.
- Almandite, Andradite } Garnets.
- Tourmaline.
- Apatite.
- Columbite.
- Alanite.
- Epidote.
- Samarskite.
- Gummite.
- Autunite.
- Pyrite.
- Magnetite.
- Zoisite (var. thulite).
- Menaccanite.
- Rogersite.
- Hatchettolite.
- Fergusonite.
- Uraninite.
- Uranotil.
- Phosphuranylite.
- Monazite.
- Zircon.
- Pyrrhotite.
- Hematite.
- Limonite.
- Rutile.
- Molybdenite.
- Opal (var. hyalite).
- Enstatite.
- Actinolite.
- Cyanite.
- Gahnite.
- Chabazite (?).
- Graphite.
- Spodumene (var. hiddenite).
- Pyrophyllite.

The Virginia mica dikes, especially those in Amelia County, have yielded a small but still an exceedingly interesting variety of rare minerals, including beryl, columbite, helvite, microlite, and monazite. The dikes in New Hampshire have also yielded a considerable number of minerals, among the most notable of which are perhaps enormous beryls, which are said to have weighed more than 2 tons, from the Alger or Beryl Hill mica dike near Grafton, and the large and beautiful tourmalines found in the mica dikes near Springfield.

In the Black Hills region the list of accessory minerals found in the mica dikes is also a considerable one, and includes among the most striking forms enormous crystals of spodumene, from 20 to 40 feet in length, which penetrate the pegmatite dike at the Etta mine, and the large specimens of columbite, which have been found both at the Etta and the Bob Ingersoll mines, one specimen of which was reported to weigh more than a ton. What is perhaps of still more interest in this region is the wide occurrence there of cassiterite associated with the mica in these dikes. In a number of the pegmatite dikes, on the north and northeast side of Harney Peak, cassiterite was found in considerable abundance, and for several years the dikes were worked extensively in search of workable deposits of this mineral. In the majority of cases it does not appear that in these tin-bearing dikes mica was found in commercial sizes, though everywhere muscovite was largely associated with cassiterite, and the Etta dike was mined first for mica and subsequently for tin. Tourmaline was somewhat rare on the north and east sides of Harney Peak but exceedingly abundant in some of the mica dikes to the south of that point. Apatite, garnet, wolframite, epidote, menaccanite, biotite, and lepidolite have been found; and among the feldspars microline and albite-oligoclase (sparingly and fairly well crystallized) have been observed. In addition to the ordinary quartz, pink and rose varieties are both found; and three other species, triphylite, heterosite, and leucopyrite, (?) have been reported by Blake as being found in the dikes near Hill City. Beryl was found in a few dikes near the base of Harney Peak and at a few points south of Custer. As intimated above, from the mica dikes of the Cribbensville district in New Mexico no accessory minerals worthy of notice have as yet been reported.

STRUCTURE AND ORIGIN OF THE MICA DIKES.

Concerning what is said above as to the nature of the mica deposits it may be added here that the coarse granitic or pegmatite material constituting the dike, while presenting a number of local variations, is yet on the whole fairly uniform in its structure. Here and there are local segregations of quartz making up the larger part of the dike on one side and somewhat similar segregations of feldspar making up the larger part of the dike at another point. But as a rule there is no distinctive banding, lamination, or other regular structural features, such as we find in many of the great fissure veins. At some points the coarsest crystallization of both the mica and feldspar may be found in the center, and at other points some of the larger semicrystalline or crystalline masses will be found in almost immediate contact with the wall rock. But it is frequently the case that the crystallization of the material is finer in immediate contact with the walls than toward the center of the dike.

In the Etta dike of the Black Hills, however, there appears to be at least a tendency toward structural features. The outcrop of the dike rises as a low hill, the place of exposure of which is nearly round, with a diameter approximating nearly 200 feet. The materials of the dike present indications of an indistinct concentric structure with a band of dark-colored small scales and blocks of mica alternating with large blocks of muscovite in the matrix nearer the country rock, and next to this is a matrix composed mainly of coarsely semicrystallized feldspar in which are embedded the enormous crystals of spodumene. Next to this and in toward the center of the dike is a matrix of feldspar, less coarsely crystallized, and numerous smaller blocks of mica which with some quartz form a coarse granitic or greisen mass in which most of the cassiterite is embedded. But this structure, which is here somewhat irregular and indefinite, has not been observed elsewhere.

As to the relation between the dike and the contiguous country rock, it may be said that in places at the Etta and some other mines there has been observed a clay selvage between the dike surface and the country rock. In the majority of cases the line of demarcation between the wall and the dike is clearly defined and without any such selvage. In some cases where the dike has broken across the lamination or "bedding" of the schists there has been a partial or complete welding. Indeed, in some such cases the quartz and feldspar of the dike have so completely impregnated the country rock, for from a few inches to several feet from the dike surface, that in some such cases it is at first glance not easy to determine where the real contact is, even the dark-colored mica gneiss being changed next the dike to a light-gray color. The gneiss is lighter near the wall and gradually decreases until the normal color of the country rock may be reached at a distance of several inches or a couple of feet away. Another way in which the contiguous country rock is often altered is in the mineralization of the wall for a distance of from several inches to a foot or more from the dike surface. The new mineral thus developed in the wall rock is so generally tourmaline that this process might be called tourmalinization of the wall. No definite effects of the wall rocks upon the adjacent pegmatite mass have as yet been observed except that in quite a number of cases in the formation and filling in of the wall of the dike, fragments of the wall rock have been broken off and embedded in the dike material. In such cases the feldspar and quartz have here, as in the case of the wall rock just mentioned, so permeated these fragments as to change their appearance in a large measure, especially near their edges, and in some such cases there has also been still further mineralization of these fragments, especially the formation of numerous small crystals of tourmaline. Perhaps as a rule the pegmatite immediately adjacent to the wall is less coarsely crystalline than nearer the center, though as suggested above there are exceptions even to these conditions.

As to the origin of these dikes there is much that is not sufficiently well understood to warrant its discussion in the present paper, but there are a few facts that appear to be fairly well ascertained which may be stated briefly, namely: (1) That the pegmatite material constituting these dikes has been forced up from below in the form of an aqueo-igneous magma; (2) which material under a great pressure has been forced along lines of least resistance. Thus along a portion of its course it would follow between the "beds" or laminæ of the crystalline schists whether these be tilted at great or small angles, and occasionally breaking across the laminæ or "beds" whenever a less resistance is offered along such lines.

Perhaps the best illustration of this condition of things is to be found in the Black Hills region. Here we have a great series of quartzites, slates, mica schists, and mica gneisses of unknown but considerable thickness. Rising up from the center of these is an enormous mass of coarse granitic or pegmatite material known as Harney Peak, which in being forced up has also lifted up the overlying rocks which now dip away from this mass on all sides, and which while in its heated condition aided in bringing about the crystallization of these contiguous rocks. Penetrating these schists and gneisses at varying distances from this center—in some cases 8 or 10 miles—are numerous large pegmatite dikes. It seems reasonable to suppose that the pegmatite in these various dikes is or has been at its lower levels directly or indirectly connected with the enormous mass of this eruptive material which constitutes Harney Peak, and that at quite, or approximately, the same time these masses of somewhat similar material also were forced up from below in a state of aqueo-igneous fusion; and this semiplastic magma, rising up through the schists and gneisses to form the mica-bearing dikes, may have been to a greater or less extent influenced or modified by the adjacent country rock up through which the material was forced.

In the Appalachian region doubtless here again the origin of these dikes is associated with great earth movements which have accompanied and resulted in mountain formation, and at some time during the later, but not the latest, stages of these movements the pegmatite dikes of the region have been developed. Here, as in the Black Hills region, the materials composing the dike have been forced upward from unknown depths. That at the time of the formation of the dikes the entire masses of adjacent rocks were considerably elevated in temperature is made evident by the exceeding coarseness of the crystallization of the dikes, and consequently the slowness at which this crystallization must have progressed.

A considerable amount of investigation will be necessary before the relative time at which the different minerals composing the dike have crystallized out of the plastic magma can be determined. As stated above, in the Etta dike of the Black Hills region enormous masses of spodumene, 20 to nearly 40 feet in length, are found in different directions through the dike in masses of feldspar and quartz. Occasional crystals of cassiterite are said to have been found in the mass of some of these spodumene crystals; and, indeed, this is one of the mines which if it were opened anew would be of greatest interest in connection with an investigation of this kind.

The age of these pegmatite dikes in different parts of the country may be said to vary considerably. Thus in the crystalline rocks exposed in the lower part of the Grand Canyon in Colorado and northern Arizona these dikes break up through the granitic and gneissic rocks, but come unconformably against, though they do not penetrate, the base of the Algonquin series, and consequently may be considered pre-Algonquin in age. Many of the larger dikes observed in the Rocky Mountain region of Colorado have been to a greater or less degree involved in the later faulting and other structural modifications of the crystalline rocks in that region, and consequently must have been formed somewhere between the earlier and the later stages of the uplift of these mountains. In the Appalachian region these dikes have not been so extensively involved in the faulting and foldings of the rock masses, but in some cases they have undergone numerous minor changes in connection with the production of these structures; and the conditions of the dike material seem to indicate that they were formed during perhaps not the earliest, but some of the early, stages of the uplift of these mountains, as in some cases, especially the smaller, dikes are involved in folds quite similar in general character to those which are typical of the Appalachian structure.

PROSPECTING AND MINING OPERATIONS.

In view of the facts stated above, one need hardly expect in the United States to find deposits of commercial mica except in regions where the country rock consists mainly of either gneiss, hornblende schist, mica schist, or crystalline rocks allied to these. Certainly one would search in vain for such deposits in regions occupied by sedimentary rocks such as sandstones, shales, and limestones, except in such special cases as that at the base of the Grand Canyon of the Colorado, where these sedimentary rocks have been removed by the eroding action of the river and the older pegmatite-bearing crystalline rocks underneath them have been exposed.

A few general statements along this line may be of service to the prospector. Deposits of commercial mica are most likely to be found:

(1) In regions where the country rock is either mica schist, hornblende schist, or a somewhat schistose gneiss.

(2) In such of these regions as where the crystalline schists and gneisses contain numerous fairly large and coarsely crystalline pegmatite dikes.

(3) In a region where these pegmatite dikes have not been greatly

crushed or sheared in connection with great earth movements, such as accompany and result in the formation of mountains, it will probably be found that these movements have destroyed in large measure the value of the mica.

(4) Where on some portion of the exposed surface of these dikes occasional blocks of good mica may be observed several inches in diameter, the outlook may be regarded as favorable to development. Of course the size of the blocks exposed on the surface of one of these dikes can not be taken as a positive indication as to what the size of the blocks will be at any considerable depth below the surface; but as a rule it has been fairly assumed that when along the surface of one of these pegmatite dikes which is exposed for a considerable distance no large blocks of mica are to be observed, none are likely to be found at greater depths.

(5) When after a limited excavation it is found that practically all or a large proportion of the mica discovered at that point is extensively ruled or generally specked with iron, the probabilities are that these defects will continue in depth, and this will of course greatly diminish the value of the product and consequently the chances of successful mining.

Bearing in mind these general facts, the prospecting for mica becomes a comparatively simple matter, especially in a region like that about the Black Hills, where the numerous large pegmatite dikes are exposed along the surface for considerable distances. The difficulties are increased in a region like that in New Hampshire, where these deposits may be partially or completely buried beneath the glacial drift of gravel and sand, and in the southern Appalachian region, where the forest vegetation is often so dense as to partially or completely cover large dikes from view.

The operations of mining for mica in the United States have generally been prosecuted on a small scale at a large number of places; and the methods in these smaller operations are almost as crude to-day as they were a decade or more past. Thus a prospector, finding on the surface of a dike a fair prospect for mica, would usually, with one or two men in addition to himself, with a few hand drills and hammers begin mining operations. The rule which he adopts in the beginning, and even to the end, is simply to "follow the mica" as long as it is in sight, whether this leads him downward in a vertical shaft or along a slope or a horizontal tunnel; and in operating along a horizontal tunnel he may follow the mica lead from one wall across to the other, removing gangue rock only in the vicinity of the mica which he finds. When the mica is lost sight of, as a rule his only method is to try in different directions until he finds another bunch or lead. Operations of this kind frequently open up a mine in a way so irregular that it may be fairly claimed to deserve the title of "ground hogging" often applied to it.

The irregular distribution of the mica blocks in the dikes, as just mentioned, adds greatly to the difficulty and uncertainty of such mining operations, and the result is that the original parties opening up the mine frequently become discouraged and discontinue operations, while a second party starting the work anew will occasionally strike large blocks of mica during the first day's operations. In the smaller mines the work is frequently prosecuted by a force not exceeding half a dozen men, sometimes even not exceeding two men in a mine, though in many other cases the number of miners will be considerably in excess of these figures, and in some cases will even approach 100 men. Some of the larger mines are now being operated with more modern methods, including the steam drill, steam hoists, and steam pumps. Of the mica mines where operations on this large scale have been undertaken the results in some cases have been highly satisfactory, while in others they have failed owing to the fact that the expenses were increased beyond the possible returns from the mine.

By far the larger part of the mica product in the United States is gotten out by the use of a hand drill and the mines operated on a small scale by from 5 to 20 men. In blasting operations dynamite is now used almost entirely as a substitute for powder, as it is found to injure the adjacent mica much less than did the powder which was formerly used.

MICA SUPPLY IN THE UNITED STATES.

The following statement concerning the future supply of mica in the southern Appalachian region is reproduced from a former report.[1] It may be fairly claimed that the statement is being confirmed by the recent mining developments in this region. Some of the old mines in North Carolina are being worked again under more favorable conditions, and new mines are being developed not only in Mitchell, Yancey, Haywood, Jackson, and Macon counties west of the Blue Ridge, but also in Cleveland, Rutherford, and Stokes counties in the Piedmont country to the east:

The opinion has sometimes been expressed by mica men that all of the valuable mica deposits in the southern Appalachian region have been discovered and worked to a depth where the supply of water and the increasing hardness of the rock add so greatly to the expense of mining as to make it unprofitable, and consequently that this region would no longer be a conspicuous factor in the world's supply of mica. The opening of several new mines, however, during 1895 and the early part of 1896 has encouraged the belief that other workable deposits may be found in the near future if careful search is made. And when the fact is borne in mind that much the greater part of the mica-bearing areas of this southern Appalachian Mountain region from Alabama to Virginia are still covered with dense forests, so that the rock surfaces are covered with an accumulation of humus and living plants, it is seen that the region has been as yet only partially explored, and there must be numerous undiscovered mica veins which will yield as rich returns as those already discovered and partially worked. The question is often asked, also, whether or not those mica mines which have already been worked to a considerable depth can be considered as future producers of mica. Bearing upon this, it may be said that a majority of these

[1] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III, 1896, p. 1003.

mines have been worked only to a depth of less than 100 feet and for a horizontal distance of only 100 to 200 yards along the line of the vein. In some cases, as was true with the famous Clarissa mine, they were abandoned, with valuable deposits of mica still in sight, owing to the inability of the miners with their crude methods (having no steam pumps) to contend with the water flowing into the mines. In many other cases, where there was no great trouble from water, mines have been abandoned at depths where the vein began to be too hard to be worked easily with a pick, for the reason that there were still other and softer deposits which could be worked at or near the surface.

There can be but little doubt that in the case of a considerable number of these mines, by the use of the steam pump, the steam drill, and other modern mining appliances, a number of these old mica mines could be opened up anew and worked at considerable profit. And thus, like the Clarissa, the Sink Hole, the Hawk, and Cloudland, in Mitchell County; the Ray mine, of Yancey County; the Iola, the Ray, and Burningtown mines, of Macon County, which together have yielded considerably more than a million dollars' worth of mica while being worked by crude mining methods, if opened up anew under more favorable conditions would undoubtedly yield a supply of mica for many years to come as great or greater than that which they have yielded in the past.

In Virginia a number of mines that were formerly worked in Amherst, Bedford, Hanover, and Amelia counties still show indications that the supply of mica in these regions has been by no means exhausted, and a number of these mines will no doubt be worked again in the near future.

In New Hampshire the working anew during the past year of the mines at Gilsum, Grafton Center, and Keene indicates well for the reopening of other mines in Grafton, Alstead, Springfield, Orange, and also in Alexandria, New Hampton, Wilmot, Acworth, and Marlboro. The pegmatite dikes in a number of these places are quite large, the dike at the Worcester mine at Hoyt Hill, in Orange, having a maximum width of 100 feet and being exposed for from 400 to 500 feet; and there is every reason to believe that they contain large quantities of workable mica, which, with modern mining methods, will be found within easy reach.

In the Black Hills region the recent activity in the mica developments has not been so great as in North Carolina; but some work has been done, both in reopening old mines and in prospecting for new ones. There are undoubtedly large quantities of mica which, with fair prices and modern mining methods, can be profitably taken from the McMackin, Climax, New York, Lost Bonanza, White Star, and a dozen other mines in that district. Besides these there are numerous other large, unopened dikes which exhibit on the surface as good prospect as did originally many of those which have been more or less developed. The mica in this district is, as a rule, good in color and free from iron specks. Its greatest defect is the considerable extent to which the blocks or "books" of mica are ruled and wedge-shaped, making the sheets smaller and the splitting defective. But notwithstanding these defects, there are still to be found in Custer and Pennington counties large quantities of high-grade mica. Indeed, it may be fairly claimed that mica mining in the Black Hills region is yet in its infancy. What is especially needed here is the mill for grinding the waste product, which in some of these mines, as the New York, is very large, owing to the great abundance of mica in portions of this dike.

In the Roberson mining district, Idaho, just east of Moscow, the Muscovite mine, which in September, 1897, had been opened up for a distance along the dike of some 400 feet and had yielded a considerable quantity of good mica, promises well for future supplies, although the dike where exposed only ranges from 6 to 10 feet wide. The Last Chance mine, a short distance west in the same district, with a dike from 5 to 15 feet thick, has also yielded a considerable quantity of clear white mica. And the same statement may be made concerning the Luella mine, probably one-half mile west of the last, which was opened up a few years since in a dike 20 to 30 feet thick. But the proportion of ruled mica at the two last-named mines is large, and the waste or scrap mica should be saved by the erection of a mill for grinding it in the vicinity of the mines. There are several additional mica prospects near the above, but no extensive developments have been made.

In the Cribbensville district of northern New Mexico, a dozen miles west of the Denver and Rio Grande Railway, large pegmatite dikes are numerous and a considerable portion of them appear to contain commercial mica in workable quantities. These dikes intersect a country rock which is a somewhat schistose micaceous gneiss. Some of these dikes have been mined for mica, while a still larger number of them have only been opened sufficiently for prospecting purposes. At the Cribben mine, the best known of them all, a considerable amount of work was done between 1884 and 1889, and on a smaller scale since that time. Openings were made on the property at several different locations: (1) The I Excell tunnel, 300 feet long; (2) San Carlos tunnel, 40 feet long, where there are also stopes and drifts under the crest of the hill; (3) an open cut of 100 feet long and a tunnel 40 feet long near the San Carlos; (4) El Capitan tunnel, shaft and open cut, some 1,000 or 1,200 feet northwest of Nos. 2 and 3; (5) Columbia tunnel, 40 feet long, with an open cut of 40 feet, in a dike 50 feet thick, located some 200 or 300 yards east of the San Carlos; (6) the Rafugea tunnel, 20 feet long and open cut 30 feet long, located some 200 feet east of the last. The larger part of the work at the Cribben mine was done and most of the mica was obtained from the San Carlos and El Capitan openings, and it is in these also that there is the greatest promise of successful future operations. The mica from these openings is all of fairly good quality, generally free from specks, though in places badly ruled. Several other claims have been prospected recently near the Cribben, notably that of the Old Judge claim, probably one-half mile to the north.

The Buckshot and Mica Producer claims, some 3 miles south of the Cribben; and the Petaca, Coyote, The Gulch, Bachelder No. 1, Bachelder No. 2, Summit, Keystone, Mica King, Fleming, Bobtail, and Young America, extending north of the Cribben for some 4 or 5 miles, have been opened up for mica to a small but varying extent and some of them are promising prospects. All yield mica of good quality, except that in many places it is badly ruled. The Old Black Horse (Sandoval or Kentucky) mine, some 3 or 4 miles northwest of the Cribben and on the slope of the canyon, is, next to the Cribben, the best known and most extensively worked mine in the district, and it may be expected to yield in the future considerable quantities of good mica. The Highland mine, on top of a hill above the Sandoval, and the California, a short distance to the east of the Highland, have both yielded considerable quantities of mica of good quality and can be counted on for further developments in this direction. The larger part of the mica found in the Cribbenville district is of good color and free of iron specks; but the proportion of merchantable sheet mica is greatly decreased by the ruling, which is found at all of them and is in some of the openings common. And here, as in the other regions mentioned, the success of the mining operations will be greatly facilitated by the introduction of mills for grinding this waste product.

In Colorado mica deposits have been examined at the following points: (1) Near Floyds Station, on the Union Pacific, Denver and Gulf Railroad, 5 miles east of Idaho Springs; (2) at the Terrell mica mine, 18 miles west-northwest of Golden, on the Blackhawk road, where the dike is 60 feet wide and shows considerable quantities of fairly good mica, and the Scheller mine in the same region, 8 or 9 miles west-northwest of Golden; (3) the Beers mica mine (Princess lode), on Soda Creek, 3 miles south of Idaho Springs, where a slightly specked but otherwise good mica occurs in an 8-foot dike; (4) the Mi Wot mica mine, in the Central mining district, some 15 miles northwest of Boulder, where the dike has a width of 50 to 60 feet, and in portions of it mica of fair quality is abundant; (5) the Pearl mica mine, 9 miles southwest of Leadville and on the north slope of Mount Massive; (6) the Snavley mine, 9 miles northwest of Cripple Creek; (7) High Creek mine, 4 miles southwest of High Park, in the Cripple Creek district.

At the two last named localities a considerable quantity of mica has been exposed, but is extensively ruled and in irregular wedge-shaped blocks. At the other localities mentioned the mica shows less ruling, though this feature is fairly common at all these places, but at each of them the indications for successful mining operations are sufficiently favorable to warrant more extensive developments.

In Nevada and Wyoming of the West, and in South Carolina, Georgia, Alabama, and Maryland, of the East, undeveloped mica-bearing dikes are known to occur, some of which may be depended upon for considerable additions to the future supply of this product.

FLUORSPAR.

By EDWARD W. PARKER.

PRODUCTION.

The production of fluorspar in 1898 amounted to 7,675 short tons, as compared with 5,062 short tons in 1897, a gain of 2,613 tons, or 52 per cent. The value increased in even greater proportion—from $37,159 in 1897 to $63,050—a gain of $25,891, or 70 per cent. The production in 1898, both in amount and value, was larger than in any year since 1893. All of the product reported in 1898 was from Marion and Crittenden counties, Kentucky, no output from the older properties near Rose-claire, Illinois, being reported to this office.

The fluorspar produced in the United States is used in the manufacture of hydrofluoric acid and opalescent glass. It is also used as a flux in iron smelting. It is one of the rare occurrences of fluoride compounds in nature. The two localities in Kentucky and one in Illinois are the only ones of commercial importance in the United States. Cryolite, a fluoride of sodium and calcium, is another of these rare minerals, occurring in large quantities in Greenland, from which our supply is obtained. Its occurrence has been observed at the base of Pikes Peak, in Colorado, but no attempt has been made to mine it.

The following table shows the annual production of fluorspar since 1882:

Production of fluorspar in the United States from 1882 to 1898.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1882	4,000	$20,000	1891	10,044	$78,330
1883	4,000	20,000	1892	12,250	89,000
1884	4,000	20,000	1893	12,400	84,000
1885	5,000	22,500	1894	7,500	47,500
1886	5,000	22,000	1895	4,000	24,000
1887	5,000	20,000	1896	6,500	52,000
1888	6,000	30,000	1897	5,062	37,159
1889	9,500	45,835	1898	7,675	63,050
1890	8,250	55,328			

IMPORTS OF CRYOLITE.

The records of the Bureau of Statistics of the Treasury Department do not make any separation of fluorspar imported into the United States; it is included among minerals and ores "not elsewhere specified." Cryolite, however, is imported from Greenland by the Pennsylvania Salt Company for use in the manufacture of sodium and alum salts.

The imports of cryolite for a series of years are shown in the following table:

Imports of cryolite from 1871 to 1898.

Year ending—	Amount.	Value.	Year ending—	Amount.	Value.
	Long tons.			*Long tons.*	
June 30, 1871..	....	$71,058	Dec. 31, 1885..	8,275	$110,750
1872..	....	75,195	1886..	8,230	110,152
1873..	....	84,226	1887..	10,328	138,068
1874..	....	28,118	1888..	7,388	98,830
1875..	....	70,472	1889..	8,603	115,158
1876..	....	103,530	1890..	7,129	95,405
1877..	....	126,692	1891..	8,298	76,350
1878..	....	105,884	1892..	7,241	96,932
1879..	....	66,042	1893..	9,574	126,688
1880..	....	91,366	1894..	10,684	142,494
1881..	....	103,529	1895..	9,425	125,368
1882..	3,758	51,589	1896..	3,009	40,056
1883..	6,508	97,400	1897..	10,115	135,114
1884..	7,390	106,029	1898..	6,201	88,501

ASBESTOS.

By EDWARD W. PARKER.

PRODUCTION.

Asbestos production in 1898, as in 1897, was limited to two States—California and Georgia—and amounted to 605 short tons, valued at $10,300, an increase as compared with the preceding year of 25 tons and $3,850. The domestic production of asbestos is insignificant, particularly when it is considered in connection with our importations and the magnitude of the manufacturing industry which is dependent upon foreign sources of supply, chiefly Canada, for its raw material. It is well, however, to repeat here the statement made in previous reports in regard to the difference between the domestic and the imported material. Two distinct minerals are included under the generic head of asbestos. The domestic product is true asbestos, a fibrous variety of hornblende, and is usually found in soapstone-producing localities. It sometimes occurs in pockets within the soapstone. The imported material is obtained almost exclusively from Canada. It is not true asbestos, but chrysotile, a fibrous variety of serpentine, very similar in appearance to asbestos, and possessing equal heat-resisting properties. It is also of superior quality in strength and elasticity of fiber, which recommends it for textile manufacture. The domestic product is esteemed as an ingredient in fireproof paints, for "packing" in the manufacture of fireproof safes, and for other purposes where resistance to heat is required and where tenacity of fiber is not essential.

It will be seen by the following tables of production and importations that the value of the domestic product has not reached $15,000 in the last fourteen years, and has aggregated only $92,074 in that period, while the value of the imports has averaged $226,091 a year since 1885, and the total value for the fourteen years has reached $3,165,273. For a corresponding period prior to 1885 the importations averaged only $11,000 per year, aggregating $154,616 for the fourteen years, nearly $50,000 of which was in 1884, and more than 50 per cent was in 1882, 1883 and 1884. Since 1888 the value of the importations in each year has exceeded the aggregate value of the imports in the entire sixteen years ending in 1884. These figures indicate that the utilization of this fibrous mineral in the manufacture of fireproof textile materials has been developed in the last decade and a half. Increasing from $49,940 in 1884 to $73,643 in 1885, the imports jumped to $135,125 in 1886, to $140,845 in 1887, to $176,710 in 1888, and in only one year (1893, the year of the panic and industrial prostration) has the value of the imports been less than $200,000, while in 1891 it reached over $350,000.

There have been no new domestic localities reported since the report for 1897 was published, and with the exception of the production at Sall Mountain, Georgia, and a trifling output in California, work on the known deposits has been limited to the assessment work required by law for preservation of title. The most promising domestic localities, those near Casper, Wyoming (judgment being based on samples of the material), can not compete in the Eastern markets with the extensive and well-developed mines of Black Lake and Thedford in Canada, and will probably remain undeveloped for some years to come.

The richness and proximity of the Canadian chrysotile deposits, added to the superior quality of the fiber, have been potential factors against the successful operations of our Eastern deposits, while the long distance from the manufacturing centers, and the consequent expensive freight costs, have militated against the development of the Western localities.

The following table exhibits the annual production of asbestos in the United States since 1880, with the value:

Annual production of asbestos since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	150	$4,312	1890	71	$4,560
1881	200	7,000	1891	66	3,960
1882	1,200	36,000	1892	104	6,416
1883	1,000	30,000	1893	50	2,500
1884	1,000	30,000	1894	325	4,463
1885	300	9,000	1895	795	13,525
1886	200	6,000	1896	504	6,100
1887	150	4,500	1897	580	6,450
1888	100	3,000	1898	605	10,300
1889	30	1,800			

Comparing the above table with that of the table of imports, which is given below, it will be seen that there is a profitable market to be supplied with domestic fiber if any be found which is equal in quality to that of the Canadian chrysotile, nearly all of the imports into the United States being from the Canadian mines.

IMPORTS.

The following table shows the value of asbestos imported since 1869:

Value of asbestos imported since 1869.

Year ending—	Unmanufactured.	Manufactured.	Total.
June 30, 1869	....	$310	$310
1870	....	7	7
1871	....	12	12
1872	....	....	....
1873	$18	....	18
1874	152	....	152
1875	4,706	1,077	5,783
1876	5,485	396	5,881
1877	1,671	1,550	3,221
1878	3,536	372	3,908
1879	3,204	4,624	7,828
1880	9,736	....	9,736
1881	27,717	69	27,786
1882	15,235	504	15,739
1883	24,369	243	24,612
1884	48,755	1,185	49,940
Dec. 31, 1885	73,026	617	73,643
1886	134,193	932	135,125
1887	140,264	581	140,845
1888	168,584	8,126	176,710
1889	254,239	9,154	263,393
1890	252,557	5,342	257,899
1891	353,589	4,872	358,461
1892	262,433	7,209	269,642
1893	175,602	9,403	185,005
1894	240,029	15,989	256,018
1895	225,147	19,731	244,878
1896	229,084	5,773	234,857
1897	263,640	4,624	268,264
1898	287,636	12,897	300,533

CANADIAN PRODUCTION.

As the supply of asbestos for the United States is drawn almost entirely from Canada, the following table of production for that country will be found of interest:

Annual product of asbestos in Canada since 1879.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1879	300	$19,500	1889	6,113	$426,554
1880	380	24,700	1890	9,860	1,260,240
1881	540	35,100	1891	9,279	999,978
1882	810	52,650	1892	6,042	388,462
1883	955	68,750	1893	6,473	313,806
1884	1,141	75,079	1894	7,630	420,825
1885	2,440	142,441	1895	8,756	368,175
1886	3,458	206,251	1896	12,250	429,856
1887	4,619	226,976	1897	*a* 30,442	445,368
1888	4,404	255,007	1898	*a* 23,785	486,227

a Including asbestic.

The increased production of nearly 150 per cent in 1897, accompanied by an increase of less than 4 per cent in value, was due to the large amount of asbestic and low grade of fiber included in the product. Conversely, the increase of 9.17 per cent in value in 1898, with a decrease of nearly 22 per cent in the product, was due to a smaller proportion of asbestic. In the foregoing statement the figures for 1898 are taken from the advance summary of production, published by the geological survey of Canada, in which the production of asbestos and asbestic is not stated separately. The annual report for 1897 gives the production of asbestos in 1896 at 10,892 tons, valued at $423,066, and that of asbestic 1,538 tons, worth $6,790. In 1897 the asbestos product was 13,202 tons, worth $399,528, and that of asbestic 17,240 tons, valued at $45,840. It will be seen from this that while there was a decline in the price per ton of both asbestos and asbestic in 1897 as compared with 1896, the greater portion of the disparity in the product and value in the two years was due to the larger percentage of asbestic in the total.

GRAPHITE.

PRODUCTION.

There were five States in which graphite was produced in 1898—Alabama, Michigan, New York, Pennsylvania, and Rhode Island. The marketable product consisted of 890 short tons of amorphous graphite and 2,360,000 pounds of crystalline graphite, the aggregate value of which amounted to $75,200. There was no graphitic coal mined in Rhode Island in 1898. The marketable product was obtained from 15,175 short tons of ore and crude material. There were 1,300 tons of crude amorphous graphite mined, of which 600 tons were sold as mined, and 290 tons were ground and prepared before shipped. The product of crude ore from which the crystalline graphite was obtained amounted to 13,875 short tons, which yielded 2,360,000 pounds of refined material, the percentage of refined product to crude ore being about 8.5.

The domestic production of crystalline graphite in 1898 was the largest on record. The output from Ticonderoga, New York, was the largest ever obtained, to which was added an increased production from Chester County, Pennsylvania, and a comparatively small product from Clay County, Alabama.

The following table shows the annual production of graphite since 1880:

Production of graphite since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1880..pounds.	622,500	$49,800	1892..pounds..	1,398,365	$87,902
1881.... do...	400,000	30,000	1893.... do....	843,103	63,232
1882.... do...	425,000	34,000	1894.... do....	918,000	64,010
1883.... do...	575,000	46,000	1895 ... do....	644,700	52,582
1884.... do...	500,000	35,000	1895 short tons	2,793	
1885.... do...	327,883	26,231	1896 pounds...	535,858	48,460
1886.... do...	415,525	33,242	1896 short tons	760	
1887.... do...	416,000	34,000	1897 pounds...	1,361,706	65,730
1888.... do...	400,000	33,000	1897 short tons	1,070	
1889..........	....	72,662	1898 pounds...	2,360,000	75,200
1890..........	....	77,500	1898 short tons	890	
1891..pounds.	1,559,674	110,000			

Outside of the increased production in 1898, the interesting feature was the transfer of the mines in Chester County, Pennsylvania, formerly owned by the Penn Plumbago Company, to a new corporation, known as the Standard Graphite Company. This company was engaged in sinking a new shaft and in placing new machinery at the close of 1898, and expected to be shipping early in 1899. The company expects to develop a considerable export trade.

The North Carolina and Texas deposits, mentioned in the report for 1897, have not been developed.

Mr. E. G. Acheson, president of the Carborundum Company, has found that when the usual forms of carbon are subjected to as high a temperature as they obtain in their electric furnaces, a temperature higher than necessary for the formation of carborundum, the carbon is principally converted into graphite. The presence of such impurities as silica seems to effect the change. During 1897 this discovery was industrially utilized in the manufacture of a considerable amount of artificial graphite, and more especially subjecting electric-light carbons and carbon for other electrodes to graphitization, with the production of graphitized electrodes, such as used in the Castner alkali process, and for the manufacture of self-lubricating motor brushes. At the close of 1897 the Acheson Graphite Company was formed, with Mr. Acheson president, for the purpose of entering at once into the production of graphite in bulk from coke or other carbonaceous materials. The crude material will most likely be "breeze" or refuse from the coke ovens, which upon being passed through the high temperature of an electric furnace is largely converted into graphite, the amount of the conversion being governed by the percentage of impurities contained in the carbon. The product will be put upon the market in the manufacture of paint, foundry facings, etc., and for similar purposes.

In 1897 Mr. Acheson graphitized 162,380 pounds of electrodes and motor brushes, and in 1898, 145,647 pounds. About 75,000 pounds of graphitized electrodes have been sent to Europe (England and Germany) for use in the Castner process, they having proved many times as efficient as the ungraphitized carbon. They are used also by the Mathieson Alkali Works at Niagara Falls.

The electrodes and other articles that so far have been graphitized by this process and are now being graphitized by the Acheson Graphite Company, have all been made into the regular form out of ordinary carbon, with considerable impurities mixed therewith, by the regular arc-light carbon companies and then delivered to the company at Niagara Falls for graphitization.

It is probable that this new industry will have the effect of extending the use of graphite in many directions.

IMPORTS.

The following table, showing the amount and value of the graphite imported into the United States, indicates that a comparatively small portion of the consumption is supplied by the domestic product. Reduced to equivalent units, the importations in 1897 amounted to 8,533 long tons, as compared with a domestic production of 1,546, and in 1898 the amount imported was 13,482 long tons, and the domestic product 1,848 long tons. In 1896 the difference was still more striking, the domestic product amounting to 999 long tons, while the imports were 15,230 long tons, the production in this year being the smallest both in amount and value since 1888, while the quantity of graphite imported was the largest on record. In making these comparisons the customary units of pounds for crystalline graphite, and short tons for amorphous graphite, have been reduced to long tons of 2,240 pounds, and combined.

Graphite imported into the United States since 1867.

Year ending—	Unmanufactured.		Manufactured.	Total.
	Quantity.	Value.	Value.	Value.
	Cwt.			
June 30, 1867	27,113	$54,131	....	$54,131
1868	68,620	149,083	....	149,083
1869	74,846	351,004	....	351,004
1870	80,795	269,291	$833	270,124
1871	51,628	136,200	3,754	139,954
1872	96,381	329,030	....	329,030
1873	157,539	548,613	....	548,613
1874	111,992	382,591	....	382,591
1875	46,492	122,050	....	122,050
1876	50,589	150,709	17,605	168,314
1877	75,361	204,630	18,091	222,721
1878	60,244	154,757	16,909	171,666
1879	65,662	164,013	24,637	188,650
1880	109,908	278,022	22,941	300,963
1881	150,927	381,966	31,674	413,640
1882	150,421	363,835	25,536	389,371
1883	154,893	361,949	21,721	383,670
1884	144,086	286,393	1,863	288,256
1885	110,462	207,228	....	207,228
1886	83,368	164,111	....	164,111
1887	168,841	331,621	....	331,621
Dec. 31, 1888	184,013	353,990	....	353,990
1889	177,381	378,057	....	378,057
1890	255,955	594,746	....	594,746
1891	212,360	555,080	....	555,080
1892	233,540	667,775	....	667,775
1893	288,740	865,379	....	865,379
1894	*a* 5,814	225,720	....	225,720
1895	8,814	260,090	....	260,090
1896	15,230	437,159	....	437,159
1897	8,533	270,952	....	270,952
1898	13,482	743,820	....	743,820

a Long tons since 1894.

CANADIAN GRAPHITE.

The Geological Survey of Canada in its report for 1897 gives the productions of graphite in Canada for a series of years. The great variations exhibited in the average price are attributed to the varying quantities of different qualities produced in different years, and these can not be separated on account of the confidential nature of the producers' returns.

The value of the product in 1897 was the largest in twelve years; but the industry at best is a small one.

Annual production of graphite in Canada since 1886.

Calendar year.	Tons.	Value.
1886	500	$4,000
1887	300	2,400
1888	150	1,200
1889	242	3,160
1890	175	5,200
1891	260	1,560
1892	167	3,763
1893	None.	None.
1894 (a)	69	223
1895	220	6,150
1896	139	9,455
1897	436	16,240

a Exports.

MINERAL PAINTS.

By Edward W. Parker.

MINERALS USED AS PIGMENTS.

The mineral substances included under this heading are those which are mined and prepared primarily as pigments. They consist of iron ores (usually hematites) which are ground and used in the manufacture of red and brown pigments, and which are not included in the production of iron ores for iron making; clay and other earths containing iron, used in making yellow and brown pigments, such as ocher, umber, sienna, etc.; barytes (barium sulphate) or "heavy spar," used as a substitute for or an adulterant of white lead; slate, or shale; soapstone; asbestos; graphite, and a pure form of gypsum producing terra alba. All of these pigments are made directly from the crude minerals and may be considered natural pigments. It is not always possible, however, to segregate the amount of soapstone, asbestos, and graphite which goes into paint, and reports of the mineral paint product are therefore partially included in the papers relating to those materials. Venetian red, obtained from iron sulphate by roasting, is also included among the mineral paints, as the amount of iron so consumed is so small when compared with the iron product that it would not affect the total. Zinc white is produced directly from the ores, and properly belongs in the product of pigments.

To the above should be added the preparations made from pig lead, namely, white lead, red lead, litharge, and orange mineral; also vermilion, made from quicksilver; chrome yellow, made from potassium bichromate; blanc fixe, made by treating barium carbonate with sulphuric acid and precipitating artificial barytes. The bases from which these pigments are obtained are included in the production of pig lead, quicksilver, chromium, etc., and the pigments themselves, being the results of chemical decomposition and combination, are not grouped among the "mineral paints," although the statistics of white lead, etc., are treated in this chapter. It has also been customary to treat barytes separately. This custom is adhered to in this report.

PRODUCTION.

As shown in the following table, the pigments classed among mineral paints, and whose production is not included elsewhere, are ocher, umber, sienna, metallic paint (iron ore), slate, soapstone, venetian red, and zinc white. The production in 1897 and 1898 also includes graphitic shale mined near and shipped from Cartersville, Georgia, which was used for coloring fertilizers.

The total amount of mineral pigments produced in the United States in 1898 showed an increase of nearly 6,000 short tons over 1897. The total value increased nearly $460,000. The production of ocher fell off from 14,006 short tons, valued at $162,764, in 1897, to 11,963 short tons, worth $123,832 in 1898, a loss of 2,043 short tons, or 14.6 per cent in amount and of $38,934, or 24 per cent in value. Venetian red production declined from 13,603 short tons, valued at $294,744, in 1897, to 10,271 short tons, valued at $160,711, in 1898, a decrease of about 25 per cent in quantity, and of nearly 46 per cent in value. About 80 per cent of these decreases in quantity were offset by an increase of 4,273 short tons, or 25 per cent in the amount of metallic paint produced in 1898. The increase in the value of the metallic paint product in 1898 was $76,285, or about 50 per cent of the combined decrease in value of ocher and Venetian reds. The production of umber (including Spanish brown) increased 97 tons, with a decrease of $3,425 in value. Sienna production showed an increase of 69 short tons, or 11 per cent in amount, and of $530, or 5 per cent, in value. The net increase in both amount and value was due to an increase of 7,000 short tons in the production of zinc white and an addition to the value from this source of $510,000.

The production of mortar colors in 1898 was 7,107 short tons, against 8,237 short tons in 1897. The value of this product decreased $676 from $75,570 in 1897 to $74,894 in 1898. The quantity of slate and shale (including what is known as "mineral black") ground for pigment has shown no material change in four years, the production in 1898 amounting to 4,571 short tons, which was 95 tons less than the output in 1897, and 224 tons less than that of 1896.

In considering the statistics of production and value as presented in the following tables, it should be remembered that in many cases the apparent fluctuations in value are not due to any rise and fall in prices, but to the increased or decreased production of different grades of material. The qualities of different natural pigments, particularly ochers and metallic paints, are by no means the same, and an increased production of a superior quality which commands a higher price in the market will cause an apparent advance in the average price. Similarly, a larger production of lower-grade material will show an apparent decline in values. These conditions are reversed with a proportionate decrease in the production of high grade or low grade material.

The production of mineral paints for the last six years has been as follows:

Production of mineral paints since 1893.

Kind.	1893.		1894.		1895.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Ocher	10,517	$129,393	9,768	$96,935	12,045	$139,328
Umber	480	7,560	265	3,830	320	4,350
Sienna	150	4,875	160	3,250	275	6,950
Metallic paint	19,960 (Metallic paint and Mortar color together)	297,289 (Metallic paint and Mortar color together)	15,225	189,922	17,315	212,761
Mortar color			10,150	94,961	11,544	106,381
Venetian red	3,214	64,400	2,983	73,300	4,595	102,900
Zinc white	24,059	1,804,420	19,987	1,399,090	20,710	1,449,700
Soapstone	100	700	75	525	270	3,200
Slate *a*	3,253	25,567	3,300	35,370	4,331	45,682
Other colors	50	600				
Total	61,783	2,334,804	61,913	1,897,183	71,405	2,071,252

Kind.	1896.		1897.		1898.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Ocher	14,074	$136,458	14,006	$162,764	11,963	$123,832
Umber	165	2,646	*b* 1,080	11,710	*d* 1,177	8,285
Sienna	395	5,416	620	10,610	689	11,140
Metallic paint	14,805	180,134	16,699	187,694	20,972	263,979
Mortar color	9,660	89,600	8,237	75,570	7,107	74,894
Venetian red	4,138	93,866	13,603	294,744	10,271	160,711
Zinc white	20,000	1,400,000	25,000	1,750,000	33,000	2,310,000
Soapstone			2	20	100	800
Slate	4,795	44,835	4,666	46,681	4,571	46,215
Other colors			*c* 2,000	6,000	*c* 2,000	6,000
Total	68,032	1,952,955	85,913	2,545,793	91,850	3,004,856

a Including mineral black.
b Includes 600 tons of "Spanish brown."
c Graphitic shale.
d Includes 640 tons "Spanish brown."

OCHER, UMBER, AND SIENNA.

Ocher is an impure hydrated oxide of iron or silicate of alumina colored by iron. Its color is usually yellow, but sometimes red or brown. The common form of ocher used commercially as a pigment is yellow in color, but of a great variety of shades, beauty, and opacity. Umber and sienna differ in composition from ocher in that manganese is present in addition to oxide of iron. Raw umber is used by painters as a brown color. Burnt umber is of somewhat richer and redder tinge than the raw, and is very popular. Sienna may be said to come between the other two. Used raw it is of a brownish-yellow hue. When burnt a redder tinge is developed, which makes a pigment of a rich russet brown.

These pigments are notable not only for their stability of color, but because they may be used with either oil or water as a vehicle for painting, in frescoing, and in the manufacture of wall paper and other colored papers.

PRODUCTION.

Ocher was produced in twelve States during 1898, viz: Alabama, California, Georgia, Illinois, Iowa, Maryland, Mississippi, Missouri, New York, Pennsylvania, Vermont, and Virginia. In each of these States, excepting Georgia, Pennsylvania, and Vermont, there were only one or two producers, and the output of the other nine States is combined in order not to divulge individual statistics. The three States mentioned produced in 1898 more than three and one-half times the output of the other nine States. Pennsylvania alone produced over one-half the entire output. Kansas, which was credited with a small production in 1897, did not produce any ocher in 1898. Illinois and Mississippi each produced a small amount (3 tons) in 1898, no output having been previously reported from either.

Umber and sienna were produced in three States—New York, Pennsylvania, and Missouri, Pennsylvania producing more than nine-tenths of the former and more than one-half of the latter. Maryland is credited with 640 tons of Spanish brown, a product not reported from any other locality.

The following tables show the production of ocher, umber, and sienna during 1896, 1897, and 1898. As previously stated, the variations in value are due chiefly to increased or decreased production of different grades of ocher, not to fluctuations in prices:

Production of ocher in 1896, 1897, and 1898, by States.

State.	1896.		1897.		1898.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Georgia	2,981	$28,005	2,608	$36,600	2,858	$30,798
Pennsylvania	2,926	26,818	6,825	81,325	5,986	61,500
Vermont	....	....	693	7,739	664	6,650
Other States	8,167	81,635	3,880	37,100	2,455	24,884
Total	14,074	136,458	14,006	162,764	11,963	123,832

Production of umber and sienna in 1896, 1897, and 1898.

Year.	Umber.		Sienna.	
	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*	
1896	165	$2,646	395	$5,416
1897	*a* 1,080	11,710	620	10,610
1898	*b* 1,177	8,285	689	11,140

a Includes 600 tons Spanish brown from Maryland.
b Includes 640 tons Spanish brown from Maryland.

For purposes of comparison the production for the last ten years is shown in the following table. Prior to 1889, when the statistics were compiled for the Eleventh Census, the production for each State was not published.

Production of ocher, umber, and sienna from 1889 to 1898, by States.

State.	1889.		1890.		1891.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Alabama	336	$3,500	350	$4,100	524	$5,840
Colorado	50	150	1,000	15,000		
Georgia	2,512	29,720	800	12,800	600	9,000
Maryland	616	12,000				
Massachusetts	80	750	300	2,700	300	2,700
Missouri			2,200	30,000	1,850	27,500
New Jersey					600	7,200
New York			365	4,493		
Pennsylvania	7,922	103,797	4,173	61,458	4,535	56,588
Vermont	1,884	7,800			935	11,095
Virginia	1,658	18,755	1,367	22,972	1,950	29,900
Wisconsin	100	1,000				
Other States			*a* 7,000	84,000	*a* 7,000	84,000
Total	15,158	177,472	17,555	237,523	18,294	233,823

a Includes all of Maryland and estimated product of some firms in other States not reporting.

Production of ocher, umber, and sienna from 1889 to 1898, by States—Continued.

State.	1892.		1893.		1894.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Alabama	375	$4,050	350	$3,000		
Georgia	1,748	26,800	2,600	39,000	1,690	$17,840
Maryland	1,000	10,000				
Massachusetts	46	418				
Missouri	1,922	28,220	555	5,413	1,800	23,160
New Jersey	175	3,600				
Pennsylvania	7,055	90,755	5,375	71,575	4,975	47,830
Vermont	544	5,731	523	5,280	336	3,384
Virginia	1,500	23,500				
Other States			*a* 1,744	17,560	*b* 1,392	11,801
Total	14,365	193,074	11,147	141,828	10,193	104,015

State.	1895.		1896.		1897.		1898.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
Georgia	2,105	$31,080	2,981	$28,005	2,608	$36,600	2,858	$30,798
Pennsylvania	*c*7,395	85,600	*c*3,486	34,880	7,595	95,245	6,953	73,245
Vermont					693	7,739	664	6,650
Other States *d*	3,140	33,948	8,167	81,635	4,810	45,500	3,354	32,564
Total	12,640	150,628	14,634	144,520	15,706	185,084	13,829	143,257

a Includes Kentucky, Maryland, Massachusetts, and Virginia.
b Includes Alabama, Kentucky, Maryland, Massachusetts, Virginia, and Wisconsin.
c Includes Missouri's and New York's product of umber and sienna.
d Includes Alabama, California, Illinois, Iowa, Kansas, Maryland, Mississippi, Missouri, New York Vermont, Virginia, and Wisconsin.

Annual production of ocher, etc., since 1884.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1884	7,000	$84,000	1892	14,365	$193,074
1885	3,950	43,575	1893	11,147	141,828
1886	6,300	91,850	1894	10,193	104,015
1887	8,000	75,000	1895	12,640	150,628
1888	10,000	120,000	1896	14,634	144,520
1889	15,158	177,472	1897	15,706	185,084
1890	17,555	237,523	1898	13,829	143,257
1891	18,294	233,823			

IMPORTS.

The following tables show the amount and value of ochers, etc., imported into the United States from 1867 to 1898:

Ocher, etc., imported from 1867 to 1883.

Fiscal year ending June 30—	All ground in oil.		Indian red and Spanish brown.		Mineral French, and paris green.		Other, dry, not otherwise specified.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1867..	11, 373	$385	....	$35, 374	....	$2, 083	1, 430, 118	$9, 923
1868..	6, 949	333	....	11, 165	....	500	3, 670, 093	32, 102
1869..	65, 344	2, 496	2, 582, 335	31, 624	8, 369	2, 495	5, 379, 478	39, 546
1870..	149, 240	6, 042	3, 377, 944	41. 607	9, 618	3, 444	3, 935, 978	32, 593
1871..	121, 080	4, 465	2, 286, 930	40, 663	33, 488	11, 038	2, 800, 148	24, 767
1872..	277, 617	9, 225	2, 810, 282	38, 763	41, 422	10, 341	5, 645, 343	56, 680
1873..	94, 245	3, 850	135, 360	2, 506	34, 382	8, 078	3, 940, 785	51, 318
1874..	98, 176	4, 623	263, 389	3, 772	102, 876	18, 153	3, 212, 988	35, 365
1875..	280, 517	12, 352	646, 009	9, 714	64, 910	13, 506	3, 282, 415	37, 929
1876..	63, 916	3, 365	2, 524, 989	19, 555	21, 222	5, 385	3, 962, 646	47, 405
1877..	41, 718	2, 269	2, 179, 631	24, 218	27, 687	6, 724	3, 427, 208	32, 924
1878..	25, 674	1, 591	2, 314, 028	23, 677	67, 655	14, 376	3, 910, 947	33, 260
1879..	17, 649	1, 141	2, 873, 550	26, 929	17, 598	3, 114	3, 792, 850	42, 563
1880..	91, 293	4, 233	3, 655, 920	32, 726	16, 154	3, 269	4, 602, 546	52, 120
1881..	99, 431	4, 676	3, 201, 880	30, 195	75, 465	14, 648	3, 414, 704	46, 069
1882..	159, 281	7, 915	3, 789, 586	34, 136	18, 293	2, 821	5, 530, 204	68, 106
1883 *a*	137, 978	6, 143	1, 549, 968	13, 788	6, 972	885	7, 022, 615	90, 593

a Since 1883 classified as "dry" and "ground in oil."

Imports of ocher of all kinds from 1884 to 1898.

Year ending—	Dry.		Ground in oil.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*	
June 30, 1884....	6, 164, 359	$63, 973	108, 966	$4, 717	6, 273, 325	$68, 690
1885....	4, 983, 701	51, 499	79, 666	3, 616	5, 063, 363	55, 115
Dec. 31, 1886....	4, 939, 183	53, 593	112, 784	6, 574	5, 051, 967	60, 167
1887....	5, 957, 200	58, 162	54, 104	7, 337	6, 011, 304	65, 499
1888....	6, 574, 608	64, 123	43, 142	9, 690	6, 617, 750	73, 813
1889....	5, 540, 267	52, 502	51, 063	9, 072	5, 591, 330	61, 574
1890....	....	....	....	......	6, 471, 863	71, 953
1891....	6, 246, 890	63, 040	52, 206	5, 272	6, 299, 096	68, 312
1892....	8, 044, 836	97, 946	49, 714	5, 120	8, 094, 550	103, 066
1893....	6, 225, 789	55, 074	52, 468	3, 354	6, 278, 257	58, 428
1894....	4, 937, 738	45, 276	22, 387	2, 100	4, 960, 125	47, 376
1895....	7, 107, 987	56, 020	41, 153	2, 239	7, 149, 140	58, 259
1896....	8, 954, 252	68, 196	27, 023	1, 561	8, 981, 275	69, 757
1897....	*a* 7, 720, 075	59, 272	20, 123	1, 000	7, 740, 198	60, 272
1898....	5, 898, 725	46, 571	31, 460	1, 546	5, 930, 185	48, 117

a Since 1896 classified as "dry—crude and powdered, washed or pulverized."

Imports of umber from 1867 to 1898.

Year ending—	Quantity.	Value.	Year ending—	Quantity.	Value.
	Pounds.			*Pounds.*	
June 30, 1867..	2, 147, 342	$15, 946	June 30, 1883..	785, 794	$8, 419
1868..	345, 173	2, 750	1884..	2, 946, 675	20, 654
1869..	570, 771	6, 159	1885..	1, 198, 060	8, 504
1870..	708, 825	6, 313	Dec. 31, 1886..	1, 262, 930	9, 187
1871..	470, 392	7, 064	1887..	2, 385, 281	16, 536
1872..	1, 409, 822	18, 203	1888..	1, 423, 800	14, 684
1873..	845, 601	8, 414	1889..	1, 555, 070	20, 887
1874..	729, 864	6, 200	1890..	1, 556, 823	19, 329
1875..	513, 811	5, 596	1891..	633, 291	6, 498
1876..	681, 199	7, 527	1892..	1, 028, 038	6, 256
1877..	1, 101, 422	10, 213	1893..	1, 488, 849	16, 636
1878..	1, 038, 880	8, 302	1894..	632, 995	6, 275
1879..	986, 105	6, 959	1895..	*a* 1, 560, 786	13, 075
1880..	1, 877, 645	17, 271	1896..	*b* 689, 075	8, 360
1881..	1, 475, 835	11, 126	1897..	*c* 1, 447, 889	14, 479
1882..	1, 923, 648	20, 494	1898..	*d* 1, 123, 079	9, 051

a Includes 6,137 pounds ground in oil and 1,554,649 pounds dry.
b Includes 5,292 pounds ground in oil and 683,783 pounds dry.
c Includes 14,471 pounds ground in oil and 1,433,418 pounds dry—crude or powdered.
d Includes 4,608 pounds ground in oil and 1,118,471 pounds "dry—crude and powdered, washed or pulverized."

Imports of sienna since 1893.

Year ending—	Dry.		Ground in oil.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
Dec. 31, 1893	1, 626, 536	$138, 889	5, 857	$610
1894	337, 909	9, 424	18, 877	895
1895	456, 861	11, 021	6, 576	501
1896	668, 461	10, 857	10, 848	877
1897	580, 468	12, 340	7, 058	481
1898	544, 713	11, 451	4, 008	280

The following table indicates the output of ocher in some of the principal producing countries for years for which comparable statistics are available. France leads in amount, with the United States second, until 1897, when Great Britain's product exceeded that of the United States. In the value of the product the United States stands first, France second, and Great Britain third. The German Empire stands fourth both in amount and value of the product:

Production of ocher in principal producing countries from 1893 to 1897.

Year.	United States.		United Kingdom.		France.		German Empire.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
1893	11,147	$141,828	11,798	$67,318	....	....	....	....
1894	10,193	104,015	9,538	68,094	....	....	....	....
1895	12,640	150,628	8,540	82,397	36,456	$142,756	9,911	$25,297
1896	14,634	144,520	11,078	99,737	30,304	125,164	9,918	26,227
1897	15,706	185,084	16,153	63,165	35,594	150,714	9,660	25,242

Year.	Canada.		Belgium.		Spain.		Cyprus.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
1893	1,070	$17,710	1,408	$1,351	1,135	$685	....	....
1894	611	8,690	400	965	132	232	1,714	$3,822
1895	1,339	14,600	800	1,930	224	760	1,500	3,293
1896	2,362	16,045	1,120	2,702	234	820	3,240	6,955
1897	3,905	23,560	560	1,400	220	772	1,721	3,776

METALLIC PAINT.

Exclusive of the amount of hematite iron ore ground and used for mortar color, the product of metallic paint in 1898 was 20,972 short tons, valued at $263,979, against 16,699 short tons, valued at $187,694, in 1897, and 14,805 short tons, worth $180,134, in 1896. Compared with the preceding year, the product in 1898 shows an increase of 4,273 short tons, or 25 per cent in quantity, and of $76,285, or a little over 40 per cent in value. These figures indicate an advance in the average value per ton from $12.17 in 1896 and $11.24 in 1897 to $12.59 in 1898, and while it is true that there was an improved tone in the trade of 1898, the increased value of the product of that year was not due entirely to an advance in price, as the apparent lower values in 1896 and 1897 were not altogether due to lower prices. As stated in connection with the statistics of the production of ocher, the average values are affected to a considerable extent by the relative production of high and medium or low grade material. In seasons of industrial depression the market for the better grades, commanding higher prices, falls off to some extent, and the comparatively larger production of low-grade material makes an apparent decline in values, larger than is actually the case. Similarly, a comparatively larger production of higher grades, as in 1898, makes a decided advance in the general average price, whereas prices were slightly if any better than in 1897. Still the demand for better material may be considered an improvement in trade conditions. This should be considered in studying the statistics of production and values. Until 1898 the average prices had shown a declining tendency since 1893, when the average price realized was $14.89 per short ton, and this included the amount and value of the mortar colors produced that year. The mortar-color pigment is usually a lower grade of material than that used for metallic paint, so that if any separation had been made in 1893 the average price for metallic paint would doubtless have been more than the figures stated. In 1894 the average price for metallic paint alone was $12.47, or $2.42 less than the combined average price in 1893. In 1895 the price had further declined to $12.29; again to $12.17 in 1896, while in 1897 it fell to $11.24, the lowest figure ever reached. In 1898 the average price was $12.59.

The annual product of metallic paint for the last nine years has been as follows:

Production of metallic paint since 1889, by States.

State.	1889.		1890.		1891.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Colorado	90	$2,500	1,300	$22,100	....	....
New York	3,658	63,698	5,224	72,952	7,352	$99,487
Ohio	540	11,123	637	16,341	800	14,500
Pennsylvania	8,849	128,036	8,955	145,243	9,175	134,138
Tennessee	3,057	24,237	5,386	46,088	4,000	30,000
Vermont	....	....	500	6,000	400	5,000
Wisconsin	1,832	26,700	2,125	31,035	2,343	34,375
Other States	3,000	30,000	50	610	1,072	16,955
Total *a*	21,026	286,294	24,177	340,369	25,142	334,455

State.	1892.		1893.	
	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*	
New York	5,200	$76,500	3,885	$57,500
Ohio	879	17,090	710	5,750
Pennsylvania	10,289	176,785	8,300	143,875
Tennessee	5,000	32,000	3,000	27,500
Vermont	400	5,000	338	4,600
Wisconsin	2,448	33,826	2,246	29,500
Other States	1,495	21,765	1,481	28,564
Total *a*	25,711	362,966	19,960	297,289

a Including mortar colors.

Production of metallic paint since 1889, by States—Continued.

State.	1894.		1895.	
	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*	
Missouri	....	....	860	$11,565
New York	4,787	$48,899	6,023	67,161
Ohio	1,006	13,516	....	....
Pennsylvania	8,683	119,674	9,098	126,400
Tennessee	5,510	37,870	5,936	38,602
Vermont	280	3,500	....	....
Wisconsin	3,057	41,889	3,486	44,476
Other States	2,052	19,535	3,456	30,938
Total	25,375	284,883	28,859	319,142
Less mortar colors	10,150	94,961	11,544	106,381
Total metallic paint	15,225	189,922	17,315	212,761

State.	1896.		1897.	
	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*	
New York	5,882	$61,800	5,775	$59,875
Ohio	1,346	11,937	1,626	12,945
Pennsylvania	4,824	76,879	7,788	109,030
Tennessee	6,400	47,200	6,468	43,276
Vermont	....	....	....	....
Wisconsin	1,417	18,958	1,627	19,043
Other States	4,596	52,960	1,652	19,095
Total	24,465	269,734	24,936	263,264
Less mortar colors	9,660	89,600	8,237	75,570
Total metallic paint	14,805	180,134	16,699	187,694

State.	1898.			
	Metallic paint.		Mortar colors.	
	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*	
New York	3,600	$45,000	4,050	$44,000
Pennsylvania	8,379	139,392	900	8,000
Other States	8,993	79,587	2,157	22,894
Total	20,972	263,979	7,107	74,894

VENETIAN RED.

Venetian red is a bright-red pigment obtained by roasting iron sulphate or green vitriol. The sulphur is driven off, leaving iron oxide of a brighter red than that found native. The amount of iron so consumed is comparatively small when considered with the total iron product, and the venetian-red product is accordingly included in the output of mineral paints.

The production of venetian reds in 1897 was abnormally large, being more than three times that of 1896 both in quantity and value. The production in 1898 was 3,332 tons less than that of 1897, a decrease of about 25 per cent. The value decreased $134,033, or nearly 46 per cent, this comparatively large decrease in value being probably due to excessive production in 1897 and 1898.

The annual production since 1890 has been as follows:

Production of venetian red since 1890.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1890	4,000	$84,100	1895	4,595	$102,900
1891	4,191	90,000	1896	4,138	93,866
1892	4,900	106,800	1897	13,603	294,744
1893	3,214	64,400	1898	10,271	160,711
1894	2,983	73,300			

SLATE GROUND FOR PIGMENT.

Including "mineral black," a pigment made from the slate partings and roofs in anthracite collieries, the amount of slate and shale ground for paint in 1898 was 4,571 short tons, a product less than that of the preceding year by 95 tons. In the production of this variety of pigment an exception to the rule is noted, in that the value per ton in 1897 was more than that which obtained in 1896. In the former year the average price was $9.35. In 1897 it advanced to $10, and again to $10.11 in 1898.

The annual product of pigments made from slate and shale since 1880 has been as follows:

Amount and value of slate and shale ground for pigment since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	1,120	$10,000	1890	2,240	$20,000
1881	1,120	10,000	1891	2,240	20,000
1882	2,240	24,000	1892	3,787	23,523
1883	2,240	24,000	1893	3,253	25,567
1884	2,240	20,000	1894	3,300	35,370
1885	2,212	24,687	1895	4,331	45,682
1886	3,360	30,000	1896	4,795	44,835
1887	2,240	20,000	1897	4,666	46,681
1888	2,800	25,100	1898	4,571	46,215
1889	2,240	20,000			

WHITE LEAD, ETC.

The production of white lead in oil decreased from 157,596,111 pounds in 1897 to 153,036,302 pounds in 1898. The value decreased about $560,000. The output of dry white lead, on the other hand, increased from 33,720,684 pounds in 1897 to 39,058,581 pounds in 1898, with an increase of $283,345 in value. The combined output of dry lead and lead in oil amounted in 1898 to 192,094,883 pounds, valued at $9,400,622, an increase in amount, as compared with 1897, of 778,088 pounds, and a decrease of $276,193 in value. The production of red lead increased from 15,317,199 pounds in 1897 to 18,435,016 pounds in 1898; litharge, from 13,266,322 pounds to 18,176,591 pounds, and orange mineral from 901,560 pounds to 1,462,715 pounds.

The production of white lead, red lead, litharge, and orange mineral in 1897 and 1898 was as follows:

Production of white lead, etc., in 1897 and 1898.

	1897.		1898.	
	Quantity.	Value.	Quantity.	Value.
White lead:	*Pounds.*		*Pounds.*	
In oil	157,596,111	$8,299,883	153,036,302	$7,740,345
Dry	33,720,684	1,376,932	39,058,581	1,660,277
Red lead	15,317,199	731,312	18,435,016	917,521
Litharge	13,266,322	572,896	18,176,591	834,965
Orange mineral	901,560	55,468	1,462,715	97,873

The following table exhibits, with quantities expressed in short tons, the annual production of white lead, red lead, etc., for a series of eight years. Previous to 1894 the values were based on white lead in oil. The statistics for the past four years include the amount of lead sold, dry and in oil, with the value in the condition in which it was sold.

Production of white lead, etc., for eight years.

	1891.		1892.		1893.		1894.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
White lead	78,018	$10,454,029	74,485	$8,733,620	72,172	$7,695,130	76,343	$6,623,071
Red lead	4,607	591,730	6,122	757,787	6,377	732,968	6,465	623,021
Litharge	5,759	720,925	5,764	611,726	11,757	1,154,819	5,652	495,406
Orange mineral	330	43,300	395	60,170	217	32,893	319	43,517
	1895.		**1896.**		**1897.**		**1898.**	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
White lead	90,513	$8,723,632	88,608	$8,371,588	95,658	$9,676,815	96,047	$9,400,622
Red lead	6,756	628,133	5,731	532,060	7,659	731,312	9,218	917,521
Litharge	6,987	601,267	6,490	539,700	6,633	572,896	9,088	834,965
Orange mineral	366	44,749	270	33,132	451	55,468	731	97,873

The annual production of white lead since 1884 has been as follows:

Production of white lead in the United States since 1884.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1884	65,000	$6,500,000	1892	74,485	$8,733,620
1885	60,000	6,300,000	1893	72,172	7,695,130
1886	60,000	7,200,000	1894	76,343	6,623,071
1887	70,000	7,560,000	1895	90,513	8,723,632
1888	84,000	10,080,000	1896	88,608	8,371,588
1889	80,000	9,600,000	1897	95,658	9,676,815
1890	77,636	9,382,967	1898	96,047	9,400,622
1891	78,018	10,454,029			

IMPORTS.

The following table shows the imports of white lead, red lead, litharge, and orange mineral since 1867:

Red lead, white lead, litharge, and orange mineral imported from 1867 to 1898.

Year ending—	Red lead.		White lead.		Litharge.		Orange mineral.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
June 30, 1867	926, 843	$53, 087	6, 636, 508	$430, 805	230, 382	$8, 941	....	....
1868	1, 201, 144	76, 773	7, 533, 225	455, 698	250, 615	12, 225	....	....
1869	808, 686	46, 481	8, 948, 642	515, 783	187, 333	7, 767	....	....
1870	1, 042, 813	54, 626	6, 228, 285	365, 706	97, 398	4, 442	....	....
1871	1, 295, 616	78, 410	8, 337, 842	483, 392	70, 889	3, 870	....	....
1872	1, 513, 794	85, 644	7, 153, 978	431, 477	66, 544	3, 396	....	....
1873	1, 583, 039	99, 891	6, 331, 373	408, 986	40, 799	2, 379	....	....
1874	756, 644	56, 305	4, 771, 509	323, 926	25, 687	1, 450	....	....
1875	1, 048, 713	73, 131	4, 354, 131	295, 642	15, 767	950	....	....
1876	749, 918	54, 884	2, 546, 776	175, 776	47, 054	2, 562	....	....
1877	387, 260	28, 747	2, 644, 184	174, 844	40, 331	2, 347	....	....
1878	170, 608	9, 364	1, 759, 608	113, 638	28, 190	1, 499	....	....
1879	143, 237	7, 237	1, 274, 196	76, 061	38, 495	1, 667	....	....
1880	217, 033	10, 397	1, 906, 931	107, 104	27, 389	1, 222	....	....
1881	212, 423	10, 009	1, 068, 030	60, 132	63, 058	2, 568	....	....
1882	288, 946	12, 207	1, 161, 889	64, 493	54, 592	2, 191	....	....
1883	249, 145	10, 503	1, 044, 478	58, 588	34, 850	1, 312	....	....
1884	265, 693	10, 589	902, 281	67, 918	54, 183	1, 797	....	....
1885	216, 449	7, 641	705, 535	40, 437	35, 283	1, 091	....	....
Dec. 31, 1886	597, 247	23, 038	785, 554	57, 340	51, 409	1, 831	....	....
1887	371, 299	16, 056	804, 320	58, 602	35, 908	1, 302	....	....
1888	529, 665	23, 684	627, 900	49, 903	62, 211	2, 248	....	....
1889	522, 026	24, 400	661, 694	56, 875	41, 230	1, 412	....	....
1890	450, 402	20, 718	742, 196	57, 659	48, 283	2, 146	....	....
1891	651, 577	23, 807	718, 228	40, 773	94, 586	3, 108	....	....
1892	812, 703	28, 443	744, 838	40, 032	56, 737	1, 811	1, 409, 601	$64, 133
1893	854, 982	27, 349	686, 490	34, 145	42, 582	1, 310	1, 385, 828	61, 360
1894	947, 873	29, 064	796, 480	40, 939	38, 595	1, 064	1, 386, 464	58, 614
1895	1, 764, 274	53, 139	1, 897, 892	79, 887	97, 667	2, 812	1, 689, 367	66, 492
1896	1, 543, 262	47, 450	1, 183, 538	52, 409	51, 050	1, 615	1, 359, 651	51, 027
1897	1, 386, 070	46, 992	1, 101, 829	48, 988	60, 984	1, 931	1, 486, 042	67, 549
1898	682, 449	25, 780	506, 739	24, 334	56, 417	2, 021	795, 116	37, 745

PRICES.

The following table is of interest, as it shows the average yearly market prices of corroding pig lead and the net price of white lead in oil (both at New York) and the difference between the two since 1874:

Average yearly net prices, at New York, of pig lead and white lead in oil since 1874.

[Per 100 pounds.]

Year.	Pig lead, in New York.	White lead in oil, in New York.	Difference.	Year.	Pig lead, in New York.	White lead in oil, in New York.	Difference.
1874	$6.00	$11.25	$5.25	1887	$4.47	$5.75	$1.28
1875	5.95	10.50	4.55	1888	4.41	5.75	1.34
1876	6.05	10.00	3.95	1889	3.80	6.00	2.20
1877	5.43	9.00	3.57	1890	4.33	6.25	1.92
1878	3.58	7.25	3.67	1891	4.33	6.37	2.05
1879	4.18	7.00	2.82	1892	4.05	6.39	2.34
1880	5.05	7.60	2.55	1893	3.73	6.03	2.30
1881	4.80	7.25	2.45	1894	3.28	5.26	1.98
1882	4.90	7.00	2.10	1895	3.28	5.05	1.77
1883	4.32	6.88	2.56	1896	3.03	4.90	1.87
1884	3.73	5.90	2.17	1897	3.64	5.00	1.36
1885	3.95	6.00	2.05	1898	3.79	5.08	1.29
1886	4.63	6.25	1.62				

In considering the variations between the value of pig lead and white lead in oil allowance should be made for the fluctuations in the value of linseed oil, which enters largely into the manufacture of lead in oil. The fluctuations in the price of linseed oil in five years have ranged from 30 cents to 59 cents a gallon. The highest price reached for linseed oil was in July, 1895, and the lowest in the early part of 1897. The highest price for linseed oil in 1898 was 46 cents. The fluctuations in the price of linseed oil in five years have been as follows, in cents per gallon:

	Highest.	Lowest.
1894	56	50
1895	59	42
1896	41	31
1897	43	30
1898	46	34

The proportions of white lead and oil vary according to trade requirements, but on an average 100 pounds of lead in oil contains 91 pounds of lead and 9 pounds of linseed oil.

ZINC WHITE.

The production of zinc oxide or zinc white for the year 1898 may be placed at 33,000 tons, showing an increase of almost a third over that of the previous year.

This increase in production is partially due to the increasing popularity of zinc white in this country, and partially to the increased foreign demand for American zinc oxide.

Although somewhat inferior in color to the zinc oxide manufactured by the French process from metallic zinc, the American oxide made direct from franklinite ores has found great favor abroad on account of its purity and uniformity and its comparatively low price.

Zinc oxide is used mainly as a paint pigment, either alone, ground in oil, or else in so-called combination paints or leads, which contain besides zinc oxide other pigments, such as white lead, sublimed lead, silica, barytes, whiting, etc. Such combinations, of which there are a large number, each paint grinder having his particular formula, are, when properly prepared, superior to any pigment used alone, as in compounding them an effort is made to counteract the defects of one pigment with the corresponding superior qualities of another. There is little doubt, however, that in many cases such ingredients as silica, whiting, barytes, etc., are added rather to cheapen the paint than to improve it.

Zinc oxide is also one of the chief ingredients of the better class of the so-called ready-mixed paints, which are yearly coming more into favor, on account of the ease with which the proper colors can be selected and the paint applied.

As is the case with combination paints, there are, however, many ready-mixed paints made entirely with a view to cheapness. In these, alkali emulsions take the place of linseed oil, and pigments with comparatively little covering power are substituted for zinc oxide and white lead. The results obtained with these are, as a rule, unsatisfactory.

Considerable controversy has sprung up during the last year regarding the relative merits of zinc white and white lead as paint pigments. The claims put forward by the advocates of zinc white are: (1) That zinc white is whiter than white lead, thus furnishing not only a superior white coating, but also clearer and brighter tints. Zinc white, being more finely divided and flocculent, absorbs a larger proportion of oil to fit it for painting purposes. It is chemically inert both on the oil and on the various coloring pigments with which it is combined. A coating of paint composed largely of zinc white, therefore, will be durable and retain its original color. Zinc white is not changed in color by the action of sulphureted hydrogen, which gas is more or less present in all dwelling houses and manufacturing districts. (2) That a coating composed largely of zinc white will present a smooth, glossy, and hard surface to the abrasive action of the elements, thereby resisting the impact of wind and rain charged with dust and sand for a long period of time. (3) That the manufacture and use of zinc white in no way endangers the health.

On the other hand, it may be said in favor of white lead that it has held an excellent reputation as a paint pigment for several centuries. It is more opaque and has better covering qualities than zinc white, due to the smaller amount of oil required to make it suitable for painting purposes. The American artisan is, as a rule, fully acquainted with the best methods of applying it, while the proper application of zinc white has still to be acquired by many of the painting craft in this country.

There is no doubt that the use of zinc oxide as a paint pigment is rapidly gaining ground in this country, as it has already done abroad. This appears to be more especially the case where the surfaces to be protected have to meet severe conditions, such as the destructive action of sea air and salt water, the influence of sulphur fumes, etc., or where for exterior or interior work a brilliant white or pleasing and clear tints and shades are desired. Aside from its use as a paint pigment, a small percentage (about 15) of the zinc oxide manufactured in this country is consumed by the rubber, wall-paper, oilcloth, linoleum, glue, insulation, and textile industries. In these branches it is used to give color, weight, or body to the manufactured articles.

The production of zinc oxide in the United States is largely controlled by the New Jersey Zinc Company. The franklinite ore from this company's mines is exceptionally well adapted for production of zinc oxide direct from the ore, as it contains no sulphur, lead, or other deleterious volatile ingredients. The extensive plant which the New Jersey Zinc Company is now erecting in Lehigh Gap at Palmerton, Pennsylvania, is rapidly nearing completion, and will be in operation by the end of the present year.

The following table shows the production of zinc oxide from 1880 to 1898:

Production of zinc white since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	10,107	$763,738	1890	....	$1,600,000
1881	10,000	700,000	1891	23,700	1,600,000
1882	10,000	700,000	1892	27,500	2,200,000
1883	12,000	840,000	1893	24,059	1,804,420
1884	13,000	910,000	1894	19,987	1,399,090
1885	15,000	1,050,000	1895	20,710	1,449,700
1886	18,000	1,440,000	1896	20,000	1,400,000
1887	18,000	1,440,000	1897	25,000	1,750,000
1888	20,000	1,600,000	1898	33,000	2,310,000
1889	16,970	1,357,600			

IMPORTS.

The imports of zinc white in 1898 were less than in any year since 1892, indicating, when taken in consideration with the increased production, that the domestic product has displaced a considerable quantity of foreign material in the home markets, although there was a general falling off in imports, due to the war with Spain. The following table exhibits the amount of zinc white imported into the United States since 1885:

Imports of zinc oxide from 1885 to 1898, inclusive.

Year ending—	Dry.	In oil.	Year ending—	Dry.	In oil.	Total value.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*	
June 30, 1885	2,233,128	98,566	Dec. 31, 1892	2,442,014	111,190	....
Dec. 31, 1886	3,526,289	79,788	1893	3,900,749	254,807	....
1887	4,961,080	123,216	1894	3,371,292	59,291	$122,690
1888	1,401,342	51,985	1895	4,546,049	129,343	153,641
1889	2,686,861	66,240	1896	4,572,781	311,023	161,188
1890	2,631,458	102,298	1897	5,564,763	502,357	206,636
1891	2,839,351	128,140	1898	3,342,235	27,050	130,039

BARYTES.

By Edward W. Parker.

PRODUCTION.

The production of crude barytes, or heavy spar, in 1898 amounted to 31,306 short tons, valued at $108,339, as against 26,042 short tons, valued at $58,295 in 1897. This shows that while the production increased about 25 per cent, the value nearly doubled. It was explained in the report for 1897 that the comparatively low value in that year was due to an increased production of low-grade material, which sold for only $1 per ton at the mine. The increased production in 1898 was in higher-grade barytes, and prices were also slightly improved.

The production of crude barytes in the United States since 1882 has been as follows:

Production of crude barytes from 1882 to 1898.

Year.	Quantity.	Value.	Average price per ton.	Year.	Quantity.	Value.	Average price per ton.
	Short tons.				*Short tons.*		
1882	22,400	$80,000	$3.57	1891	31,069	$118,363	$3.81
1883	30,240	108,000	3.57	1892	32,108	130,025	4.05
1884	28,000	100,000	3.57	1893	28,970	88,506	3.06
1885	16,800	75,000	4.46	1894	23,335	86,983	3.73
1886	11,200	50,000	4.46	1895	21,529	68,321	3.17
1887	16,800	110,000	*a* 6.55	1896	17,068	46,513	2.72
1888	22,400	75,000	3.35	1897	26,042	58,295	2.24
1889	21,460	106,313	*b* 4.95	1898	31,306	108,339	3.50
1890	21,911	86,505	3.95				

a Value at St. Louis and includes some floated barytes.
b Value includes floated barytes when sold first in that form.

IMPORTS.

The following table shows the imports of barytes into the United States from 1867 to 1898:

Imports of barytes from 1867 to 1898.

Year ending—	Manufactured.		Unmanufactured.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
June 30, 1867	14, 968, 181	$141, 273	....	....
1868	2, 755, 547	26, 739	....	....
1869	1, 117, 335	8, 565	....	....
1870	1, 684, 916	12, 917	....	....
1871	1, 385, 004	9, 769	....	....
1872	5, 804, 098	43, 521	....	....
1873	6, 939, 425	53, 759	....	....
1874	4, 788, 966	42, 235	....	....
1875	2, 117, 854	17, 995	....	....
1876	2, 655, 349	25, 325	....	....
1877	2, 388, 373	19, 273	....	....
1878	1, 366, 857	10, 340	....	....
1879	453, 333	3, 496	....	....
1880	4, 924, 423	37, 374	....	....
1881	1, 518, 322	11, 471	....	....
1882	562, 300	3, 856	....	....
1883	411, 666	2, 489	....	....
1884	3, 884, 516	24, 671	5, 800, 816	$8, 044
1885	4, 095, 287	20, 606	7, 841, 715	13, 567
Dec. 31, 1886	3, 476, 691	18, 338	6, 588, 872	8, 862
1887	4, 057, 831	19, 769	10, 190, 848	13, 290
1888	3, 821, 842	17, 135	6, 504, 975	9, 037
1889	3, 601, 506	22, 458	13, 571, 206	7, 660
1890	*a* 1, 563	16, 453	*a* 4, 815	13, 133
1891	2, 149	22, 041	2, 900	8, 816
1892	1, 389	15, 419	2, 789	7, 418
1893	1, 032	11, 457	2, 983	7, 612
1894	836	10, 556	1, 884	5, 270
1895	1, 629	17, 112	2, 551	7, 561
1896	2, 467	23, 345	509	1, 274
1897	1, 300	13, 822	502	579
1898	687	8, 678	1, 022	2, 678

a Tons since 1890.

FULLER'S EARTH.

PRODUCTION.

During the last few years fuller's earth has been found in New York, Colorado, Nebraska, Florida, South Dakota, Utah, and California; but Florida continues to produce the greatest quantity and the best quality of this material. The output for the last four years in the United States is shown in the following table:

Production of fuller's earth in the United States from 1895 to 1898.

Year.	Quantity.	Value.
	Short tons.	
1895	6,900	$41,400
1896	9,872	59,360
1897	17,113	112,272
1898	14,860	106,500

The decline of the output in America is presumably due to the manufacture of powdered fuller's earth in England and the fact that it costs less to import the prepared material than to produce it from the lump, the tariff on the powdered product being very low. Its utility in bleaching and deodorizing oils and greases was originally an American discovery, but is now well understood in England, where the use of the lump earth for such purposes has been in vogue for many years.

Bone black, which was formerly used for the clarifying, purifying, and deodorizing of the mineral oils, is now no longer essential for that purpose, the fuller's earth from Florida having proved of such value as to replace it. In quality it is considered to be really finer than that imported from England, although it does not reach the standard set by the English product in its effect on the animal and vegetable oils and in the fulling of wool.

An analysis of the earth from Ocala, Florida, made in March, 1898, is as follows:

Analysis of fuller's earth from Ocala, Florida.

Constituent.	Per cent.
SiO_2	36.73
TiO_2	1.27
CO_2	None.
P_2O_5	5.54
Al_2O_3	27.78
Fe_2O_3	3.21
CaO	.81
MgO	.64
K_2O	.42
Na_2O	None.
H_2O at 110°	7.38
H_2O above 110°	12.14
Organic matter *a*	3.61
Total	99.53

a The organic matter is based on the assumption of Wolff that humus contains 58 per cent carbon, the latter being directly determined.

Recent reports from Valentine, Nebraska, would seem to indicate that the discovery of fuller's earth there will be valuable. The promoters of the plant state that the earth is "abundant, runs in heavy veins under the most favorable conditions for mining, and is of the best quality yet found in the United States."

Following is the analysis made by a professor of the State University at Lincoln:

Analysis of fuller's earth from Valentine, Nebraska.

Constituent.	Per cent.
SiO_2 (silicic acid)	47.37
Fe_2O_3 (iron)	3.89
Al_2O_3 (aluminum)	7.08
CaO (calcium)	32.19
MgO (magnesium)	1.19
K_2O (potassium)	.98
Na_2O (sodium)	Trace.
SO_3 (sulphuric acid)	.20
CO_2 (carbonic acid)	17.73
P_2O_5 (phosphoric acid)	.21
Moisture in air-dried sample	2.53
Calculated to water-free material (dried)	110 C.

Below are comparative tables showing the difference between fuller's earth from England, Florida, and Nebraska:

Comparison of fuller's earth from England, Florida, and Nebraska.

Locality.	Moisture in air-dry sample.	Organic matter.	Gravel 2-1 mm.	Coarse sand 1-0.5 mm.	Medium sand 0.5-0.25 mm.
England	15.62	4.15	....	....	0.18
Nebraska	10.30	3.34	....	....	0.07
Florida	7.72	8.39	....	0.50	16.76

Locality.	Fine sand 0.25-0.1 mm.	Very fine 0.1-0.05 mm.	Silt 0.05-0.01 mm.	Fine silt 0.01-0.005 mm.	Clay 0.005-0.000 mm.
England	5.58	21.51	20.04	5.09	29.60
Nebraska	0.96	14.63	21.15	9.16	41.98
Florida	17.26	0.51	4.22	0.97	43.84

IMPORTS.

The amount and value of the fuller's earth imported into the United States in 1898 are shown in the following table:

Fuller's earth imported into the United States during 1898.

Class.	Quantity.	Value.
	Long tons.	
Unwrought or unmanufactured	2,038	$15,921
Wrought or manufactured	6,315	55,123
Total	8,353	71,044

In Wyoming a recently discovered clay called bentonite, some of which has been shipped to Chicago, is said to be fuller's earth, or to have many of its properties; and in California a "mountain of fuller's earth" is said to have been discovered in Kern County. The first carload prepared in the State arrived in San Francisco in December (1898) from Famoso, Kern County, which shows that the business there is being carried on in earnest.

QUARTZ AND FELDSPAR.

By HEINRICH RIES.

PRODUCTION.

There was an increase in the production of both quartz and feldspar during the year 1898, although the number of firms in operation was less. The chief increase was in quartz.

Much of the quartz and feldspar quarried is used in the manufacture of wood filler, over one-third of the quartz produced being utilized for that purpose.

Feldspar deposits of commercial value have been described by T. C. Hopkins[1] from southern and central Chester County, Pennsylvania. The spar is orthoclase and forms veins in the serpentine.

Production of feldspar in 1898.

State.	1898.	
	Quantity.	Value.
	Long tons.	
Connecticut and New York	6,700	$12,020
Maine and Pennsylvania	5,300	20,375
Total	12,000	32,395

Production of quartz in 1897 and 1898.

State.	1897.		1898.	
	Quantity.	Value.	Quantity.	Value.
	Long tons.		*Long tons.*	
Alabama	1,500	$7,500	820	$4,100
Connecticut and New York	2,400	5,100	9,120	20,875
Maine	250	525	250	525
Maryland	4,300	4,100	2,700	6,300
Massachusetts	500	1,000		
Pennsylvania	1,502	1,502	6,240	10,870
Wisconsin	1,500	6,500		
Total	11,952	26,227	19,130	42,670

The average price of feldspar decreased from $3.86 per ton in 1897 to $2.70 in 1898.

This great decrease in price seems to be partly due to the fact that less of the product is ground before shipment than was the case in 1897.

The production of feldspar for Pennsylvania is, in part, estimated.

[1] Am. Assoc. Adv. Sci., Vol. XLVII, p. 293.

MINERAL WATERS.

By A. C. Peale.

PRODUCTION.

To the list of springs for 1897 51 springs have been added, making the total for the list of 1898 484, which is a net gain of 43, the total for 1897 being 441. From this 8 springs have been dropped, the waters from them being no longer in the market. Of this total of 484 (the largest yet published) 78 are not represented in the figures presented in the following report. This is the largest delinquent list of any year, and is 18 more than that of 1897. Many of these, however, reported that no sales were made in 1898, but that there were prospects of sales for 1899. The present report is based on returns from 25 more springs than were heard from in 1897. The springs not heard from have, as in previous years, been estimated for at one-half their previously reported figures, most of them having reported in 1897.

In three of the sections there has been a very considerable increase in production, with a corresponding increase in the total valuation of the product, while in the other two there has been a decrease.

The total production reported for 1898 is 28,853,464 gallons, which is an increase of 5,597,553 gallons over the number reported for 1897. The total valuation of the product of 1898 is $8,051,833, an increase over the figures of 1897 of $3,452,727.

The average price per gallon is $27\frac{9}{10}$ cents, the largest yet reported.

When the 406 springs actually reporting their figures in 1898 are compared with the 381 of 1897, the figures given show an increase for 1898 of 5,319,357 gallons, with an increased valuation of $3,420,873.

In the list of the North Atlantic States for 1898 the net gain in the number of springs is 18, as 19 have been added and 1 dropped. The total number for the section is 158, as compared with 140 for 1897. Reports of sales have been received from 131, which is 6 more than were heard from in the previous year. They report a total of 11,161,300 gallons, which is an increase of 1,453,034 gallons over 1897, with an increase in valuation of $681,558, the total valuation for 1898 being $3,288,915.

The springs new to the list are as follows:

Connecticut: Cherry Hill Spring.

Maine: Highland Spring, Ishka Springs, Utona Springs.

Massachusetts: Belmont Crystal Spring, Egypt Springs, Fulton Natural Spring, Monatiquot Spring, Mount Holyoke Lithia Spring.

New York: Clyde Mineral Spring, Franklin Lithia Spring, Gurn Spring, Mountain Mist Spring, Vita Spring, Wagner Mineral Spring.

New Jersey: Indian Kalium Spring, Pine Lawn Spring.

Pennsylvania: Buena Vista Springs, Tuckahoe Mineral Springs.

In the South Atlantic States the total number of springs on the list for 1898 is 86, a net gain of 6 springs, 8 having been added to the list of 1897 and 2 having been taken from it, the total for that year being 80. Reports of sales have been received from 71, which is 2 more than reported in 1897, and 15 are on the delinquent list. The number of gallons reported as sold in 1898 is 5,073,941, which is 3,829,378 greater than the production of 1897. The total valuation of the product of 1898 is $3,165,171, an increase of $2,817,454 over that of 1897. The springs new to the list of 1898 are the following:

Maryland: Indian Spring, Virginia Rock Springs.

South Carolina: Aiken Artesian Well, Rives Mineral Spring.

Virginia: Fonticello Lithia Spring, Rubino Natural Lithia Springs, Taskinas Springs.

West Virginia: Greenbrier Alum Springs.

The North Central States make a net gain for 1898 of 9 springs, 12 having been added to the list of 1897, while 3 have been dropped from it. The total number for the section on the list of 1898 is 130, instead of 121 as on the list of 1897. Of these 107 report their sales for 1898, 3 more than in the previous year. The number of gallons sold is reported as 7,499,563, an increase over 1897 of 896,153. The valuation of this product is given as $1,217,632, which is $177,971 more than that of the previous year. The following are the springs that were not on the list for 1897:

Illinois: Deer Lick Mineral Spring, Sidell Mineral Spring.

Indiana: Attica Lithia Springs, Magnesia Mineral Springs.

Michigan: Royal Oak Mineral Springs.

Missouri: Jackson Lithia Springs, Mulkey Springs.

Ohio: Fargo Mineral Springs.

South Dakota: Minnehaha Springs.

Wisconsin: Elim Springs, Plymouth Rock Spring, Waukesha Lithia Spring.

The South Central States for 1898 are represented by 43 springs, showing no change in the number of springs from the preceding year. Reports have been received from 35, which is 1 less than in 1897, leaving 8 on the delinquent list. The number of gallons sold is reported as 1,253,517, which is 1,179,130 gallons less than were reported in 1897. The valuation is $35,748 less, $93,437 being the value of the product of 1898.

In the Western States and Territories 12 springs have been added to the list and 2 have been dropped, leaving a net gain of 10. The total number of the list for 1898 is 67, as compared with 57 the previous year. Notwithstanding the increase in the number of springs and in the number reporting, which is 14 more than in 1897, there is a decrease for 1898 in the number of gallons reported as sold amounting to 1,557 gallons. The total reported is 2,693,318 gallons. The valuation of the product is $482,817, which is a decrease of $220,362 from the figures of 1897. The springs new to the list of 1898 are the following:

California: Allen Springs, Duncan Springs, Humboldt Springs, Isham's Springs, Mercy Medicinal Well, Paso Robles Springs, Ramona Natural Mineral Spring, San Cayetanó Springs, San Benito Springs, Tassajara Hot Springs.

Colorado: Strontia Medicinal Spring, the Ximo Spring.

Production of mineral waters in 1898, by States and Territories.

State or Territory.	Springs reporting.	Product.	Value.
		Gallons.	
Alabama	4	10, 976	$13, 877
Arkansas	6	48, 331	10, 195
California	36	1, 203, 318	383, 321
Colorado	12	1, 244, 000	43, 321
Connecticut	10	200, 203	26, 385
Florida	2	17, 500	7, 875
Georgia	6	197, 100	39, 230
Illinois	17	419, 760	23, 391
Indiana	11	127, 150	19, 080
Iowa	3	61, 800	11, 610
Kansas	4	42, 215	3, 372
Kentucky	4	9, 000	3, 000
Maine	14	406, 278	52, 850
Maryland	7	278, 390	29, 779
Massachusetts	30	3, 755, 657	220, 052
Michigan	17	858, 100	131, 690
Minnesota	4	1, 976, 150	34, 792
Mississippi	4	54, 110	13, 445
Missouri	10	238, 165	59, 341
New Hampshire	3	1, 537, 000	1, 133, 950
New Jersey	4	367, 000	217, 550
New Mexico	5	51, 000	8, 010
New York	41	3, 358, 541	1, 291, 010
North Carolina	6	93, 950	19, 175
Ohio	11	417, 200	54, 200
Oregon	3	39, 100	9, 000
Pennsylvania	20	1, 300, 541	321, 199
Rhode Island	4	188, 000	11, 600
South Carolina	5	149, 569	29, 682
South Dakota	2	50, 935	6, 219

Production of mineral waters in 1898, by States and Territories—Continued.

State or Territory.	Springs reporting.	Product.	Value.
		Gallons.	
Tennessee	4	134,000	$20,050
Texas	12	842,100	25,120
Utah	2	8,500	2,375
Vermont	5	48,080	14,319
Virginia	37	4,293,532	3,022,470
Washington	2	53,400	3,900
West Virginia	7	33,000	15,325
Wisconsin	27	3,296,838	549,646
Other States *a*	5	271,150	45,097
Total	406	27,681,639	7,926,493
Estimated production of springs not reporting sales	78	1,171,825	125,340
Grand total	484	28,853,464	8,051,833

a These include the States in which only one spring in each has made a report. These States are District of Columbia, Idaho, Montana, Nebraska, and Louisiana.

Production of natural mineral waters from 1883 to 1898.

Geographic division.	Springs reporting.	Quantity sold.	Value.
1883.		*Gallons.*	
North Atlantic	38	2,470,670	$282,270
South Atlantic	27	312,090	64,973
North Central	37	1,435,809	323,600
South Central	21	1,441,042	139,973
Western	6	169,812	52,787
	129	5,829,423	863,603
Estimated	60	1,700,000	256,000
Total	189	7,529,423	1,119,603
1884.			
North Atlantic	38	3,345,760	328,125
South Atlantic	27	464,718	103,191
North Central	37	2,070,533	420,515
South Central	21	1,526,817	147,112
Western	6	307,500	85,200
	129	7,715,328	1,084,143
Estimated	60	2,500,000	375,000
Total	189	10,215,328	1,459,143

Production of natural mineral waters from 1883 to 1898—Continued.

Geographic division.	Springs reporting.	Quantity sold.	Value.
1885.		*Gallons.*	
North Atlantic	51	2,527,310	$192,605
South Atlantic	32	908,692	237,153
North Central	45	2,925,288	416,211
South Central	31	540,436	74,100
Western	10	509,675	86,776
	169	7,411,401	1,036,845
Estimated	55	1,737,000	276,000
Total	224	9,148,401	1,312,845
1886.			
North Atlantic	49	2,715,050	177,969
South Atlantic	38	720,397	123,517
North Central	40	2,048,914	401,861
South Central	31	822,016	58,222
Western	14	781,540	137,796
	172	7,087,917	899,365
Estimated	53	1,862,400	384,705
Total	225	8,950,317	1,284,070
1887.			
North Atlantic	40	2,571,004	213,210
South Atlantic	34	614,041	147,149
North Central	38	1,480,820	208,217
South Central	29	741,080	87,946
Western	12	1,236,324	288,737
	153	6,643,269	945,259
Estimated	62	1,616,340	316,204
Total	215	8,259,609	1,261,463
1888.			
North Atlantic	42	2,856,799	247,108
South Atlantic	32	1,689,387	493,489
North Central	38	2,002,373	325,839
South Central	19	426,410	71,215
Western	15	1,853,679	421,651
	146	8,828,648	1,559,302
Estimated	52	750,000	120,000
Total	198	9,578,648	1,679,302

Production of natural mineral waters from 1883 to 1898—Continued.

Geographic division.	Springs reporting.	Quantity sold.	Value.
1889.		*Gallons.*	
North Atlantic	60	4, 106, 464	$471, 575
South Atlantic	47	646, 239	198, 032
North Central	86	6, 137, 776	604, 238
South Central	33	500, 000	43, 356
Western	32	1, 389, 992	431, 257
Total	258	12, 780, 471	1, 748, 458
1890.			
North Atlantic	55	5, 043, 074	1, 175, 512
South Atlantic	39	647, 625	245, 760
North Central	71	5, 050, 413	737, 672
South Central	30	604, 571	81, 426
Western	25	869, 504	253, 578
	220	12, 215, 187	2, 493, 948
Estimated	53	1, 692, 231	106, 802
Total	273	13, 907, 418	2, 600, 750
1891.			
North Atlantic	62	5, 724, 752	1, 591, 746
South Atlantic	41	796, 439	313, 443
North Central	68	8, 010, 556	482, 082
South Central	29	629, 015	106, 022
Western	27	1, 123, 640	414, 564
	227	16, 284, 402	2, 907, 857
Estimated	61	2, 108, 330	88, 402
Total	288	18, 392, 732	2, 996, 259
1892.			
North Atlantic	65	6, 853, 722	1, 933, 416
South Atlantic	47	1, 062, 945	353, 193
North Central	74	11, 566, 440	1, 834, 732
South Central	32	693, 544	109, 334
Western	24	1, 261, 453	594, 469
	242	21, 438, 104	4, 825, 144
Estimated	41	438, 500	80, 826
Total	283	21, 876, 604	4, 905, 970

Production of natural mineral waters from 1883 to 1898—Continued.

Geographic division.	Springs reporting.	Quantity sold.	Value.
1893.		*Gallons.*	
North Atlantic	79	8,351,192	$1,844,845
South Atlantic	49	1,092,829	304,736
North Central	78	8,833,712	1,073,427
South Central	35	1,139,959	122,331
Western	29	675,041	307,623
	270	20,092,733	3,652,962
Estimated	60	3,451,762	593,772
Total	330	23,544,495	4,246,734
1894.			
North Atlantic	83	8,217,528	1,488,361
South Atlantic	55	660,120	129,143
North Central	82	6,914,900	1,115,322
South Central	37	2,319,813	273,836
Western	29	859,905	274,235
	286	18,972,266	3,280,897
Estimated	71	2,597,342	460,949
Total	357	21,569,608	3,741,846
1895.			
North Atlantic	88	8,668,907	1,572,881
South Atlantic	51	953,713	287,623
North Central	92	6,428,582	1,577,118
South Central	35	2,346,806	161,073
Western	31	886,185	292,832
	297	19,284,193	3,891,527
Estimated	73	2,179,350	362,710
Total	370	21,463,543	4,254,237
1896.			
North Atlantic	90	9,234,890	2,069,336
South Atlantic	60	1,306,088	400,408
North Central	97	8,123,080	808,307
South Central	34	4,364,957	255,943
Western	31	1,577,185	400,998
	312	24,606,200	3,934,992
Estimated	65	1,189,112	201,200
Total	377	25,795,312	4,136,192

Production of natural mineral waters from 1883 to 1898—Continued.

Geographic division.	Springs reporting.	Quantity sold.	Value.
1897.		*Gallons.*	
North Atlantic	125	9, 708, 266	$2, 607, 357
South Atlantic	68	1, 244, 563	347, 717
North Central	104	6, 281, 931	718, 182
South Central	36	2, 432, 647	129, 185
Western	48	2, 694, 875	703, 179
	381	22, 362, 282	4, 505, 620
Estimated	60	893, 629	93, 486
Total	441	23, 255, 911	4, 599, 106
1898.			
North Atlantic	131	11, 161, 300	3, 288, 915
South Atlantic	71	5, 073, 941	3, 165, 171
North Central	107	7, 499, 563	896, 153
South Central	35	1, 253, 517	93, 417
Western	62	2, 693, 318	482, 817
	406	27, 681, 639	7, 926, 493
Estimated	78	1, 171, 825	125, 340
Total	484	28, 853, 464	8, 051, 833

LIST OF COMMERCIAL SPRINGS.

The list given below contains only the names of springs actually reporting for the year 1898.

ALABAMA.

There is no change in the list of springs for Alabama, and the 4 springs credited to the State all report. They are the following:

Bailey Springs, Bailey Springs, Lauderdale County.
Healing Springs, Healing Springs, Washington County.
Jackson White Sulphur Springs, Jackson, Clarke County.
Wilkinson's Matchless Mineral Water, Greenville, Butler County.

ARKANSAS.

Of the 7 springs credited to Arkansas all but 1 have been heard from. The 6 reporting are as follows:

Arkansas Lithia Springs, Hope, Hempstead County.
Blanco Springs, near Hot Springs, Garland County.
Dovepark Springs, Dovepark, Hot Spring County.
Eureka Springs, Eureka Springs, Carroll County.
Potash Sulphur Spring, Hot Springs, Garland County.
Sulphur Springs, Sulphur Springs, Benton County.

CALIFORNIA.

The State of California makes a net gain for 1898 of 8 springs, 10 having been added to the list of 1897 and 2 taken from it. The total number, therefore, is 38, and of these 36 report their sales for 1898. They are the following:

Adams Springs, Lake County.
Ætna Springs, Lidell, Napa County.
Alhambra Mineral Spring, Martinez, Contra Costa County.
Allen Springs, Allen Springs, Lake County.
Almaden Vichy Springs, New Almaden, Santa Clara County.
Azule Natural Seltzer Water, San Jose, Santa Clara County.
Bartlett Springs, Bartlett Springs, Lake County.
Bythnia Springs, Santa Barbara, Santa Barbara County.
Byron Hot Springs, Byron Hot Springs, Contra Costa County.
California Geysers, The Geysers, Sonoma County.
Castle Rock Natural Mineral Spring, Castella, Shasta County.
Cooks Springs, Colusa County.
Coronado Mineral Spring, Coronado, San Diego County.
Duncan Springs, Hopland, Mendocino County.
Fouts Springs, Colusa County.
Highland Springs, near Clear Lake, Lake County.
Humboldt Springs, Eureka, Humboldt County.
Isham Springs, near San Diego, San Diego County.
Lytton Seltzer Spring, Lytton, Sonoma County.
Lytton Soda Spring, Lytton, Sonoma County.
Madrone Mineral Springs, Santa Clara County.
Matilija Hot Springs, Matilija, Ventura County.
Mercy Medicinal Well, Little Panoche, Fresno County.
Mount Ida Mineral Spring, Oroville, Butte County.
Napa Soda Springs, Napa Soda Springs, Napa County.
Pacific Congress Springs, Saratoga, Santa Clara County.
Paso Robles Springs, Paso Robles, San Luis Obispo County.
Ramona Natural Mineral Spring, Los Angeles, Los Angeles County.
Samuel Soda Springs, Napa County.
San Benito Springs, Tres Pinos, San Benito County.
San Cayetano Springs, Santa Paula, Ventura County.
Shasta Springs, Shasta Springs, Siskiyou County.
Tassajara Hot Springs, Monterey County.
Tolenas Springs, near Suisun, Solano County.
Tuscan Springs, Redbluff, Tehama County.
Veronica Springs, Santa Barbara, Santa Barbara County.

COLORADO.

The 1897 list for Colorado is increased by 2, making a total of 12 for the State, all of which report their sales for 1898. They are as follows:

Boulder Springs, Boulder Canyon, Boulder County.
Canyon City Vichy Springs, Canyon City, Fremont County.
Carlile Soda-Iron Springs, near Pueblo, Pueblo County.
Clark Magnetic Mineral Springs, near Pueblo, Pueblo County.
Colorado Carlsbad Springs, Barr, Arapahoe County.
Hiawatha and Ute Chief Springs, Manitou, El Paso County.
Manitou Iron Spring, Manitou, El Paso County.

Manitou Mineral Springs, Manitou, El Paso County.
    Cheyenne Spring.
    Manitou Spring.
    Navajo Spring.
    Shoshone Spring.
Mumford's Medicinal Well, Longmont, Boulder County.
Strontia Medicinal Spring, near Deansbury, Douglas County.
The Ximo Spring, Soda Springs, Lake County.
Yampah Springs, Glenwood Springs, Garfield County.

CONNECTICUT.

Connecticut gains 1 spring, and of the 13 now on the list 10 report. They are:

Althea Springs, Waterbury, New Haven County.
Arethusa Springs, Seymour, New Haven County.
Aspinock Mineral Springs, Putnam Heights, Windham County.
Cherry Hill Spring, Hamden, New Haven County.
Highland Rock Mineral Spring, Highland Park, Hartford County.
Live Oak Spring, Meriden, New Haven County.
Oxford Mineral Spring, Oxford, New Haven County.
Stillman Homestead Springs, Bridgeport, Fairfield County.
The Puritan Spring, Norwich, New London County.
Tonica Springs, Highland Park, Hartford County.

DISTRICT OF COLUMBIA.

The District of Columbia is still represented on the list by 1 spring, as follows:

Columbia Natural Lithia Spring, Washington.

FLORIDA.

One spring is dropped from the list for Florida, leaving the total at 2, and both springs report. They are:

Magnolia Springs, Magnolia Springs, Clay County.
Panacea Mineral Springs, Wakulla County.

GEORGIA.

Of the 8 springs credited to Georgia the following 6 report sales:

Anipa Springs, Rome, Floyd County.
Bowden Lithia Springs, Lithia Springs, Douglas County.
Daniels Spring, near Union Point, Greene County.
Hughes Mineral Spring, near Rome, Floyd County.
Medlock Lithia Springs, Austell, Cobb County.
Ponce de Leon Spring, near Atlanta, Fulton County.

IDAHO.

There is no change in the number of springs reported for Idaho. It is still represented by 1 spring, as follows:

Idanha Spring, Soda Springs, Bannock County.

ILLINOIS.

The list for Illinois is increased by 2 springs, making the total 19. Of these the following 17 report:

American Carlsbad Springs, Nashville, Washington County.
Apollo Springs, Glenellyn, Dupage County.
Aurora Lithia Spring, Montgomery, Kane County.
Black Hawk Springs, Rock Island, Rock Island County.
Cumberland Mineral Spring, near Greenup, Cumberland County.
Deer Lick Mineral Spring, Deerfield, Lake County.
Diamond Mineral Springs, Grantfork, Madison County.
Glen Flora Springs, Waukegan, Lake County.
Magnesia Spring, Montgomery, Kane County.
Min-ni-ni-yan Spring, Bristol, Kendall County.
Perry Mineral Springs, Perry Springs, Pike County.
Red Avon Mineral Spring, Avon, Fulton County.
Sailor Springs, Sailor Springs, Clay County.
Sanicula Springs, Ottawa, Lasalle County.
Tivoli Spring, Chester, Randolph County.
Sidell Mineral Spring, Sidell, Vermilion County.
Sylvan Dell Sulpho-Magnesia Spring, Galewood, Cook County.

INDIANA.

Indiana's list has had 2 springs added to it but 2 have also been dropped, leaving the total at 13 as in the previous year. Of these 11 report as follows:

Attica Lithia Springs, Attica, Fountain County.
Elliott or Willow Valley Springs, Proctor, Martin County.
French Lick Springs, French Lick, Orange County.
Greenwood Mineral Well, Greenwood, Johnson County.
Indiana Mineral Springs, Indiana Mineral Springs, Warren County.
Kickapoo Magnetic Springs, Kickapoo, Warren County.
King's Mineral Springs, Muddyfork, Clark County.
Lodi Artesian Well, Silverwood, Fountain County.
Magnesia Mineral Springs, Pierceton, Kosciusko County.
Magnetic Mineral Springs, Terre Haute, Vigo County.
West Baden Springs, West Baden, Orange County.

IOWA.

Of the 5 springs credited to Iowa 3 report as follows:

Colfax Mineral Spring, Colfax, Jasper County.
Mynster Springs, Council Bluffs, Pottawattamie County.
Ottumwa Mineral Springs, Ottumwa, Wapello County.

KANSAS.

Of the 6 springs on the list for Kansas 4 report. They are the following:

Blazing's Natural Medical Spring, Manhattan, Riley County.
Geuda Mineral Springs, Geuda Springs, Cowley County.
Jewell County Lithium Spring, Montrose, Jewell County.
Waconda Springs, Waconda, Mitchell County.

KENTUCKY.

No change is made in the list of Kentucky's springs. Of the 5 springs credited to the State 4 report as follows:

Anita Springs, Lagrange, Oldham County.
Bedford Springs, Bedford, Trimble County.
Bluelick Springs, Bluelick Springs, Nicholas County.
Crab Orchard Springs, Crab Orchard, Lincoln County.

LOUISIANA.

The only spring representing Louisiana on the list is:

Abita Springs, Abita Springs, St. Tammany Parish.

MAINE.

Three springs added to the list for Maine bring the total up to 19. Of these the following 14 report sales:

Cold Bowling Spring, Steep Falls, Limington, York County.
Crystal Mineral Springs, Auburn, Androscoggin County.
Glenrock Springs, Greene, Androscoggin County.
Glenwood Mineral Spring, St. Albans, Somerset County.
Highland Spring, Lewiston, Androscoggin County.
Ishka Springs, Hancock, Hancock County.
Keystone Mineral Spring, East Poland, Androscoggin County.
Mount Hartford Cold Spring, Hartford, Oxford County.
Paradise Spring, Brunswick, Cumberland County.
Pine Spring, Topsham, Sagadahoc County.
Pownal Spring, West Pownal, Cumberland County.
Seal Rock Springs, Saco, York County.
Underwood Spring, Falmouth Foreside, Cumberland County.
Utona Spring, Eastport, Washington County.

MARYLAND.

Maryland gains 2 springs, making the total 9, and of these 7 report as follows:

Blackiston Island Diuretic Mineral Spring, Blackiston Island, St. Marys County.
Carroll Springs, Forest Glen, Montgomery County.
Chattolanee Springs, Chattolanee, Baltimore County.
Indian Spring, near Sligo, Montgomery County.
Strontia Mineral Spring, Brooklandville, Baltimore County.
Tacoma Springs, Tacoma, Montgomery County.
Virginia Rock Spring, Baltimore County.

MASSACHUSETTS.

The list for Massachusetts is increased by 5 springs, bringing the total up to 33. Of these, 30 report. They are the following:

Ballardvale Lithia Spring, Ballardvale, Essex County.
Belmont Crystal Spring, Belmont, Middlesex County.
Belmont Hill Spring, Everett, Middlesex County.
Belmont Natural Spring, Belmont, Middlesex County.
Burnham Spring, Methuen, Essex County.
Columbia Lithia Spring, Revere, Suffolk County.

Commonweath Mineral Spring, Waltham, Middlesex County.
Chapman's Crystal Spring, Stoneham, Middlesex County.
Crystal Mineral Spring, Methuen, Essex County.
Diamond Spring, Lawrence, Essex County.
Egypt Springs, Egypt, Plymouth County.
Electric Spring, Lynn, Essex County.
Everett Crystal Spring, Everett, Middlesex County.
Farrington's Silver Spring, Milton, Norfolk County.
Fulton Natural Spring, Medford.
Geddes Mineral Spring, Marlboro, Middlesex County.
Goulding Spring, Whitman, Plymouth County.
Katahdin Spring, Lexington, Middlesex County.
Linden Mineral Spring, Linden, Middlesex County.
Massasoit Spring, Springfield, Hampden County.
Monatiquot Spring, South Braintree, Norfolk County.
Moose Hill Spring, Swampscott, Essex County.
Mount Holyoke Lithia Spring, South Hadley, Hampshire County.
Myles Standish Spring, South Duxbury, Plymouth County.
Nobscot Mountain Spring, Framingham, Middlesex County.
Shawmut Spring, West Quincy, Norfolk County.
Sheep Rock Spring, Lowell, Middlesex County.
Simpson Spring, South Easton, Bristol County.
Undine Crystal Spring, Brighton, Suffolk County.
Whittier Spring, Danvers, Essex County.

MICHIGAN.

The total number of springs on the list for Michigan is 19, one new spring being added to last year's list. The following springs, 17 in number, report for 1898:

Bromo-Hygeia Springs, Coldwater, Branch County.
Americanus Well, Lansing, Ingham County.
Clarke Red Cross Well, Big Rapids, Mecosta County.
Eastman Mineral Springs, Benton Harbor, Berrien County.
Excelsior Springs, Benton Harbor, Berrien County.
Magnetic Mineral Spring, Spring Lake, Ottawa County.
Medea Spring, Mount Clemens, Macomb County.
Midland Mineral Springs, Midland City, Midland County.
Moorman Springs, Ypsilanti, Washtenaw County.
Mount Clemens Sprudel Water, Mount Clemens, Macomb County.
No-che-mo Mineral Spring, Reed City, Osceola County.
Plymouth Rock Well, Plymouth, Wayne County.
Ponce de Leon Springs, Paris Township, Kent County.
Royal Oak Mineral Springs, Royal Oak, Oakland County.
Salutaris Spring, St. Clair Springs, St. Clair County.
Ypsilanti Mineral Spring, Ypsilanti, Washtenaw County.
Zauber Wasser Springs, Hudson, Lenawee County.

MINNESOTA.

No changes noted in the list for Minnesota, and of the 5 springs credited to the State, the following 4 report:

Indian Medical Spring, Elk River, Sherburn County.
Inglewood and Glenwood Springs, Minneapolis, Hennepin County.
Mankato Mineral Springs, near Mankato, Blue Earth County.
Trio Siloam Springs, Austin, Mower County.

MISSISSIPPI.

The State of Mississippi shows no change in the number of springs on the list for 1898. Of the 5 springs credited to the State 4 report their sales for 1898. They are the following:

Browns Wells, Browns Wells, Copiah County.
Castalian Springs, Durant, Holmes County.
Godbold Mineral Well, Summit, Pike County.
Stafford Mineral Springs, near Vosburg, Jasper County.

MISSOURI.

The total for Missouri is raised to 11 by the addition of 2 springs, and of these 10 report. They are as follows:

B. B. Mineral Springs, Bowling Green, Pike County.
Blue Lick Springs, Blue Lick, Saline County.
Eldorado Springs, Eldorado Springs, Cedar County.
Excelsior Springs, Excelsior Springs, Clay County.
Jackson Lithia Springs, near Kansas City, Jackson County.
Lineville Mineral Springs, Mercer County, near Lineville, Iowa.
McAllister Springs, McAllister, Saline County.
Randolph Springs, Randolph Springs, Randolph County.
Mulky Springs, Ray County, near Lexington.
Sweet Springs, Sweet Springs, Saline county.

MONTANA.

Only 1 of Montana's 2 springs reports sales for 1898, viz:

Lissner's Mineral Springs, Helena, Lewis and Clarke County.

NEBRASKA.

Nebraska, as usual, for 1898, reports 1 spring, viz:

Victoria Mineral Springs, New Helena, Custer County.

NEW HAMPSHIRE.

New Hampshire's list remains unchanged, its 3 springs reporting as usual. They are as follows:

Amherst Mineral Spring, Amherst, Hillsboro County.
Londonderry Lithia Spring, Londonderry, Rockingham County.
Pack Monadnock Lithia Spring, Temple, Hillsboro County.

NEW JERSEY.

Two springs new to the list for New Jersey increase it to 4, and all report as follows:

Indian Kalium Spring, Camden, Camden County.
Kalium Springs, Collingswood, Camden County.
Pine Grove Mineral Spring, Woodbury, Gloucester County.
Pine Lawn Spring, Hohokus, Bergen County.

NEW MEXICO.

The 5 springs credited to New Mexico all report for 1898. They are:

Coyote Canyon Springs, Coyote Canyon, Bernalillo County.
Harsch's Iron Springs, Coyote Canyon, Bernalillo County.
Hudson Hot Springs, Hudson, Grant County.
Macbeth Springs, East Las Vegas.
Ojo Caliente Spring, Ojo Caliente, Taos County.

NEW YORK.

New York's list now contains 47 springs, 6 being added for 1898. Of these, 41 report their sales. They are the following:

Avon Sulphur Spring, Avon, Livingston County.
A. D. Ayer Amherst Mineral Springs, near Williamsville, Erie County.
Binghamton Vichy Spring, Binghamton, Broome County.
Boonville Mineral Springs, Boonville, Oneida County.
Cayuga Water, Cayuga, Cayuga County.
Clyde Mineral Spring, Clyde, Wayne County.
Colonial Mineral Spring, West Deer Park, Suffolk County.
Crystal Rock Spring, Fairport, Monroe County.
Deep Rock Spring, Oswego, Oswego County.
Elixir Spring, Clintondale, Ulster County.
Franklin Lithia Springs, Franklin Springs, Oneida County.
Geneva Lithia Mineral Water Spring, Geneva, Ontario County.
Great Bear Spring, Fulton, Oswego County.
Gurn Spring, Gurnspring, Saratoga County.
Kirkland Springs, Franklin Iron Works, Oneida County.
Massena Springs, Massena, St. Lawrence County.
Mountain Mist Spring, West Hills, Suffolk County.
Saratoga County Artesian Lithia Spring, Ballston Spa, Saratoga County.
Saratoga Springs, Saratoga County:
- Champion Spring.
- Empire Spring.
- Excelsior Spring.
- Geyser Spring.
- Hathorn Spring.
- High Rock Spring.
- Lincoln Spring.
- Old Putnam Spring.
- Patterson Mineral Spring.
- Royal Spring.
- Saratoga Carlsbad Spring.
- Saratoga Kissingen or Arondack Spring.
- Saratoga Star Spring.
- Saratoga Vichy Spring.
- Saratoga Victoria Spring.
- Union Spring.

Table Rock Mineral Spring, Honeoye Falls, Monroe County.
The Vita Spring, Fort Edward, Washington County.
Verona Mineral Springs, Verona, Oneida County.
Victor Mineral Springs, Darien, Genesee County.
Wagner Mineral Spring, Palatine Bridge, Montgomery County.
White Sulphur Springs, Richfield Springs, Otsego County.
White Sulphur Spring, Sharon Springs, Schoharie County.

NORTH CAROLINA.

North Carolina shows no change from the previous year. The total for the State remains at 8; and of these, 6 report sales for 1898. They are:

Ashley Bromide and Arsenic Spring, Ashe County.
Barium Rock Spring, Barium Springs, Iredell County.
Lemon Springs, Lemon Springs, Moore County.
Park's Springs, Caswell County, near Danville, Va.
Panacea Springs, Warren County.
Thompson's Bromine Arsenic Springs, Crumpler, Ashe County.

OHIO.

One spring taken from Ohio's list and 1 added leaves the total at 14, and of these the following 11 report sales for 1898:

Concord Crystal Spring, Concord, Lake County.
Crum Mineral Springs, Austintown, Mahoning County.
Crystal Rock Spring, Erie County.
Devonian Mineral Spring, Lorain, Lorain County.
Magnetic and Saline Spring, Marysville, Union County.
Puritas Mineral Springs, Rockport, Cuyahoga County.
Purtlebaugh Mineral Spring, Urbana, Champaign County.
Rex Mineral Spring, New Richmond, Clermont County.
Sulphur Lick Springs, Anderson, Ross County.
Talewanda Mineral Springs, near College Corner, Preble County.
Fargo Mineral Springs, Ashtabula, Ashtabula County.

OREGON.

The 3 springs credited to Oregon all report for 1898. They are the following:

Lehman Springs, Camas Creek, Umatilla County.
Siskiyou or Wagner's Mineral Spring, Soda Springs, Jackson County.
Wilhoit Springs, Wilhoit, Clackamas County.

PENNSYLVANIA.

The list for Pennsylvania is increased by 2 springs, making the total 28, as 1 spring has been dropped. Of these, 20 report for 1898. They are the following:

Black Barren Mineral Spring, Pleasant Grove, Lancaster County.
Bedford Springs, Bedford, Bedford County.
Buena Vista Springs, Franklin County.
Charmian Springs, Charmian, Franklin County.
Cloverdale Lithia Springs, Newville, Cumberland County.
Cresson Springs, Cresson, Cambria County.
East Mountain Lithia Well, near Factoryville, Wyoming County.
Great Indian Spring, Glen Summit, Luzerne County.
Glen Summit Spring, Glen Summit, Luzerne County.
Magnesia Springs, Cambridge Springs, Crawford County.
Pavilion Spring, Wernersville, Berks County.
Petticord Mineral Springs, Cambridge Springs, Crawford County.

Ponce de Leon Spring, Meadville, Crawford County.
Pulaski Natural Mineral Springs, Pulaski, Lawrence County.
Rennyson Tredyffrin Springs, Rennyson, Chester County.
Rosscommon Springs, Windgap, Monroe County.
Saegertown Mineral Spring, Crawford County.
Sizer Mineral Springs, Sizerville, Cameron County.
Springboro Mineral Springs, Springboro, Crawford County.
Tuckahoe Mineral Springs, Northumberland, Northumberland County.

RHODE ISLAND.

The 4 springs credited to Rhode Island report for 1898. They are the following:

Gladstone Spring, Narragansett Pier, Washington County.
Holda Spring, Lymansville, Providence County.
Holly Mineral Spring, Woonsocket, Providence County.
Ochee Mineral and Medicinal Springs, Johnston, Providence County.

SOUTH CAROLINA.

South Carolina gains 2 springs, making the total for the State 7. Of these, 5 report, as follows:

Aiken Artesian Well, Aiken, Aiken County.
Bellevue Mineral Spring, Columbia, Richland County.
Chick Springs, near Taylor Station, Greenville County.
Harris Lithia Spring, Waterloo, Laurens County.
Rives Mineral Spring, Lancaster, Lancaster County.

SOUTH DAKOTA.

South Dakota gains 1 locality, making the total 2, both being represented in the reports for 1898. They are as follows:

Hot Springs of South Dakota, Hot Springs, Fall River County:
  Kidney Spring.
  Lakotah Springs.
  Minnekahta Spring.
Minnehaha Springs, Sioux Falls, Minnehaha County.

TENNESSEE.

Of the 6 springs on the list for Tennessee the following 4 report sales for 1898:

Idaho Springs, St. Bethlehem, Montgomery County.
Red Boiling Springs, Red Boiling Springs, Macon County.
Rhea Springs, Rhea Springs, Rhea County.
Tate Epsom Springs, Tate Spring, Grainger County.

TEXAS.

Of the 15 springs credited to Texas the following 12 report:

Capp's Mineral Wells, Longview, Gregg County.
Dalby Springs, Dalby Springs, Bowie County.
Elkhart Mineral Wells, Elkhart, Anderson County.
Farrier Springs, Dalby Springs, Bowie County.

Georgetown Mineral Well, Georgetown, Williamson County.
High Island Mineral Spring, near Galveston.
Hynson Iron Mountain Springs, Marshall, Harrison County.
Mineral Wells, Mineral Wells, Palo Pinto County.
Overall Mineral Wells, Franklin, Robertson County.
Sour Mineral Springs, near Luling, Caldwell County.
Tioga Mineral Wells, Grayson County.
Wootan Wells, Wootan Wells, Robertson County.

UTAH.

Utah shows no change from the previous year. Of the 3 springs on the list the following 2 report for 1898:

Deseret Lithia Springs, Deseret, Millard County.
Wasatka Springs, Salt Lake City, Salt Lake County.

VERMONT.

Of Vermont's 7 springs 5 report for 1898. They are the following:

Clarendon Springs, Clarendon Springs, Rutland County.
Crystal Spring, Barnet, Caledonia County.
Equinox Spring, Manchester, Bennington County.
Missisquoi Mineral Springs, Sheldon, Franklin County.
Old Sweet Lithia Spring, Hinesburg, Chittenden County.
Vermont Mineral Spring, Brookline, Windham County.

VIRGINIA.

One spring is dropped from Virginia's list and 3 are added to it. The total for the State is now 43. Of these 37 report, as follows:

Ætna Lithia Springs, Roanoke, Roanoke County.
Beaufont Lithia Springs, Beaufont, Chesterfield County.
Blue Ridge Springs, Botetourt County.
Buffalo Lithia Springs, Buffalo Lithia Springs, Mecklenburg County.
Chase City Mineral Springs, Chase City, Mecklenburg County.
Colonial Spring, near Claybank Wharf, Gloucester County.
Como Lithia Spring, Henrico County.
Crockett Arsenic Lithia Spring, Shawsville, Montgomery County.
Farmville Lithia Springs, Cumberland County, near Farmville, Prince Edward County.
Fonticello Lithia Spring, near Richmond, Chesterfield County.
Harris Anti-Dyspeptic and Tonic Spring, Burkeville, Nottoway County.
Healing Springs, Healing Springs, Bath County.
Hunter's Pulaski Alum Springs, Sassin, Pulaski County.
Iron Lithia Springs, Tiptop, Tazewell County.
Jefferson Park Springs, near Charlottesville, Albemarle County.
Jordan White Sulphur Spring, Stephenson, Frederick County.
Magee's Chlorinated Lithia Springs, Clarksville, Mecklenburg County.
Massanetta Springs, Harrisonburg, Rockingham County.
Nye Lithia Springs, Wytheville, Wythe County.
Old Dominion Lithia Springs, Clarksville, Mecklenburg County.
Otterburn Lithia and Magnesia Springs, Amelia, Amelia County.
Powhatan Lithia and Alum Springs, Tobaccoville, Powhatan County.
Rawley Springs, near Harrisonburg, Rockingham County.
Roanoke Red Sulphur Springs, near Salem, Roanoke County.

Rockbridge Alum Springs, Alum Springs, Rockbridge County.
Rockingham Virginia Springs, McGaheysville Station, Rockingham County.
Rubino Natural Lithia Spring, Healing Springs, Bath County.
Seawright Magnesia Lithia Spring, Staunton, Augusta County.
Seven Springs, near Glade Spring, Washington County.
Shenandoah Alum Springs, Shenandoah County.
Stribling Springs, Stribling Springs, Augusta County.
Swineford's Arsenic Lithia Springs, Chesterfield County.
Taskinas Springs, Toano, James City County.
Virginia Magnesian Alkaline Springs, near Staunton, Augusta County.
Virginia Waukesha Lithia Springs, Staunton, Augusta County.
Wallawhatoola Alum Springs, near Millboro Spring, Bath County.
Wolf Trap Lithia Springs, Wolf Trap, Halifax County.

WASHINGTON.

Only 2 of the 3 springs credited to the State of Washington report their sales for 1898. They are the following:

Cascade Springs, near Cascades, Skamania County.
Medical Lake, Medical Lake, Spokane County.

WEST VIRGINIA.

The total number of springs on the list of 1898 for West Virginia is 8, having been increased by 1 spring. Of these 7 report, as follows:

Greenbrier Alum Springs, near Lewisburg, Greenbrier County.
Greenbrier White Sulphur Springs, White Sulphur Station, Greenbrier County.
Irondale Spring, Independence, Preston County.
Red Sulphur Springs, Red Sulphur Springs, Monroe County.
Salt Sulphur Springs, Salt Sulphur Springs, Monroe County.
Triplet Well, Calf Creek, Grant District, Pleasants County.
Webster Springs, Addison, Webster County.

WISCONSIN.

Wisconsin gains 3 springs new to the list of 1897, making the total 35 for 1898. Of these the following 27 report their sales:

Aurelian Spring, Palmyra Springs, Jefferson County.
Bethania Mineral Spring, Osceola, Polk County.
Chippewa Spring, Chippewa Falls, Chippewa County.
Castalia Springs, Wauwatosa, Milwaukee County.
Darlington Mineral Springs, Darlington, Lafayette County.
Fort Crawford Springs, Prairie du Chien, Crawford County.
Lebens Wasser Spring, Green Bay, Brown County.
Nee-Ska-Ra Mineral Spring, Wauwatosa, Milwaukee County.
Rainbow Mineral Spring, Wautoma, Waushara County.
Shealtiel Mineral Spring, Farmington, Waupaca County.
Sheboygan Mineral Spring, Sheboygan, Sheboygan County.
Silver Sand Spring, Milwaukee, Milwaukee County.
Solon Springs, Upper St. Croix Lake, Douglas County.
Sparkling Spring, Wauwatosa, Milwaukee County.
St. John Mineral Spring, Green Bay, Brown County.

Waukesha Springs, Waukesha County:
- Almanaris Springs.
- Arcadian Spring.
- Bethesda Mineral Spring.
- Elim Spring.
- Horeb Spring.
- Minniska Mineral Spring.
- Plymouth Rock Spring.
- Siloam Spring.
- Silurian Mineral Spring.
- Sotarian Spring.
- Waukesha Lithia Spring.
- White Rock Mineral Spring.

Summary of reports of mineral springs for 1898.

State or Territory.	Springs reporting.	Springs not reporting.	Total used commercially.
NORTH ATLANTIC STATES.			
Maine	14	5	19
New Hampshire	3	0	3
Vermont	5	2	7
Massachusetts	30	3	33
Rhode Island	4	0	4
Connecticut	10	3	13
New York	41	6	47
New Jersey	4	0	4
Pennsylvania	20	8	28
SOUTH ATLANTIC STATES.			
Delaware	0	0	0
Maryland	7	2	9
District of Columbia	1	0	1
Virginia	37	6	43
West Virginia	7	1	8
North Carolina	6	2	8
South Carolina	4	1	5
Georgia	6	2	8
Florida	2	0	2
SOUTH CENTRAL STATES.			
Kentucky	4	1	5
Tennessee	4	2	6
Alabama	4	0	4
Mississippi	4	1	5
Louisiana	1	0	1
Texas	12	3	15
Indian Territory	0	0	0
Arkansas	6	1	7
Oklahoma	0	0	0

Summary of reports of mineral springs for 1898—Continued.

State or Territory.	Springs reporting.	Springs not reporting.	Total used commercially.
NORTH CENTRAL STATES.			
Ohio	11	3	14
Indiana	11	2	13
Illinois	17	2	19
Michigan	17	2	19
Wisconsin	27	8	35
Minnesota	4	1	5
Iowa	3	2	5
Missouri	10	1	11
North Dakota	0	0	0
South Dakota	2	0	2
Nebraska	1	0	1
Kansas	4	2	6
WESTERN STATES AND TERRITORIES.			
Alaska	0	0	0
Wyoming	0	0	0
Montana	1	1	2
Colorado	12	0	12
New Mexico	5	0	5
Arizona	0	0	0
Utah	2	1	3
Nevada	0	0	0
Idaho	1	0	1
Washington	2	1	3
Oregon	3	0	3
California	36	2	38
Total	406	78	484

IMPORTS AND EXPORTS.

Prior to 1884 the Treasury Department did not distinguish natural mineral waters from those that were artificial; since 1883 the distinction has been made, but the artificial waters have not been classified according to the receptacles in which they have been imported. The importation is shown in the two tables following, with a table of exports appended.

Mineral waters imported and entered for consumption in the United States, 1867 to 1883, inclusive.

Fiscal year ending June 30—	In bottles of 1 quart or less.		In bottles in excess of 1 quart.	
	Quantity.	Value.	Quantity.	Value.
	Bottles.		*Quarts.*	
1867	370,610	$24,913	3,792	$360
1868	241,702	18,438	22,819	2,052
1869	344,691	25,635	9,739	802
1870	433,212	30,680	18,025	1,743
1871	470,947	34,604	2,320	174
1872	892,913	67,951		
1873	35,508	2,326		
1874	7,238	691		
1875	4,174	471		
1876	25,758	1,899		
1877	12,965	1,328		
1878	8,229	815		
1879	28,440	2,352		
1880	207,554	19,731		
1881	150,326	11,850		
1882	152,277	17,010		
1883	88,497	7,054		

Fiscal year ending June 30—	Not in bottles.		All not artificial.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Gallons.		*Gallons.*		
1867		$137			$25,410
1868	554	104			20,594
1869	1,042	245			26,682
1870	2,063	508			32,931
1871	1,336	141			34,919
1872	639	116			68,067
1873	355	75	394,423	$98,151	100,552
1874	95	16	199,035	79,789	80,496
1875	5	2	395,956	101,640	102,113
1876			447,646	134,889	136,788
1877		22	520,751	167,458	168,808
1878			883,674	350,912	351,727
1879	3	4	798,107	282,153	284,509
1880			927,759	285,798	305,529
1881	55	26	1,225,462	383,616	395,492
1882			1,542,905	410,105	427,115
1883			1,714,085	441,439	448,493

Imports for years 1884 to 1898.

Year ending—	Artificial mineral waters.		Natural mineral waters.	
	Quantity.	Value.	Quantity.	Value.
June 30—	*Gallons.*		*Gallons.*	
1884	29, 366	$4, 591	1, 505, 298	$362, 651
1885	7, 972	2, 157	1, 660, 072	397, 875
Dec. 31—				
1886	62, 464	16, 815	1, 618, 960	354, 242
1887	13, 885	4, 851	1, 915, 511	385, 906
1888	12, 752	4, 411	1, 716, 461	341, 695
1889	36, 494	8, 771	1, 558, 968	368, 661
1890	22, 328	7, 133	2, 322, 008	433, 281
1891	26, 700	8, 700	2, 019, 833	392, 894
1892	16, 052	9, 089	2, 266, 123	497, 660
1893	6, 086	2, 992	2, 321, 081	506, 866
1894	7, 753	3, 047	1, 891, 964	417, 500
1895	101, 115	19, 151	2, 104, 811	506, 384
1896	51, 108	11, 739	2, 273, 393	551, 097
1897	....	....	*a* 2, 942, 200	*a* 501, 684
1898	....	....	*a* 1, 955, 723	*a* 526, 071

a Including artificial.

Exports of natural mineral waters of domestic production from the United States.

Fiscal year ending June 30—	Value.	Fiscal year ending June 30—	Value.
1875	$162	1881	$1, 029
1876	80	1882	421
1879	1, 529	1883	*a* 459
1880	1, 486		

a None reported since 1883.

MINERAL RESOURCES OF PORTO RICO.

By Robert T. Hill.

INTRODUCTION.

The island of Porto Rico consists of three geologic elements: (1) a central system of deeply ribbed and corrugated mountains, with V-shaped gorges and ridges; (2) lower hills, forming irregular bands along the north and south coast; (3) playa plains, consisting of alluvial soil, occupying old reclaimed estuaries, which extend from the foot of the central mountains across the line of foothills to the seashore.

It is roughly estimated that nine-tenths of the island is of the mountainous character and that the remaining tenth is of the foothill and playa character. The central mountains are composed of water-sorted volcanic ejecta—tuffs and conglomerates—with occasional dikes and masses of interbedded subcrystalline bluish limestone of rare or exceptional occurrence, all of which is entirely decayed at the surface, breaking down into a red clay resembling that of the southern Appalachians. The dikes are of hard, black igneous rock, with small white porphyritic crystals. In the east the substructure is said to be granites and especially syenites. In Naguabo and in Mayaguez some serpentine rocks have been observed.

The foothills are composed exclusively of rocks of sea origin, consisting of the peculiar type of tropical white limestones, of a loose-textured, chalky, marly, and shelly nature, of various degrees of induration. The rocks of the central mountain region are of Cretaceous and possibly early Eocene age; at least no evidence tending to establish other dates for their formation has been as yet discovered. The white limestones of the coastal hills are all of later Tertiary and Pleistocene age.

The playa deposits are alluvial formations, consisting usually of a rich, chocolate-colored, sandy loam.

CLAYS.

Material for construction of every kind exists upon the island and is utilized with great skill by the inhabitants. Brick and tile clays, building stone, lime, sand, cement, gypsum, and paving blocks occur. The natives, like all people of Spanish descent, are expert in masonry construction, and especially that kind which includes the manipulation of mortar, cement, and rubble. The excellence and durability of the works of this character upon the island were everywhere noted. The cement and mortar work of old fortresses constructed two hundred years ago shows remarkable durability, and in some of the cities the mortar seams of the brick-laid pavements stand up in sharp ridges between the bricks, which have been worn thin.

Porto Rico abounds in clay suitable for the making of ordinary building brick and ordinary jug ware. This material is of two general classes: First, the residual clays of the interior mountains, resulting from the breaking down of the volcanic rocks. This is a stiff, red clay, resembling very much the red clays of the southern Appalachians. No white clays were anywhere observed, and after careful inquiry I am inclined to believe that they do not exist. This opinion is substantiated by the fact that the rocks are very free from the pure feldspars from which such clays are derived.

The second class of clays are the redeposits found in the alluvial playas. The latter are the kinds usually employed by the local brick yards, which everywhere abound. The bricks manufactured are longer, wider, and thinner than those used in this country, and are usually rather friable and sandy. The quality could no doubt be improved by more careful selection, manipulation, and firing. These bricks are used for construction and for sidewalks. Houses built of them are always superficially stuccoed. One or two notable exceptions to this rule were observed, such as the immense cavalry cuartel or barracks at Cayey, which is a very substantial brick building, void of outer protection. In Mayaguez the sidewalks are constructed of bricks laid upon the flat side. They seem to be fairly durable. The streets of San Juan are superbly paved with brick, but these are composed of vitrified slag and were manufactured in England. Formerly all the houses were roofed with heavy red tile, but of late years the corrugated iron roofs have been imported so cheaply that the tile industry has practically ceased.

Only a few potteries were observed upon the island, notably at Ponce. The ware manufactured is of the crudest kind, being a rough, red, unglazed jug ware. The quality of the output could be immensely improved by a little washing and more careful manipulation.

SAND.

Good building sand is found in nearly all the rivers, but none of sufficient purity for glass-making purposes.

STONE.

Lime of excellent character is produced from all the white limestones of the coastal formations. The blue and gray crystalline limestones of the mountainous region are also well adapted for lime making, but are not utilized.

Many of the impure limestones present every indication of a natural cement rock, but inasmuch as fuel is scarcé and very expensive, it is doubtful if these can be utilized profitably.

The building stone of the island is of several kinds: Volcanic bowlders, lumps of porous white limestone, massive quarry limestone, and limestone flags. The chief material used, it may appear strange to say, is of the first two classes mentioned, native masons excelling in the art of constructing walls of this lumpy material, binding it solidly together with cement. The houses constructed of the volcanic bowlders are usually neatly pointed with mortar and present a picturesque and rubbled appearance. Those constructed of the softer white limestone lumps are always stuccoed. The most elaborate and satisfactory houses of the tropics are made with the latter material, resulting in thick and light walls well adapted to the climate. Of this character are nearly all the public buildings of Cuba and Porto Rico, including great fortresses, such as those at San Juan and Santiago de Cuba, upon which the shells of our navy seem to have had but little effect, no doubt owing to the sponge-like texture of the rock, which prevented shattering beyond a short radius from the point of contact—at least such shattering as would occur in material of denser nature.

Massive limestones abound along the southern slope of the central mountain range from Guayama westward to Cabo Rojo. These are of several classes. The principal kind is a gray or drab limestone of the color of commercial lithographic stone, but of intense hardness. When sawn into paving tiles this would be of great durability, and it would serve for use in all structures requiring strength. This limestone is practically a marble, being highly crystalline and of a dense and compact texture.

Near Juana Diaz there is a belt of beautiful marble of great hardness, which is quarried into large blocks. It is variegated in color, consisting of a reddish matrix mottled with numerous small white spots. At present the material is used only for structural purposes, such as piers for bridges, etc. Its ornamental properties have not been developed.

Sandstone is comparatively rare, although in the western portion of the island fairly good grindstones are made out of some of the native rocks.

A very fine flagstone is abundant on the island. It is used in San Juan for sidewalks and floor tiles, for the lining of reservoirs, and for other structural purposes. This is a very hard, black, fissile limestone, which is found in great quantities near the summit of the central range between Cayey and Aibonito, occurring in alternating layers with the volcanic tuffs. It is an excellent stone for general use. Stone material for dams, riprap, and road metal are found everywhere, convenient for local use. On the north side of the island a white coral limestone occurs in the coastal formation. This is thoroughly crystalline in places, and breaks into a firm, hard road metal. The igneous rocks of the central mountain ranges and the older limestones are also extensively used for such purposes. Inasmuch as the development of the highways of Porto Rico is a necessity which needs to be met immediately, it is gratifying to note the abundance of suitable road metal throughout the island.

Granite, of a syenitic character, is said to be quarried near Fajardo and at other places on the eastern end of the island. I saw no true granite on the island.

GYPSUM.

Gypsum occurs rather abundantly in a formation consisting of yellowish marl, which is extensively developed along the southern side of the central mountains, just north of the village of Juana Diaz. It is also reported at other localities, notably near Ponce. The deposits seen by the writer are of an impure character, being largely mixed with sand and clay, but are sufficiently valuable to be of service for the manufacture of a low grade of plaster, such as is extensively used in the country for stucco and for fertilizers. This material is extensively used for plaster in the city of Ponce, and is considered a most valuable resource by the inhabitants.

Chalk, clay, and silica for artificial cements also abound in the coastal formations.

SOILS.

The soils of the central mountain region, which, as has been noted, constitutes nine-tenths of the island, are mostly ferruginous clays, and are of such character that, while naturally forming a good matrix for retaining fertilizers, they are subject to loss of lime, phosphate, potash, etc. The cultivation of the two standard crops, coffee and tobacco, is very exhaustive of these chemical elements, and there is great need of fertilizing material. The remainder of the island is alluvial or calcareous.

FERTILIZERS.

In my travels upon the island I was struck by the occurrence in close proximity to this mountain region of great beds of greensand, gypsiferous marl, shell marl, chalk marls, and lime phosphates, of a nature apparently specially adapted for the revivification of the exhausted mountain lands. Greensand marls occur in great abundance on the road from Lares to San Sebastian, immediately adjacent to a rich and most productive coffee region, in which many abandoned acres of "ruinate"—as exhausted lands are called in the tropics—are already observable.

Lime marls abound everywhere around the coast. The gypsum marls occur near Juana Diaz, adjacent to the Rio Portugues, and near Ponce. Inasmuch as the future of this beautiful island depends entirely upon its scientific agricultural development, in my opinion these natural fertilizers, when appreciated, will constitute one of the most valuable sources of wealth. Agricultural methods have heretofore been somewhat primitive, and the products have been largely plantation crops. Within less than ten years the whole island will be devoted to growing oranges, bananas, and other export fruits for the American market, and higher and more scientific methods of agriculture will be initiated, and I venture to predict that the amelioration and improvement of the soils will be one of the first results of the island's renaissance.

A large area of the southern coast consists of rocks similar to those of Sombrero, Navassa, and other islands which abound in phosphates.

So far as I am aware, the industry has been developed only upon Mona Island, lying off the west end of Porto Rico. There is reason to believe that much of this material may be found in the rocks along the southern coast of the main island. In the vicinity of Ponce and elsewhere there are numerous caves filled with rich deposits of guano, which are now being worked and prepared for shipment to the United States.

FUELS.

It is said that near Moca there is a deposit of lignite well worthy of development. Amber has also been found in these beds.

In the western part of the island, near San Sebastian, there is an extensive formation of bituminous clay, which contains a very fair quality of lignite, although the quantity has not as yet been determined. Two specimens of this are before me, one of which is a firm, hard, fibrous lignite containing considerable pyrites, and the other, from Guatemala village, is a firm lignite of dull, glassy luster and free from impurities. The second has every aspect of a good cannel coal. The field in which this material occurs is worthy of thorough prospecting and study.

SALT.

There are many lagoons around the island, from which considerable salt is obtained by natural evaporation of the brine. The principal deposits are the salines of Coama, Guanica, and Sierra de Piñones de Cabo Rojo. The last named have made their owners wealthy. Sufficient salt for the necessities of the island can easily be obtained from these deposits.

MINERAL WATERS.

There are several thermal mineral springs upon the island, notably the Quintana at Ponce and the springs of Coamo. At these places bath houses are established and they are resorted to by invalids from all parts of the island. The waters are sulphurous and ferruginous, and are said to be of great curative value for skin diseases and rheumatic troubles.

The Licentiate Jimenez obtained in 1,000 parts of water the following components:

Analysis of mineral water from Coamo, Porto Rico.

Carbonic acid .... parts in 1,000..	21.37
Hydrosulphuric acid .... do....	23.47
Hydrochloric acid .... grams per gallon..	0.5444
Carbonate of lime .... do....	0.2514
Carbonate of magnesia.................. do....	13.72
Sulphate of lime......................... do....	0.2637
Sulphate of magnesia .... do....	0.540
Sulphate of iron .... do....	3.7
Silica.................................. do....	0.708

The temperature of this water is about 42° C., and the average temperature of the air 27.3° C.

The following analysis of the mineral water of Coamo was made by Mr. J. J. Heller in 1847:

Analysis of mineral water from Coamo, Porto Rico.

Carbonic acid.................parts in 1,000..	18.05
Hydrosulphuric acid....................do....	28.54
Carbonate of lime ....grams per gallon..	0.1304
Hydrochloric acid ....do....	0.544
Carbonate of magnesia..................do....	13.000
Sulphate of lime.........................do....	0.2637
Sulphate of iron ....do....	2.9697
Sulphate of magnesia ....do....	0.544
Silica.......................................do....	0.705
Magnesia ....do....	Trace.

METALS.

The metallic minerals most frequently found, and which form the object of much search, are gold, carbonate and sulphide of copper, and magnetic oxide of iron. Traces of lead and indications of mercury, manganese, and bismuth have also been noted.

Gold.—Almost since the date of the discovery of the island gold has been washed in small quantities from many of its rivers, especially those of the north and east end, notably the Luquillo and Loiza. Gold also occurs in the streams near Corozal, a village on the north-central side of the island. It has never been found in great quantities, fifty cents to a dollar a day representing the average product of a hard day's labor. The gold is obtained by the natives from the river sand and gravel. The mother rock of this metal has never been determined. Lately a great many American prospectors have been seeking for quartz veins toward the heads of the streams. It is my opinion, however, that such will not be found, as there are no evidences of their existence upon the island, at least no visible quartz veins could be detected by me anywhere, although there may be small stringer veins. It is more probable that the vein material of the gold in the mother rocks is pyrite, as this is quite frequently encountered along the contacts.

While it is impossible to reach any positive conclusion as to the quantity or value of the gold of the island, experience has shown that the placer deposits are not rich or extensive. The question of its occurrence in the mother rocks is a problem which will require careful and patient exploration by scientific methods. The prospector from the United States will find that the matrix is entirely different from that with which he has been familiar, the general geologic conditions resembling those of Colombia and Panama more than those of the North American gold fields.

Copper.—Copper pyrite and the stains of carbonate of copper are frequently met with in the central mountain region, but nowhere in quantity sufficient to justify expectations of extensive occurrence. One deposit of impure malachite, upon which the owners placed great hopes, was developed, but a single small shipment of ore exhausted the deposit.

Zinc.—Zinc sulphide (?) crystals have been found in small quantities near Malapascua, and tin has been reported, but its occurrence could not be proved.

Iron.—Nine-tenths of the rocks of the island are of a basic nature, containing a large proportion of iron. Inasmuch as these are and have long been undergoing oxidation and alteration, the conditions are theoretically favorable for the occurrence of valuable iron deposits, and in one or two instances these undoubtedly exist, notably north of Juncos. At this place there is a large deposit of magnetic iron ore of great purity, containing 66 per cent of iron and less than 0.023 of phosphorus. A French engineer has calculated that there are at least 35,000,000 tons of this ore in sight. At present it is many miles from a seaport, and its development will necessitate the construction of a railway. In my opinion this deposit is the most valuable metallic resource of the island at present in sight, and American capital will develop it as soon as allowed to do so legally. It is said that the conditions of this deposit could not be more favorable. The ore is encountered in compact masses, easy of extraction, and covered only by a light layer of earth. It constitutes a small hill, about 150 meters high, at the opening of a plain, which leads to a port by a 2 per cent grade. The construction of a railway 15 kilometers long could be done quickly and with little cost. The shipping port, Naguabo, is said to admit ships of 20 feet draft. It has been estimated that this deposit contains 10,000,000 tons of metallic iron, but I am not in a position to verify this estimate.

The following is an analysis made for Messrs. Patterson and Strad, of Middleborough, England:

Analysis of Juncos, Porto Rico, iron ore, dried at 212° F.

Constituent.	Per cent.
Peroxide of iron	72.500
Protoxide of iron	19.671
Protoxide of magnesia [manganese?]	0.232
Alumina	Trace.
Lime	0.271
Magnesia	0.170
Silica	5.300
Sulphur	0.008
Phosphoric acid	0.056
Arsenic	0.000
Carbonic acid	Trace.
Water	1.790
Total	99.998
Total metallic iron	65.05

Magnetic sands, like those so abundant in the adjacent island of Martinique, occur in many of the stream beds, notably those in the western part of the island. These are worthy of further investigation. In the course of my reconnaissance I noticed many ferruginous deposits, but none of them seemed of sufficient importance to warrant development. However, all were of such nature as to indicate that the possibilities are worthy of careful study.

Pyrite.—Pyrite is frequently encountered in the igneous rocks of the central mountains. Many specimens were brought to me, but no great quantity has as yet been discovered.

CONCLUSION.

In conclusion, a few remarks concerning the striking difference, in occurrence and appearance, of the economic resources of Porto Rico from those of the United States, and of the North American continent in general, may be of interest. The geologic type of the island is Antillean in its aspects, and the sequence, arrangement, and composition of the rocks are entirely different from those of the rocks with which we are familiar in our country. The matrix and country rock of the metallic minerals are not of the quartziferous type familiar to prospectors in the United States, but are made up entirely of basic igneous rocks, such as tuffs and volcanic conglomerates, of the kind known in Central America and Colombia as "caleche," while the dike and vein material is largely of hornblendic andesite-porphyry. Furthermore, the bituminous material, instead of occurring in rocks of the Carboniferous period, as it largely does in the United States, is found entirely in strata of the Tertiary period. The ordinary prospector will find these conditions so foreign to those of the United States that he will be entirely lost in endeavoring to follow what are to him ordinary indications of mineral wealth.

Owing to this fact, it is necessary that the mineral resources of Porto Rico should receive thorough scientific study and exploitation. In my opinion such investigation may result in the discovery and development of many interesting resources which have escaped the observation of practical mining prospectors and my own eye in my brief reconnaissance. It is especially important that the sands and alluvial deposits of each of the 1,200 streams of the island should be carefully studied, for it is possible, if not probable, that they contain platinum and other rarer minerals. I am inclined to the latter opinion because of the resemblance of the formations, in a general way, to those of Colombia, in which these minerals occur. Furthermore, the contact phenomena are worthy of scientific investigation, and the phosphatic limestones of the coastal formations deserve systematic study.

INVESTIGATIONS OF SOME OF THE MINERAL RESOURCES OF PORTO RICO.

By H. B. C. Nitze.

INTRODUCTION.

The mineral resources of Porto Rico are practically entirely undeveloped. With the exception of some primitive alluvial gold washing by the natives and the abortive attempts to work certain phosphate deposits, no mining operations of any kind have ever been prosecuted. It may be said that the mineral resources of the island have not even been fairly explored.

Passing over the many causes of this lack of development in the past, it may be pointed out that one serious factor among them still remains, and that is the limited means of transportation. The total length of the railroad lines is about 135 miles; these are disconnected, and being confined to the coast are of little value for the development of the interior of the island. There are about 170 miles of graded macadamized roads. Outside of these the only means of travel and transportation are horse trails, and during the wet season these are well-nigh impassable.

The harbor facilities of Porto Rico are extremely poor. With few exceptions the coast is a shallow, sandy beach, affording few opportunities for close anchorage and little shelter from storms. The exceptions are at Guanica and Jobos, on the south coast; Fajardo, Ensenada-Honda, and Naguabo, on the east coast, and San Juan on the north coast. The latter is the only port that has dock facilities, and these are very limited.

Timber for mine and fuel purposes is very scarce. There are few large forest tracts, and the majority of the woods are too valuable for the above purposes, being of the hard-wood varieties.

Charcoal, in small quantities, is worth 37 to 75 cents per 100 pounds. Coal is imported at a cost of $6 to $8 per ton delivered; the present import duty being 20 cents per 1,000 kilograms.

There are abundant water powers on the island, though entirely undeveloped as yet.

Native labor is plentiful. Ordinary farm or road labor is paid 30 cents a day of ten hours. Fair mining labor will cost 40 to 50 cents a day.

The mining laws are favorable to the mine owner. All mineral deposits are originally the property of the Government, and are acquired by private owners by concession. In order to take up a mining claim the following steps are necessary: A petition must be filed in the bureau of the insular secretary of the interior, containing a general description of the claim, the proper name by which known, the location (specifying the barrio and jurisdiction), the approximate bearings and measurements of the boundary lines, the approximate area in hectares, the name or names of the surface land owners, and the character of the mineral. This petition is advertised for sixty days in the Official Gazette, at the expiration of which time the claim is granted, provided there has been no valid protest from others claiming prior rights. At the time that the above petition is filed a deposit of 5 pesos must be made for every hectare up to 12, and 2 pesos for every hectare in excess, this money being the fee of the Government engineer who is detailed to make an accurate survey and plat after the claim is granted. In case the claim be not granted, the amount of the deposit is refunded. At the time that the claim is granted an additional fee must be paid for the title of concession. This, in the case of the more valuable minerals, such as gold, silver, lead, nickel, copper, etc., amounts to 1 peso per hectare, and in the case of such minerals as iron ore, coal, etc., to 6 pesos for the first 15 hectares, and 50 centavos for every hectare in excess.

The land owner is compelled to sell the necessary surface for mining purposes, the value of which may be appraised by a court.

The size of a mining claim is a square of 100 meters, called a "pertenencia," equal to 1 hectare. There is no limit to the number of claims which may be granted to any one person, but it can not be less than four.

According to the records of the bureau of public works in San Juan, the following mining claims were granted from August, 1894, to May, 1899:

Date.	Name of mine.	To whom granted.	Mineral.	Area in hectares.	Location.
Aug. 7, 1894	El Trabajo	Joaquin de Alarcon	Phosphate of lime		Barrio of Arenales-bajo; municipal of Isabella.
Aug. 18, 1894	La Confianza	Miguel Arzuaga	do		Municipal of Manati; mado of las Boquellas.
Feb. 6, 1896	La Esperanza	Pedro Santisteban y Chiavarri.	Iron	96	Barrio of Ceiba Norte; jurisdiction of Juncos.
Sept., 1896	Joachin y San Jose	Jose Sanchez y Valdes	Phosphate of lime		Municipal of Ponce.
Oct., 1898	Buena Suerte	Periandro Serram and Jose A. Menendez.	Bituminous clay		Barrio of Cidral; municipal of San Sebastian.
Do	Santa Teresa	M. Argueso and L. Miner	Copper, etc	64	Barrio of Rio Blanco; jurisdiction of Naguabo.
Do	Eruestita	do	Gold and nickel	100	Do.
Do	Sta. Amalia	do	Copper, etc	100	Do.
Nov., 1898	Reina del Cobre	Jas. A. Pearce	Copper		Barrio of Dos Bocas; jurisdiction of Bayamon.
Do	Momernate	Pedro Santisteban y Chiavarri.	Salt		Jurisdiction of Salinas.
Do	Union	J. R. Latimer y Fernandez	Gold		Barrio of Mameyes; jurisdiction of Rio Grande.
Dec., 1898	Brijida	do	Silver, etc		Barrio of Gurmengribe; jurisdiction of Rio Grande.
Dec. 12, 1898	Eloisa	Pedro Santisteban y Chiavarri.	Iron	25	Barrio of Collores; jurisdiction of Las Piedras.

Date.	Name of mine.	To whom granted.	Mineral.	Area in hectares.	Location.
Dec., 1898	Labina	Pedro Santisteban y Chiavarri.	Iron and silver	120	Barrio of Duque; jurisdiction of Naguabo.
Do	Maria	M. Argueso and L. Miner	Iron, etc		Barrio of Mariana; jurisdiction of Humacao.
Do	America	do	Silver, etc		Barrio of Mameyes; jurisdictions of Fajardo and Rio Grande.
Do	Borinquen	do	Copper, etc	12	Barrio of Mabu; jurisdiction of Humacao.
Do	Washington	Antony F. Dignowitz	Gold and silver		Barrio of Dos Bocas; municipal of Corozal.
Do	Puerto Rico	Daniel Hogan	Silver, platinum, etc		Do.
Jan., 1899	Santa Agueda	Pedro Santisteban y Chiavarri.	Copper, silver, etc		Barrio of Lajas-arriba.
Do	La Fe	do	Iron		Barrio of Ceiba; jurisdiction of Juncos.
Do	Sta. Olalla	M. Argueso and L. Miner	Iron, etc	12	Barrio of La Barbera; jurisdiction of Humacao.
Do	Purificacion	do	do	12	Barrios of La Barbera and Buenavista; jurisdiction of Humacao.
Do	Elena y Eugenia	Pedro Santisteban y Chiavarri.	Copper, etc	15	Barrio of Lajas-arriba; jurisdiction of Lajas.
Jan. 16, 1899	Capron	do	do	15	Do.
Jan. 20, 1899	La Esperanza	Daniel Hogan and A. Dignowitz.	Iron, silver, gold, copper, etc.	30	Barrio of Padilla; municipal of Corozal.
Jan. 23, 1899	Finita	M. Argueso and L. Miner	do	30	Barrio of Mabu; jurisdiction of Humacao.
Jan. 24, 1899	Maria	do	do	30	Barrio of Dos Bocas; municipal of Corozal.
Jan. 26, 1899	Panchita	Antonio Rotger	Iron, etc	4	Barrio of Collores; jurisdiction of Las Piedras.

Date.	Name of mine.	To whom granted.	Mineral.	Area in hectares.	Location.
Jan. 30, 1899	Valentina	Pedro Santisteban y Chiavarri.	Copper, etc	12	Barrio of Rio; jurisdiction of Las Piedras.
Feb. 7, 1899	Caranzana	do	Iron	20	Barrio of Collores; jurisdiction of Juncos.
Do	Caridad	do	do	21	Barrio of Mamey; jurisdiction of Gurabo.
Do	Polonia	do	do	40	Barrio of Boqueron; jurisdiction of Las Piedras.
Feb. 8, 1899	San Miguel	do	do	21	Barrio of Collores; jurisdiction of Las Piedras.
Feb. 13, 1899	San Anton	do	do	12	Barrio of Collores; jurisdiction of Humacao.
Apr. 1, 1899	Corcega	Arthur H. Noble	Copper	12	Barrio of Guilarte; jurisdiction of Adjuntas.
Apr. 20, 1899	Begonia	Pedro Santisteban y Chiavarri.	Iron	21	Barrio of Collores; jurisdiction of Las Piedras.
Do	Luisa	do	do	30	Do.
Do	Buen Suceso	do	do	71	Barrio of Mamey; jurisdiction of Gurabo.
Apr. 26, 1899	La Esperanza	Francisco Sato Amador	Graphite	50	Barrios of Capaez and Juan Gonzalez; jurisdiction of Adjuntas.
May 1, 1899	Providencia	Pedro Santisteban y Chiavarri.	Iron	50	Jurisdiction of Patillas.
May 3, 1899	Borinquen	Nicanor Fernandez Cuadra.	Silver, etc	12	Barrio of Rio; jurisdiction of Las Piedras.
May 8, 1899	San Pedro	Pedro Santisteban y Chiavarri.	Iron	39	Barrio of Boqueron; jurisdiction of Las Piedras.
Do	San Ramon	do	do	47	Do.

GOLD.

So far as known, the chief occurrence of gold is confined to the placer deposits of the northern drainage basins of the Luquillo and the Corozal Mountains. The former district is situated in the extreme northeastern part of the island, and comprises the rivers Loiza, Canóvanas, Herrera, Grande, Espiritu-Santo, Mameyes, Sabana, and their affluents. The Corozal district is situated in the northern central part of the island, and comprises the rivers Mabille, Corozal, Negros, Cibuco, and their affluents.

There are no reliable records regarding these deposits, and until they are intelligently prospected little can be said on the subject. Auriferous quartz veins appear to be very scarce on the island. The occurrence of iron pyrites in the igneous rocks, of which the mountains are largely composed, is very common, and I am inclined to believe that this mineral will be found to be the chief source of the gold.

LEAD.

Galena-bearing quartz veins have been found in the barrio of Carmen, a short distance north of the town of Guayama, in the southeastern part of the island. They have been prospected by shallow diggings, which are, however, caved in and inaccessible at present. It is doubtful whether these veins have any considerable thickness. The ores are said to be argentiferous. Similar ores are reported from the barrio of Guadiana, in the jurisdiction of Naranjito, about 15 miles southwest of San Juan.

COPPER.

The copper minerals appear to have a fairly wide distribution in the rocks of Porto Rico, and more attention has perhaps been paid to prospecting for copper than for any other mineral. It will, however, require much more extended exploratory work to determine whether there are deposits of value.

One of the most important localities is the Santa Amalia claim, situated on the south slope of the Luquillo Mountain range, at an elevation of 2,200 feet above the Naguabo Valley, in the barrio of Rio Blanco, jurisdiction of Naguabo, about 7½ miles northwest of the harbor of Naguabo. The ore body appears in a large and prominent outcrop of pyrrhotite, resting at an angle of 20° to 25° on a floor of white crystalline limestone.

This outcrop has been exposed by stripping for a distance of over 100 feet, and by a tunnel extending at right angles 40 feet into the hillside. The total thickness of the ore body is 5 to 10 feet. The lower portion (8 to 15 inches) is heavily mineralized with copper pyrites, grading insensibly into the more or less homogeneous pyrrhotite mass above, which is slightly copper bearing throughout. The lower chalcopyrite zone should average from 10 to 15 per cent metallic copper.

Several analyses, made by Ricketts and Banks, of New York, show:

Copper	per cent..	11.77	13.60
Gold	do....	0.21	1.45
Silver	do....	0.03	0.26

Active exploratory work is now in progress. The tunnel will be extended 200 feet, and the mine put in shape to produce, if the present promising prospects continue.

Several miles south of this place is the Santa Teresa copper claim, which was at one time worked in a very small way. It is now so inaccessible that it could not be examined.

Immediately to the west of the town of Humacao, in the barrio of Mabu, is a series of low hills composed of altered rhyolitic rocks, stained and impregnated with copper carbonates. The Borinquen and Finita claims are located here, but no development work has yet been done.

In the vicinity of Corozal, about 17 miles in a straight line southwest of San Juan, is situated the Reina del Cobre copper-mining claim, owned by the Porto Rico Mining and Development Company, of Boston. There are numerous signs here of former workings, said to have been abandoned about thirty years ago. The present company is sinking a shaft, which at the time of my visit was down 30 feet, and from the bottom of which about 50 feet of drifting had been done.

The country rock is a siliceous conglomerate tuff and a basic ferromagnesian rock, in which the copper minerals, carbonates, and oxides occur in thin irregular streaks and seams. Several tons of such material, which probably carries 10 to 15 per cent copper, had been taken from this prospect. The company proposes sinking to 100 feet, and then drifting in search of the supposed main ore body under the old workings.

The Esperanza and Maria copper claims are located in the same district.

Other copper claims have been located in the barrio of Guamani, jurisdiction of Guayama; in the barrio of Jayuya-arriba, jurisdiction of Jayuya; in the barrio of Guilarte, jurisdiction of Adjuntas; in the barrio of Lajas-arriba, jurisdiction of Lajas; in the barrio of Rio, jurisdiction of Las Piedras, etc.

IRON PYRITES.

The common occurrence of iron pyrites in the igneous granites, diorites, syenites, etc., of Porto Rico has been alluded to. In only one instance, however, was a notable deposit of this mineral observed. On the coffee plantation of Mr. Simon Pierluissi, about 4 miles southeast of Adjuntas, on the Ponce-Adjuntas road, a heavy gossan outcrop may be seen on the immediate banks of the Portuguese River. The width of this body of highly oxidized, coarse, granular pyrites appears to be from 5 to 10 feet. No development work has been done. According to Mr. Pierluissi assays have shown traces of gold, silver, and arsenic.

IRON.

The iron ores form the most important of the mineral resources of Porto Rico. Ores of excellent quality were seen in many parts of the island; but when quantity and quality both are to be considered, the only deposits of value, so far as present discoveries have shown, are situated in the jurisdictions of Gurabo, Juncos, Las Piedras, and Humacao, in the eastern part of the island.

The ores are massive magnetites, partially altered to red hematite in places. In structure they are very fine grained and homogeneous, and almost entirely free from gangue matter, which, when it does occur, is white, glassy quartz. In one instance the presence of copper minerals was observed in the ores, but in no case was iron pyrites seen. These are high-grade Bessemer ores, extremely low in phosphorus and sulphur, and free from titanic acid. A shipping product averaging above 60 per cent—probably nearer to 65 per cent—of metallic iron can be depended upon. The following analysis by Patterson and Strad, of Middleborough, England, taken from Mr. R. T. Hill's report on the mineral resources of Porto Rico, may be considered typical of these ores as a class:

Analysis of iron ore from Porto Rico.

Constituent.	Per cent.
Metallic iron	65.050
Silica	5.300
Phosphorus	0.024
Sulphur	0.008

The country rocks are of igneous effusive types, largely porphyritic in structure, and usually basic in composition. I saw no evidence of replacement of limestone by ore, and consider the ore bodies as magmatic segregations and concentrations in the original igneous rocks.

These ore deposits occur in a broken line of ridges, which extend along the south bank of the Gurabo River, from a point about midway between Gurabo and Juncos, in an easterly direction, to the divide between the waters of the Gurabo and Naguabo, a total distance of some 8 or 10 miles. The ridges rise to an altitude of 300 to 1,000 feet above the river, with steep slopes and sharp and narrow crests. Their continuity is interrupted by frequent transverse valleys, some of which are several miles wide.

There is no regularity about the ore occurrence. Some of the hills are ore bearing, others are not. In some localities the ore occurs in apparently large masses, the solid outcrops being clearly visible; in others the quantity is unimportant and only small amounts of surface float ore can be seen.

There are no developments whatever, but the prominence and magnitude of the outcrops indicate that there are extensive bodies of ore here that can largely be worked in open quarries.

The principal mining claims in this district are the Esperanza, Eloisa, Polonia, La Fe, Panchita, Caranzana, Caridad, San Miguel, San Anton, Begonia, Luisa, Buen-Suceso, San Pedro, and San Ramon. These have recently been acquired by an American company, which proposes an early and active development of the resources.

As to the accessibility of the ore deposits of this district, it may be said that the valleys of the Naguabo and Gurabo rivers will furnish a very favorable railroad route to the port of Naguabo. Seventeen miles of road will reach the farthest deposit. Seven additional miles will connect with the harbor of Ensenada-Hondo, which has some advantages over Naguabo, being the deepest and best sheltered harbor on the east coast.

Of the other iron-ore deposits in Porto Rico none that I saw have any commercial value. The Maria, Santa Olalla, and Purificacion claims, situated about 2 miles southwest of the town of Humacao, are massive hornblende-diorite bodies containing only a small percentage of disseminated magnetite, and hence of no value aside from the fact that the magnetite contains from 4 to 6 per cent of titanic acid.

A report that there was a large deposit of ore on the plantation of Mr. Ramon Cortado, about 7 miles north of Ponce, proved to be entirely erroneous. The ore is of excellent quality, very similar to the eastern ores, but the quantity is very small.

Specular hematites occur in various parts of the island, and such were visited at several localities near Utuado, and at Pozo-Hondo, near Guayama, but they may be said to exist merely as mineral specimens.

PEAT AND LIGNITE.

The only mineral fuels found in Porto Rico are peat and lignite. The former occurs in the marshy region along the north coast, and covers considerable areas, though the deposits have never been developed.

The lignites, so far as they came to my attention, are of inferior quality, being freely impregnated with iron pyrites. They are found in the western part of the island, some of the principal localities being Utuado, Moca, Lares, San Sebastian, San German, and Caba-Rojo.

PHOSPHATE OF LIME.

Deposits of phosphate of lime exist on the islands of Mona and Monita, off the west coast; on the island of Caja de Muertos, off Ponce, and in the northwest corner of the main island, near the town of Isabella. These deposits have been repeatedly explored and partially developed without commercial success, and it is probable either that the extent of the beds is too limited or that the quantity of phosphate that the rock contains is small.

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