Barite Resources of the United States

GEOLOGICAL SURVEY BULLETIN 1072-B

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By DONALD A. BROBST

MINERAL RESOURCES OF THE UNITED STATES

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A study of the production and use of ore, geochemistry and geology of the deposits, with consideration of mining methods and exploration, and estimates of reserves

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ABSTRACT

Barite ($BaSO_4$) is widely distributed in the United States; the greatest production is now obtained from Arkansas, Missouri, Nevada, and Georgia. Nearly half of the States have yielded some barite or have potential resources. Since World War I domestic production has climbed steadily, reaching more than one million tons in 1956. About 90 percent of the barite consumed annually in the United States is used by the oil industry for drilling mud and the other 10 percent by the chemical and other industries in many processes and products. Barite is a desirable industrial mineral because it is generally white in powder form, heavy, mainly nonabrasive, and available in large quantities.

Barite occurs in sedimentary, igneous, and metamorphic rocks in many geologic environments. Most deposits can be classified as vein or cavity-filling, bedded, and residual.

Vein or cavity-filling deposits are commercially most important in the West. Barite in veins is commonly associated with fluorite, calcite, dolomite, quartz, and sulfide minerals including chiefly pyrite, chalcopyrite, galena, and sphalerite and their oxidation products. Rare-earth, gold, and silver minerals are associated with some western deposits. Some of the associated minerals may be recovered as byproducts or coproducts.

Bedded deposits of commercial importance are found in Arkansas, Nevada, Idaho, and California in sedimentary rocks of late Paleozoic age. The barite is fine grained and accompanied by chert, pyrite, secondary iron oxides, and various carbonate and clay minerals.

Residual deposits are abundant in Georgia, Tennessee, Virginia, and Missouri, where they generally occur in the residuum derived from the weathering of sedimentary rocks, especially the readily soluble limestones of Cambrian and Ordovician age. Most of the barite is white and forms mammillary, fibrous, or dense, fine-grained masses. Pyrite, galena, and sphalerite occur with barite in some deposits. Chert, rock fragments, and red, yellow, or brown clay make up the rest of the deposits.

An index map and tables illustrate and list the location, summarize the geology, and cite literature pertaining to over 100 prospects, mines, and districts in the United States.

The demonstrated reserves in the United States are estimated to be about 285 million tons containing about 46 million tons of barite. The inferred reserves are large—more than 365 million tons of material containing about 67 million tons of barite. The greatest reserves are in the residual deposits of Missouri, the bedded deposits of Arkansas and Nevada, and the various deposits of California and other western States.

INTRODUCTION

The minerals barite ($BaSO_4$, barium sulfate) and witherite ($BaCO_3$, barium carbonate) are the common sources of barium and its compounds needed for many industrial processes and products. Barite, the principal ore mineral, is found the world over and is abundant and widely distributed throughout the United States. Witherite is much less common than barite and is mined chiefly in England. The only deposit of witherite ever mined in the United States (near El Portal, Calif.) has been exhausted. The demand for barium and its compounds in the United States and abroad increased almost steadily in the years 1945 to 1956 (table 1).

Barite, sometimes called barytes, tiff, cawk, or heavy spar, is white to gray and brown, rarely black, and opaque to transparent. The calculated maximum specific gravity of 4.5 makes it one of the heaviest of the nonmetallic minerals. The hardness is variable but averages 3 on Moh's scale, or about the same as calcite ($CaCO_3$, calcium carbonate). The industry recognized two types of barite, the "hard" glossy variety that cannot be broken in the hand and the "soft" milky variety that can be crushed in the hand. The soft variety is preferred by grinders because it is easier and cheaper to grind and can be beneficiated more easily than the harder ore. The hard variety, however, can be used advantageously in the chemical industry where lump material is preferable to a powder.

The compilation of this resource report was preceded by extensive library research and study that resulted in the preparation of an annotated bibliography and index map of barite deposits in the United States (Dean and Brobst, 1955). During the spring and summer of 1954 the author spent 4 months examining the principal operating barite deposits as well as many prospects and marginal and submarginal deposits of the United States. The owners and operators of many mining companies and the residents of the various mining districts visited generously supplied much information for this report; their kind help is gratefully acknowledged.

Time in the field was too short to make detailed studies of each mine and district, so that some portions of the report describing details of individual mines and districts have been compiled from the literature.

Some of the material presented here is of a controversial nature. This author has tried to summarize accurately the work and opinions of other authors and to keep their opinions and conclusions clearly separated from his own. Some of the stratigraphic nomenclature is outdated or contested, but it is preserved here because these are the geologic names readers will find if they consult the papers cited here.

The purpose and scope of this report are to summarize the status of knowledge of the geology and distribution of deposits of barite and to tabulate briefly the resources of barite in the United States.

USES

Barite is marketed as either a lump or a finely ground product. It has many industrial uses, chiefly as a weighting agent in drilling fluids for the oil industry, or as a fragmental product called "crude", which is used in the preparation of lithopone and various barium chemicals.

In 1956, 1,503,010 short tons, or nearly 80 percent of the barite used in the United States, was ground or crushed before being put to commercial use (table 1). Of this amount, about 1,421,033 short tons, or 95 percent of the ground barite, was a component of the fluid used in the rotary drilling of oil wells (table 2).

Barite for drilling mud must have a specific gravity of at least 4.0 and preferably 4.25 to 4.30, or contain 92 to 94 percent barium sulfate. Several percent of iron oxide is not objectionable. At least 90 to 95 percent of ground barite should be finer than 325 mesh. Most drilling muds used in wells are various mixtures of water, clay, and barite. The composition of the mixtures varies because of local reservoir conditions. The final mud mixture may attain a specific gravity of 2.5, but filter loss and viscosity must remain low.

Most of the remaining 5 percent of ground or crushed barite (81,977 short tons in 1956) was used in the paint, rubber, and glass industries. In 1956, only 1 percent of the ground barite was used as an extender in white lead paint and as a white pigment in the better grade of paints. Some offcolor or unbleached barite is used as filler in colored paints. Barite containing less than 0.2 percent ferric oxide is used in the manufacture of glass in continuous tanks; barite added to the melt homogenizes it and gives the glass a greater brilliance. Barite also is used as a weighting material in concrete aggregate. Heavy concrete is especially useful in helping to keep pipelines buried in marshy areas or in bodies of water, and in foundations for certain structures such as steel towers. As a filler, ground barite is used in many products such as bristol board, playing cards, linoleum, brake linings, rope finishes, soft rubber goods, and some plastics.

Crude or lump barite is the chief raw material of the lithopone and barium-chemical industries. The barite destined for the lithopone and barium-chemical industries must contain 95 to 98 percent barium sulfate and not more than 1 percent iron oxides.

Lithopone is a white pigment that contains about 70 percent barium sulfate and 30 percent zinc sulfide. About 1 ton of barite ore is needed to make 1 ton of lithopone. The amounts of lithopone used

TABLE 1.—*Production and use of barite and barium chemicals in the United States, 1945–1956*

[Data from U. S. Bureau of Mines (1954, 1956)]

	1945–49 (average)	1950	1951	1952	1953	1954	1955	1956
Barite:								
Primary:								
Produced....short tons..	762,184	693,424	845,579	1,012,811	920,025	946,744	[1] 1,114,117	1,351,913
Sold or used by producers....do....	754,333	695,414	860,669	941,825	944,212	912,895	[1] 1,108,103	1,299,888
Do....value..	$5,819,678	$6,193,906	$7,968,023	$8,797,944	$9,435,749	$8,723,610	[1] $10,809,119	$13,421,142
Imports for consumption....short tons..	46,832	58,381	52,755	107,918	334,788	317,093	359,636	583,229
Do....value..	$333,710	$431,879	$419,494	$923,336	$2,514,828	[1] $2,274,834	[2] $2,181,119	[2] $3,563,544
Consumption....short tons..	778,529	[2] 786,131	[2] 950,893	[2] 1,033,843	[2] 1,149,451	[2] 1,215,678	1,459,671	2,062,076
Ground and crushed sold by producers....do....	531,919	573,359	703,014	839,428	920,084	1,037,590	1,232,176	1,503,010
Do....value..	$9,011,861	$11,305,209	$14,590,000	$16,608,546	$20,372,002	$29,407,921	$30,613,095	$41,623,390
Barium chemicals sold by producers....short tons..	70,121	73,689	86,032	83,156	97,508	86,745	105,913	102,892
Do....value..	$6,641,354	$7,885,586	$11,656,497	$12,101,474	$13,347,359	$11,599,394	$14,473,458	$13,510,212
Lithopone sold or used by producers....short tons..	133,311	105,650	102,837	61,832	52,439	44,011	42,845	38,434
Do....value..	$12,996,332	$13,129,363	$14,470,742	$8,475,200	$6,923,487	$5,929,789	$6,002,832	$5,630,991

[1] Owing to changes in tabulating procedures by the U. S. Department of Commerce, data known not to be comparable with previous years.
[2] Includes some witherite.

TABLE 2.—*Ground (and crushed) barite sold annually by producers in the United States, 1945–1956*

[Data from the U. S. Bureau of Mines (1954, 1956)]

Industry	1945–49 (average)		1950		1951		1952		1953		1954		1955		1956	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Well drilling	461,532	86	483,519	84	594,668	85	758,240	90	824,050	90	968,429	94	1,142,309	93	1,421,033	95
Glass	26,786	5	24,638	4	25,779	4	24,604	3	24,853	3	23,208	2	28,737	2	32,661	2
Paint	23,600	5	28,000	5	28,000	4	25,000	3	24,000	2	22,000	2	25,633	2	20,602	1
Rubber	15,800	3	19,000	3	15,000	2	18,000	2	21,000	2	20,000	2	25,104	2	22,101	2
Concrete aggregates	------	------	15,784	3	38,143	5	12,000	2	25,000	3	(1)	(1)	(1)	(1)	------	------
Undistributed	4,201	1	2,418	1	1,424	(2)	1,584	(2)	1,181	(2)	3,953	(2)	10,393	1	6,613	(2)
Total	531,919	100	573,359	100	703,014	100	839,428	100	920,084	100	1,037,590	100	1,232,176	100	1,503,010	100

[1] Included with "Undistributed." [2] Less than 1 percent.

in various products are shown in table 3. The production of lithopone is declining, largely because of increased use of titanium pigments.

Chemically produced barium sulfate called "blanc fixe" is used as filler in paint, ink, linoleum, textiles, and other products where a higher purity is required than is normally found in natural barite. This product also is used as an indicator in X-ray photography.

Additional barium chemicals used in large quantities by industry are the carbonate, chloride, hydroxide, and oxide (table 4). All other barium chemicals are a very small part of the total amount manufactured.

New uses for barium products suggest that the demand for barite will continue at a high rate. New developments include the manufacture of an oxide of barium and iron for use in permanent magnets suitable for use in motors, some transformers, and dynamos. Barium titanate is used as a ceramic ferroelectric material. Barium acetate has received new importance as the electrolyte in the process of depositing phosphor powder on the inside faces of television tubes. Barium metal is used as a "getter" to absorb gases to improve the vacuum of tubes. Canadian scientists (U. S. Bur. Mines Minerals Yearb., 1952) report that a concrete aggregate containing 80 percent barite and 10 percent iron oxide can be a low-cost building material with a high resistance to penetration by gamma rays. A mixture of synthetic rubber and fine-grained barite can be combined with hot asphalt for roads, airport runways, and parking lots to produce a tight, flexible seal coating which prolongs the life of the road surface.

The great number of uses for barite and barium products indicates the important role they play in the national economy. Barite is vital to the oil industry for drilling deeper wells in the constant search for new oil fields. Comparatively, the amount of barite used as fillers and chemical reagents is not large, but a steady supply is vitally necessary to assure the constant flow of other products requiring these materials in the product or in their manufacture.

Further details on the uses of barite and the uses and preparation of barium products may be found in various publications (Williams, 1949; Santmyers, 1930; Winston, 1949; Mineral Resources of the United States, U. S. Geol. Survey, 1882–1923; U. S. Bureau of Mines, 1924–31; U. S. Bureau of Mines, 1932–54).

DOMESTIC PRODUCTION AND CONSUMPTION

Barite mining in the United States probably began about 1845 in the vein deposits of Prince William County, Va. (Watson, 1907, p. 710). Production began in the residual deposits of Missouri about 1860, and by 1893 Virginia and Missouri were yielding nearly equal

TABLE 3.—*Annual shipments of lithopone in the United States, 1945–1956*

[Data from the U. S. Bureau of Mines (1954, 1956)]

Industry	1945–49 (average)		1950		1951		1952		1953		1954		1955		1956	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Paints, varnishes, and lacquers	[1] 105, 619	79	78, 177	74	76, 614	75	45, 267	73	37, 452	72	32, 177	73	30, 522	71	28, 238	74
Floor coverings			5, 297	5	4, 620	4	3, 009	5	2, 575	5	2, 351	9	2, 378	6	1, 600	4
Coated fabrics and textiles	16, 460	13	7, 945	8	4, 814	5	5, 698	9	5, 806	11	3, 995	5	4, 242	10	(2)	(2)
Paper	(2)	(2)	2, 290	2	6, 462	6	3, 089	5	2, 096	4	1, 841	4	1, 970	4	(2)	(2)
Rubber	2, 621	2	4, 092	4	3, 295	3	1, 523	3	1, 723	3	1, 701	4	2, 163	5	(2)	(2)
Other	8, 611	6	7, 849	7	7, 032	7	3, 246	5	2, 787	5	1, 946	5	1, 570	4	8, 596	22
Total	133, 311	100	105, 650	100	102, 837	100	61, 832	100	52, 439	100	44, 011	100	42, 845	100	38, 434	100

[1] Includes a quantity, not separable, used for printing ink. [2] Included with "Other".

TABLE 4.—*Barium chemicals produced and used or sold by producers in the United States annually, 1954–56*

[Data from the U. S. Bureau of Mines (1956)]

Chemical	Plants	Produced (short tons)	Used by producers [1] in other barium chemicals [2] (short tons)	Sold by producers [3]	
				Short tons	Value
Black ash: [4]					
1954	11	116,246	112,863	1,020	$73,902
1955	9	135,455	134,202	1,943	165,502
1956	10	128,661	127,624	6,356	524,359
Carbonate (synthetic):					
1954	4	65,319	29,150	43,325	3,985,674
1955	4	78,946	31,938	53,274	5,021,001
1956	5	76,352	35,712	45,925	4,439,647
Chloride (100 percent $BaCl_2$):					
1954	3	12,167	45	10,733	1,407,811
1955	3	14,668	120	12,343	1,672,662
1956	3	14,517	130	11,926	1,705,643
Hydroxide:					
1954	5	12,616	326	11,697	2,200,510
1955	4	15,540	74	16,150	3,174,167
1956	5	16,957	120	16,762	3,051,368
Oxide:					
1954	3	15,195	7,035	7,400	1,853,449
1955	3	16,509	8,102	8,722	2,128,911
1956	3	19,816	8,117	11,222	1,969,817
Sulfate (synthetic):					
1954	6	10,495	-----------	10,486	1,356,346
1955	5	10,722	367	9,976	1,347,248
1956	6	9,981	192	9,281	1,263,575
Other barium chemicals: [5]					
1954	(6)	2,660	722	2,084	721,702
1955	(6)	2,396	176	3,505	963,967
1956	(6)	1,808	190	1,420	555,803
Total: [7]					
1954	17	-----------	-----------	86,745	11,599,394
1955	16	-----------	-----------	105,913	14,473,458
1956	17	-----------	-----------	102,892	13,510,212

[1] Of any barium chemical.
[2] Includes purchased material.
[3] Exclusive of purchased material and exclusive of sales by one producer to another.
[4] Black-ash data include lithopone plants.
[5] Includes acetate, nitrate, peroxide, sulfide and other unspecified compounds of barium. Specific chemicals may not be revealed by specific years.
[6] Plants included in above figures.
[7] A plant producing more than 1 product is counted but once in arriving at grand total.

amounts of barite. Barite mining began in Kentucky about 1903, in Alabama about 1906, and in Georgia and Nevada about 1907. The distribution of operating mines during this early period indicated that barite was available for potential markets over the United States.

In the 10 years before World War I, domestic production and imports fluctuated (tables 5 and 6), but both were rising. With the outbreak of World War I, the East Coast markets were cut off from their supplies, chiefly in England and Germany. Mining was stimulated on the eastern seaboard, particularly in Georgia and Tennessee, and to a lesser degree in Kentucky and the Carolinas. By 1916 Georgia supplanted Missouri as the chief barite-mining State because it was closer to eastern factories, and because the residual deposits

TABLE 5.—*Production and value of crude barite in the United States annually, 1882–1956*

[Data from Santmyers (1930); U. S. Bureau of Mines (1932–54, 1956)]

Year	Quantity (short tons)	Value	Year	Quantity (short tons)	Value
1882	22,400	$80,000	1920	228,113	$2,142,464
1883	30,240	108,000	1921	66,369	531,958
1884	28,000	100,000	1922	155,040	1,123,950
1885	16,800	75,000	1923	214,183	1,664,156
1886	11,200	50,000	1924	196,332	1,540,744
1887	16,800	110,000	1925	228,063	1,703,097
1888	22,400	75,000	1926	237,875	1,773,293
1889	21,460	106,313	1927	254,265	1,670,878
1890	21,911	86,505	1928	269,544	1,754,924
1891	31,069	118,363	1929	277,269	1,850,706
1892	32,108	130,025	1930	234,932	1,538,171
1893	28,970	88,506	1931	174,520	994,655
1894	23,335	86,983	1932	129,854	445,955
1895	21,529	68,321	1933	167,880	852,611
1896	17,068	46,513	1934	209,850	1,109,378
1897	26,042	58,295	1935	225,111	1,251,268
1898	31,306	108,339	1936	283,160	1,674,631
1899	41,894	139,528	1937	355,888	2,225,727
1900	67,680	188,089	1938	309,663	2,004,521
1901	49,070	157,844	1939	383,609	2,344,103
1902	61,668	203,154	1940	409,353	2,596,743
1903	50,397	152,150	1941	503,156	3,134,234
1904	65,727	174,958	1942	429,484	2,673,002
1905	48,235	148,803	1943	420,343	2,796,776
1906	50,231	160,367	1944	518,617	3,558,489
1907	89,621	291,777	1945	696,062	5,348,652
1908	38,527	120,442	1946	724,362	5,242,755
1909	61,945	209,737	1947	834,082	6,171,342
1910	42,975	121,746	1948	799,848	6,693,413
1911	38,445	122,792	1949	717,313	5,642,226
1912	37,478	153,313	1950	695,414	6,193,906
1913	45,298	156,275	1951	860,669	7,968,023
1914	52,747	155,647	1952	941,825	8,797,944
1915	108,547	381,032	1953	944,212	9,435,749
1916	221,952	1,011,232	1954	912,895	8,723,610
1917	206,888	1,171,184	1955	1,114,117	10,809,119
1918	155,368	1,044,905	1956	1,351,913	13,421,142
1919	209,300	1,727,822			

were mined by power shovels, in marked contrast to the hand-mining methods used in Missouri and elsewhere.

After World War I, the domestic barite industry was strengthened to such a degree that European producers found only a small market in this country, in spite of a rising demand. Most of the domestic mining was limited to two regions—one in Missouri and the other in the southern Appalachians, especially in Georgia and Tennessee, and some in Kentucky.

In the early 1920's, the production in general continued to climb, with the exception of the depression year of 1921. In 1926, the oil industry began to add barite to the fluid used in the rotary drilling of some wells, and this started the nearly continuous increase in the demand for barite, which is still in effect. According to the Petroleum Administration for Defense, rotary drill hole footage was 170 million feet in 1951; it was estimated to reach 276 million feet by 1956 (Arundale, 1956, p. 92). This suggests that drilling fluids will continue to take large quantities of barite.

TABLE 6.—*Crude barite imported into the United States annually for consumption, 1890–1956*

[Data from Santmyers (1930) and the U. S. Bureau of Mines (1932–54, 1956)]

Year	Quantity (short tons)	Value	Average price per ton	Year	Quantity (short tons)	Value	Average price per ton
1890	4,815	$13,133	$2.73	1924	21,502	$104,264	$4.85
1891	2,900	8,816	3.04	1925	28,655	91,016	3.18
1892	2,789	7,418	2.66	1926	51,016	195,004	3.82
1893	2,983	7,612	2.55	1927	70,274	253,284	3.60
1894	1,844	5,270	2.86	1928	61,765	190,756	3.09
1895	2,551	7,561	2.96	1929	85,729	284,436	3.32
1896	509	1,274	2.50	1930	52,111	179,579	3.45
1897	502	579	1.15	1931	73,080	329,114	4.50
1898	1,022	2,678	2.62	1932	45,758	177,954	3.89
1899	1,739	5,488	3.16	1933	49,958	216,955	4.34
1900	2,568	8,301	3.23	1934	40,031	174,937	4.37
1901	3,150	12,380	3.93	1935	47,047	246,254	5.23
1902	3,929	14,322	3.65	1936	33,843	170,316	5.03
1903	7,105	22,777	3.21	1937	64,992	327,224	5.03
1904	7,492	27,363	3.65	1938	24,845	151,235	6.09
1905	14,256	62,459	4.38	1939	11,588	55,985	4.83
1906	9,190	27,584	3.00	1940	7,391	41,342	5.59
1907	20,544	76,883	3.74	1941	456	2,518	5.52
1908	13,661	58,822	4.31	1942	4,680	34,756	7.43
1909	11,647	29,028	2.49	1943	[1]	[1]	[1]
1910	21,270	48,457	2.28	1944	67,888	459,664	6.75
1911	20,214	36,643	1.81	1945	56,894	382,611	6.75
1912	26,186	52,467	2.00	1946	44,662	274,267	6.15
1913	35,840	61,409	1.71	1947	53,222	378,294	7.00
1914	24,423	46,782	1.92	1948	53,204	443,515	8.32
1915	2,504	4,877	1.95	1949	26,178	192,567	7.35
1916	17	245	14.41	1950	58,381	431,879	8.20
1917	6	63	10.50	1951	52,755	419,494	7.97
1918	0	0	----------	1952	107,918	923,336	8.64
1919	118	594	5.03	1953	334,940	2,514,828	7.58
1920	24,874	146,858	5.90	1954	317,093	[2] 2,274,834	[2] 7.17
1921	11,054	59,371	5.37	1955	359,636	[2] 2,181,119	----------
1922	23,239	104,680	4.50	1956	583,229	[2] 3,569,544	----------
1923	15,045	93,721	6.23				

[1] Data not available.
[2] Owing to changes in tabulating procedures by the U. S. Department of Commerce, data cannot be compared with previous years.

The ratio of barite mined in the United States to that imported has fluctuated through the years, but a sharp increase in imports has occurred since 1951 (table 6). The increase has come in spite of a tariff of about $3 per long ton on crude ore and $7.50 per long ton on a ground or manufactured product. The imported ore comes mostly from Nova Scotia, Canada, by boat to East Coast or Gulf Coast ports for further processing. Since 1950 four grinding plants have been built along the Gulf Coast to produce from the imported ore a drilling-grade product to be used locally. The construction of these plants adds a flexibility to the domestic industry which permits processing ore from any source for markets near these plants. The life of these plants is not dependent upon any one deposit or group of deposits. The coastal location also means that fluctuations in shipping rates of ore from different sources can be taken advantage of as they occur. The four plants processed about 85 percent of the ore imported in 1953.

In 1956 the United States produced 1,351,913 tons of barite, nearly 3 times the amount produced in 1944, just before the expansion of industry in the United States following World War II (table 5). Current production is about five times as great as in the years 1925–35.

Table 7 indicates that by 1938 barite was being mined in Arkansas and in Rocky Mountain and Pacific States, which are all close to markets, mostly in the oil industry. Most of the barite now produced in the United States is mined in the Magnet Cove area, Arkansas, and in Washington County, Mo. These deposits supply raw material for the drilling mud used by the oil industry of the Gulf Coast. Missouri supplies most of the chemical grade ores for the manufacturing plants of the Midwestern States. The Battle Mountain district, Nevada, yields most of the barite mined in the State and provides raw material for the chemical and oil industries of California.

TABLE 7.—*Domestic barite sold or used by producers in the United States (1938–1956)*

[Data from U. S. Bureau of Mines]

	Arkansas	Georgia [1]	Missouri	Nevada	Tennessee	Other States	Totals (short tons)
1938	(2)	64, 304	156, 539	(2)	29, 898	[3] 58, 922	309, 663
1939	(2)	86, 589	171, 642	(2)	57, 140	[4] 68, 238	383, 609
1940	(2)	92, 302	179, 455	(2)	70, 767	[5] 66, 829	409, 353
1941	(2)	104, 446	212, 718	(2)	104, 511	[5] 81, 481	503, 156
1942	(2)	86, 636	146, 270	(2)	83, 291	[6] 113, 287	429, 484
1943	(2)	98, 680	124, 147	12, 157	52, 593	[7] 132, 766	420, 343
1944	159, 686	108, 851	150, 748	22, 390	43, 033	[8] 33, 909	518, 617
1945	260, 660	110, 393	225, 467	28, 919	32, 812	[9] 37, 811	696, 062
1946	288, 286	69, 274	270, 850	(2)	33, 595	[10] 62, 578	724, 362
1947	376, 017	61, 202	291, 619	37, 388	31, 476	[11] 36, 380	834, 082
1948	362, 470	62, 781	278, 071	(2)	25, 818	[12] 70, 708	799, 848
1949	363, 382	50, 267	181, 891	70, 576	13, 376	[13] 32, 821	717, 313
1950	343, 168	72, 888	212, 736	47, 608	(14)	[15] 19, 014	695, 414
1951	407, 085	73, 117	281, 895	63, 201	(14)	[16] 35, 371	860, 669
1952	428, 522	97, 540	304, 080	68, 062	(14)	[16] 43, 621	941, 825
1953	380, 763	81, 846	330, 763	99, 525	(14)	[17] 51, 315	944, 212
1954	376, 621	75, 492	312, 791	83, 833	(14)	[18] 40, 546	883, 283
1955	462, 986	130, 396	363, 692	[19] 113, 694	(14)	[17] 37, 335	1, 108, 103
1956	486, 254	174, 139	381, 642	178, 440	(14)	[20] 79, 413	1, 299, 888

[1] Included South Carolina and Tennessee in 1950–56.
[2] Included in other States.
[3] Arizona, Arkansas, California, Nevada, South Carolina, and Texas.
[4] Alabama, Arizona, Arkansas, California, Colorado, Montana, Nevada, South Carolina, and Virginia.
[5] Arkansas, California, Colorado, Nevada, South Carolina, Texas, and Virginia.
[6] Alabama, Arkansas, California, Nevada, South Carolina, and Virginia.
[7] Arizona, Arkansas, California, Kentucky, and South Carolina.
[8] California, North Carolina, and South Carolina.
[9] California and North Carolina.
[10] Arizona, California and Nevada.
[11] Arizona and California.
[12] Arizona, California, and Nevada.
[13] Arizona, California, Idaho, New Mexico, and South Carolina.
[14] Included with Georgia.
[15] Arizona, California, Idaho, and New Mexico.
[16] Arizona, California, Idaho, Montana, and New Mexico.
[17] Arizona, California, Idaho, Montana, New Mexico, and Washington.
[18] Arizona, California, Idaho, Montana, and New Mexico.
[19] Partly estimated.
[20] California, Idaho, Montana, and Washington.

Mining of barite in the southern Appalachian region continues, but this area supplies a smaller tonnage and a proportionally smaller part of the market than years ago. Large deposits of barite are currently mined in the Sweetwater district, Tennessee, the Cartersville district, Georgia, and the Kings Creek district, South Carolina. It is unprofitable to work the many small deposits in central and northeastern Tennessee, central Kentucky, western North Carolina, Virginia, and other eastern States, under the economic conditions of 1956.

According to the Engineering and Mining Journal in April 1958, the prices of domestic crude barite ore were $18 per ton f. o. b. the mines in Georgia and $16 to $18 per ton f. o. b. the mines in Missouri for ore containing 94 percent $BaSO_4$. Water-ground, floated, and bleached barite sold for about $40 per ton. All of these prices are high as compared to prices in past years. The chronicle of price fluctuation is as old as the industry and is recorded in volumes of the U. S. Geological Survey and the U. S. Bureau of Mines on mineral statistics and reviews. Price changes have been affected by such economic factors as proximity to market, tariff regulations, and availability of foreign supplies.

Federal tax laws allow producers of barite to have a percentage depletion allowance of 15 percent of gross income not to exceed 50 percent of the net income without depletion deduction. Some states levy severance taxes.

OCCURRENCE

GEOCHEMISTRY OF BARIUM [1]

Barium and the similar and closely associated elements calcium and strontium are concentrated in the silicate crust of the earth (Rankama and Sahama, 1950, p. 458). The concentrations of these elements in the various kinds of rocks are listed in table 8. Among the igneous rocks, the basic varieties contain less barium than the alkali-rich varieties. Of the sedimentary rocks, shales contain the most barium and evaporites contain the least.

Barium is a common trace element of great abundance that generally does not form independent minerals in igneous rocks. Barium can substitute extensively for potassium because of the similarity of

TABLE 8.—*Abundance of calcium, strontium, and barium in selected rocks*

[In grams per ton. Data from Rankama and Sahama (1950, p. 458, 476, 482).]

	Ca	Sr	Ba		Ca	Sr	Ba
Silicate meteorites	17,300	26	9	Sandstone (average)			170
Igneous rocks	36,300	150	250	Shale (average)		170	630
Gabbro, basalt, anorthosite		170	60	Limestone		425–765	120
Granite and liparite		90	430	Red clay		60	200
Nepheline syenite and phonolite		1,200	520	Evaporites (maximum)			9

[1] Much of the following discussion is based on Rankama and Sahama, 1950, p. 457–484.

their ionic radii.[2] For this reason, potassium feldspar, muscovite, and biotite contain most of the barium of igneous rocks. The barium feldspars are celsian, Ba $[Al_2Si_2O_8]$; and hyalophane, (KBa) $[Al(Al, Si)Si_2O_8]$, which is essentially a barian adularia. Oellacherite, a variety of muscovite, may contain as much as 9 percent barium; some biotite contains as much as 6 percent barium.

Noll (1934) and Von Engelhardt (1936) have shown that the content of barium in potassium feldspar is a function of temperature. Barium enters the early crystals, resulting in the formation of pure potassium feldspar after the originally available barium has been depleted.

The barium ion is too large to replace those of calcium, iron, magnesium, and manganese.[2] Ions of barium and strontium can exchange places. The inability of barium to replace calcium accounts for the lack of barium in plagioclase feldspars. A differential in size of ions equal to about 15 percent is the maximum difference that will allow for replacement of any given ion.

Barium also is an important constituent of some deposits of manganese oxides. This is because $Mn(OH)_4$ sol is negatively charged and attracts cations such as barium. This association is caused by adsorption rather than ion exchange; ions of Ba and Mn are not mutually replaceable because of dissimilarity of their ionic radii. The barium content of some iron oxides and bauxite is low (90 g per ton), probably because these sols are positively charged, thus attracting only anions (Rankama and Sahama, 1950, p. 484).

Barium may be enriched, but not greatly concentrated, in terrestrial and aquatic plants and animals.

According to Rankama and Sahama (1950, p. 477–478) hydrothermal solutions may extract barium from rocks. These solutions are enriched in barium with regard to potassium as they are also enriched in calcium with regard to sodium. Thus in the series celsian–potassium feldspar and anorthite-albite the component with the higher melting point is preferentially attacked and dissolved. Barium is also removed by gases containing fluorine, thus giving rise to veins containing both fluorite and barite.

Barium generally precipitates as the sulfate or the carbonate. Precipitation as the sulfate occurs by evaporation, neutralization (especially in limestone environment), and an increase in the concentration of the sulfate ion. Precipitation as the carbonate occurs when carbon dioxide is lost from the solution.

The spectrographic analyses of 27 samples of barite and barite ore from deposits of different types widely distributed across the United

[2] Rankama and Sahama (1950, p. 471) list the following ionic radii in crystal angstroms for selected elements: Ba^{++}, 1.43; Sr^{++}, 1.27; Ca^{++}, 1.06; K^{+}, 1.33; Mg^{++}, 0.78; Fe^{++}, 0.83; and Mn^{++}, 0.91.

States are shown in table 9. The samples were collected by the author and Mr. Ralph L. Erickson. The barite samples from residual and vein deposits were selected for their apparent purity. The barite ore from the bedded deposits was chosen for high-grade ore by its apparent heavy weight. The number of analyses presented here is insufficient to draw any sweeping conclusions.

In review of the group of analyses, some silicon is in the barite from all areas and geologic environments. It is highest in the bedded deposits, but that is not surprising because these ores are most impure. Traces of copper are common to all the samples but one. The absence of lead and zinc from the bedded and residual deposits is notable, because these elements are rather common as the sulfide, in accessory amounts, in the deposits in these two geologic environments. The small amounts of manganese and its low frequency of occurrence in barite are noteworthy, especially because of the relative abundance of manganese in the environments of the bedded and residual deposits. Notice the frequent occurrence of vanadium, especially in the bedded deposits of Arkansas. The rare earths in the sample of barite from the Mountain Pass district, California, are probably a contamination from rare earth minerals that are intimately intergrown with the barite. Some strontium occurs in all the samples as expected because it can replace ions of barium in the crystal structure of barite. The strontium values, however, are lowest in the bedded deposits, suggesting that these ores might be valuable for use in chemical plants where ores low in strontium are most desirable.

MINERALOGY OF THE ORES

The chief ore mineral is barite ($BaSO_4$, barium sulfate) which contains 65.7 percent BaO and 34.3 percent SO_3 in pure samples. Mine-run barite ores may contain some strontium, calcium, or lead as trace elements or in discrete particles of associated minerals. Barite crystallizes in the dipyramidal class of the orthorhombic system. Crystals are tabular or rectangular and flat parallel to the basal pinacoid or elongated parallel to the a or b axis. The crystals may form aggregates whose edges project into crestlike forms. Barite also forms concretionary masses and rosettelike aggregates of tabular crystals. In other occurrences the barite may be massive, granular to compact, and cryptocrystalline; laminated; in concretions of nodular or globular nature that are fibrous to columnar within a radiated or parallel pattern; stalactitic or stalagmitic; or earthy. The brittle mineral has 3 cleavages, parallel to (001) perfect, (210) less perfect, (010) imperfect to indistinct, but might be equal to that of (210). The fracture is uneven. The luster is vitreous to resinous and sometimes pearly. The mineral is colorless to white or gray but in places

TABLE 9.—*Spectrographic analyses of barite and barium ores*

[Harry Bastron, analyst]

Type of deposit	Locality	Laboratory No.	Ba	Sr	Ca	Mg	Si	Cu	Pb	Zn	Mn	Fe	Al	Cr	V	Ti	Zr
Residual	Bertha mine, Calhoun County, Ala.	141380	M	0.5	M	0.4	0.03	0.0008			0.01	0.03	0.02		0.003		
	Do	141380A	M	.3	0.005	.007	.3	.0002			.005	.4	.2		.001	0.006	
	Cartersville district, Georgia	141386	M	1.0	.001	.004	.4	.0006				.02	.005				
	Old Mines area, Washington County, Mo	141388	M	2	.001		.008	.0001					.01				
	Fountain Farm area, Washington County, Mo	141389	M	.4	001		005	.0001					.01				
	Sesteck mine, Cole County, Mo	141390	M	.2	001		004	.0005				.002	.005				
	Ballard mine, Sweetwater district, Tennessee	141396	M	2 0	1.1		.005	.0002				.2	.006		.001		
	Kiker mine, Sweetwater district, Tennessee	141397	M	2 0	.001		.09	.002				.02	.04				
Vein and Cavity Filling	Macco mine, Maricopa County, Ariz.	141381	M	3 0	0 01	0.003	0.008	0 0002					0.01	0.0002			
	Wet Mountains, Custer County, Colo	[1] 141384	M	.03	.2	005	1.0	.0006	0.002		.005	.08	.05				
	F and S mine, Missoula County, Mont.	141391	M	.4	.001		2.0	.0005					.009				
	Mex-Tex mine, Hansonburg district, Socorro County, N. Mex	141395	M	1.0	.001		.5	.001	.01			.002	.006				
	Dry Creek prospects, DeKalb County, Middle district, Tennessee	141398	M	6.0	1.5	.003	.02	.002					.02		.001		
	Lead Hill mine, Pend Oreille County, Wash.	141402	M	.001	.2	.2	1.0	.001	.03	0.2			.03				
	Mountain Pass district, San Bernardino County, Calif.	[2] B-2-A-1	M	9.0	.4	.4	1.0	.0005	.002	.06	.06	.3	.08	.0002	.002		0.002
	Moccasin Gap mine, Del Rio district, Cocke County, Tenn.	141400	M	.4	.006		.04	.0001					.004				
	Williams mine, Del Rio district, Cocke County, Tenn.	141401	M	.6	.8		.5	.001				.001	.02				
	El Portal mine, Mariposa County, Calif.	141382	M	0.02	0.4	0.2	2.0	0.0005			0.004	0.1	0.2	0.0001	0.001		
	Spanish mine, Nevada County, Calif.	[3] 141383	M	.3	.001		.02	.0008					.02				
	Sun Valley mine, Blaine County, Idaho	141387	M	.2	.007	.004	M					.04	.4	.001	.002	.01	.001
	Greystone mine, Battle Mountain district, Nevada	141392	M	.05	.02	.005	.5	.0002			.004	.02	.1				

Bedded	Mountain Springs mine, Battle Mountain district, Nevada	141393	M	.001	.02	.02	2.0	.0004	------	------	------	.06	.4	.0002	.001	.005	------
	National Lead Co. mine, near Dunphy, Eureka County, Nev	141394	M	.01	.06	------	1.0	.002	------	------	------	.01	.04	------	------	------	------
	Magnet Cove, Hot Spring County, Ark	[4] 135523	M	.6	.9	.4	M	.0006	------	------	.2	.4	1.0	.001	.002	.9	.02
	Massive ore, Fancy Hill, Montgomery County, Ark	[5] 135524	M	.6	.06	.2	M	.002	------	------	.01	.4	1.0	.002	.004	.5	.005
	Sulphur Mountain, Montgomery County, Ark	[6] 135226	M	.7	.1	.1	M	.0004	------	------	.007	.3	1.0	.001	.002	.1	.003
	Concretion from Lucky 13 deposit, Sevier County, Ark	142595	M	.1	.001	.07	M	.0005	------	------	.001	.2	2.0	.0007	.001	.1	------

M=major constituent. In all samples the following were looked for, but not found: Au, Hg, Ru, Rh, Pd, Ir, Pt, Mo, W, Re, Ge, Sn, As, Sb, Bi, Te, Cd, Tl, In, Ni, Ga, Th, Nb, Ta, U, Li, and P.

[1] Sample also contained 0.0001 of Be.

[2] Sample also contained 0.4 Ce, 0.004 Sc, 0.002 Y, 0.0002 Yb, and 0.6 La.

[3] Sample also contained 0.0004 Ag.

[4] Sample also contained 0.006 Co, 0.002 B, 0.7 Na, and 0.5 K.

[5] Sample also contained 0.003 B and 0.5 K.

[6] Sample also contained 0.001 B.

is black, yellow, brown, red, green, or blue. The color may be distributed in growth zones or face loci; the color might be lost by heating or exposure to sunlight. Some barite is fetid. The hardness is generally 3–3.5 and the specific gravity is calculated to be 4.5, although inclusions and impurities in natural barite may reduce this figure considerably (Palache and others, 1951, p. 408–414).

The most common associated minerals in barite are calcite; dolomite; siderite; silica as quartz, chert, or jasper; fluorite; celestite; and various sulfide minerals such as chalcopyrite, sphalerite, galena, and pyrite, and their oxidation products. Ferruginous clays make up a large part of residual deposits. The clays coat the surface of barite and fill voids, cracks, and pits in the crystals or aggregates.

Witherite ($BaCO_3$, barium carbonate) occurs as a minor accessory mineral in some barite deposits of the United States. A large body of witherite was mined near El Portal, Calif. Witherite forms commercial ore bodies in England and Germany. The composition of the pure mineral is 77.7 percent BaO and 22.3 percent CO_2. The mineral crystallizes in the dipyramidal class of the orthorhombic system; cleavage parallel to (010) is distinct, (110) imperfect. The fracture is uneven, and the luster is vitreous, or perhaps resinous on fracture surfaces. The transparent to translucent crystals or complex masses are colorless to milky, white, gray, or tints of yellow, brown, and green. The hardness is 3–3.5 on Moh's scale, and the specific gravity is 4.29 by calculation (Palache and others, 1951, p. 194–196).

GEOLOGY OF THE DEPOSITS

Barite occurs in many geological environments in sedimentary, igneous, and metamorphic rocks. Three major types of deposits can be defined: vein and cavity filling, bedded, and residual.

The vein and cavity-filling deposits are those in which barite and associated minerals occur along faults, gashes, joints, and bedding planes, and breccia zones, solution channels, and various sink structures. The solution channel and sink structures are most abundant in limestone.

The bedded deposits are those in which barite of either epigenetic or syngenetic origin is restricted to certain beds or a sequence of beds in sedimentary rocks. Commercially important deposits of this type contain fine-grained, massive barite or abundant crystals and masses of barite.

The residual deposits are those concentrations of barite, generally in clay, that are derived from preexisting rocks containing barite. Most residual deposits, such as those in Missouri, Georgia, and Tennessee, are derived from barite deposits that might not have been of commercial grade in their original occurrence as veins in bedrock.

VEIN AND CAVITY-FILLING DEPOSITS

Some important geologic features of vein and cavity-filling deposits of barite are summarized as follows: (1) The host rocks are igneous, metamorphic, or sedimentary rocks of Precambrian to Tertiary age. (2) Deposits in Mesozoic rocks are uncommon. (3) Most of the deposits are associated with faults, gashes, joints, bedding planes, breccia zones, and solution structures that range in length, width, and depth from a few inches to many hundreds of feet. (4) Large-scale replacement of the host rock beyond the ore-controlling structures is rare. (5) In the Western States many deposits are associated with igneous rocks of Tertiary age; notable exceptions are the deposits associated with igneous rocks of Precambrian age at Mountain Pass, San Bernardino County, Calif., and in the Wet Mountains, Custer County, Colo. (6) In most deposits in the Midwestern and Eastern States, the association with igneous rocks is not obvious. The ore occurs in structural features formed no earlier than late Paleozoic time. (7) Barite is a common gangue mineral in many veins containing metallic ore deposits, and some of this might be produced as a byproduct of mining. Barite production from such deposits will be affected mostly by the need for the associated metals.

RELATION TO WALL ROCK

Sharp contacts of the veins and fillings with wall rocks are common, and large-scale replacement of the host rocks by vein minerals is rare. In the Hansonburg district, Socorro County, New Mexico, this lack of replacement has been attributed to earlier silicification that sealed off the wall rocks, thus preventing or minimizing any further replacement of the host rocks by mineralizing solutions (Lasky, 1932, p. 71). Banding of the ore minerals in the veins, so common in Kentucky, Tennessee, and New Mexico, might also be a factor in the lack of large-scale replacement of the wall rocks, because the formation of the first band of ore in the filling might be an effective seal of the walls against further penetration by solutions moving along the channelways.

CHARACTER OF BRECCIA DEPOSITS

Barite cements breccia along fault zones by replacement and filling voids. The amounts of barite and other minerals in these deposits vary greatly with the space available, which is dependent upon the degree of brecciation and the extent of favorable host structure. Deposits of this type generally are scattered and irregular, and range from a few inches to several feet in thickness and from tens to hundreds of feet in length. They are found in the zones between two or more competent beds or in fault zones. Deposits in fault breccia in the Eastern United States are generally thin and of small extent. Typical of these deposits are the Moccasin Gap, Williams, and similar mines in the Del Rio district, Cocke County, Tenn. (Ferguson and Jewell, 1951, p. 135–186, 192–201). In the Western States, especially in the Oscura Mountains, Socorro County, N. Mex., and in Maricopa County, Ariz., fault breccia deposits were being mined in 1954. Vugs in the breccia of the Oscura Mountains contain euhedral crystals of calcite, fluorite, galena, and barite as much as 4 inches across. On weathering, fault breccia deposits may form commercial bodies of residual ore.

Some of the breccia deposits are in sedimentary rocks, especially limestones, where the roof or walls of solution channels had collapsed. The resultant breccia contains clay, mixed sizes of angular fragments of wall rocks, and in places chert. The rock and chert fragments were cemented subsequently with barite, carbonate minerals, silica, and a little galena and sphalerite. Some masses of barite in the breccia weigh as much as 300 pounds. These deposits are generally irregular and small because of the limited lateral and vertical extent of most solution or sink structures. They are most common in central Missouri and the Appalachian States. Although deposits of this kind may be comparatively rich, they have been commercially important only in central Missouri, where they are known as circle deposits. These deposits also may weather to form minable residual ore deposits.

In the Eastern States, especially in Kentucky and Virginia, many mineral fillings occupy fractures along which little or no movement occurred. Fohs (1913, p. 456) observes in central Kentucky that ". . . good deposits occur more frequently in normal faults of small displacement than in those of greatest displacement." Structural relations like these are of importance in prospecting and mining.

MINERALOGY OF THE ORES

Barite in veins and cavity fillings is generally dense, hard, and gray to white. It is commonly associated with purple, green, or colorless fluorite, calcite, dolomite, ankerite, quartz, and many sulfide minerals including pyrite, chalcopyrite, galena, sphalerite, and their oxidation products. Gold and silver minerals are common associates, especially in deposits in the Western States. The gold may occur free or disseminated in the sulfide minerals; much of the silver occurs in galena. Less commonly, cinnabar and stibnite occur with barite, the former in Orange County, Calif., and the latter in Lemhi County, Idaho (table 10). In the Mountain Pass district, Calif., and in the Wet Mountains, Colo., rare-earth and radioactive minerals occur with pink to red barite. The amounts of these associated minerals that occur in the veins may vary greatly within a deposit or from district to district, but many of the veins can yield more than one product. Some of the vein deposits regarded as commercial or potentially commercial might yield coproducts or byproducts of fluorspar, lead, zinc, copper, rare earths, and perhaps precious metals. In 1954, barite and galena were recovered from the Hansonburg district, Socorro County, N. Mex. In years past, some barite was recovered with galena and sphalerite in the Middle Tennessee district. Barite is not but could be recovered with rare-earth minerals in the Mountain Pass district, Calif. (Zadra and others, 1952).

GRADE OF ORE

The grade of ore in vein deposits of barite varies greatly within any one deposit and from deposit to deposit. No figures on the grade of ore in the vein deposits as a group can be given because the choice of a deposit for mining is dependent upon economic factors.

ORIGIN OF DEPOSITS

The minerals of the vein and cavity-filling deposits are typical of the epithermal suite precipitated from low-temperature hydrothermal solutions. Many geologists agree that most vein deposits containing barite in the Western States had such an origin. Most of the recent investigators (Kesler, 1950, p. 49; Edmundson, 1938, p. 24; Adams and Jones, 1940, p. 16) also favor a hydrothermal origin for the vein deposits in Midwestern and Eastern States; the term "telethermal" has been applied to such deposits. This term implies that the solutions probably traveled farther from their source, and therefore, were probably somewhat cooler than those termed "epithermal".

REPRESENTATIVE DISTRICTS

MOUNTAIN PASS DISTRICT, CALIFORNIA

The Mountain Pass district, San Bernardino County, Calif., contains one of the largest single concentrations of barite in the world. The barite occurs in veins with rare-earth minerals. The geology and ore deposits have been described by Olson and others (1954).

The Mountain Pass district is in a block of metamorphic rocks of Precambrian age. The rocks of the metamorphic complex are gneisses, schists, migmatites, granitic pegmatites and small amounts of foliated mafic rocks. The block is bounded on the north by a fault, on the east and south by alluvium of the Ivanpah Valley, and on the west by the Clark Mountain normal fault that brings volcanic and sedimentary rocks of Paleozoic age into contact with rocks of Precambrian age.

The vein deposits are related to several large intrusive bodies and several hundred thin dikes of potash-rich rocks of probable Precambrian age that cut the metamorphic complex. The composition of these igneous rocks ranges from biotite shonkinite through syenite to granite. The granitic rocks generally appear to be the youngest and the shonkinites the oldest in the cycle of intrusion. Rare earths and barite are most abundant in and near the southwest side of the largest shonkinite-syenite body, which is about 6,300 feet long. Most of the 200 carbonate-rich veins mapped by Olson and others (1954) are less than 6 feet thick, but one large body of carbonate rock near the Sulphide Queen mine is 2,400 feet long and has an average width of 400 feet. This large body has more than 10 times the exposed area of all the other veins combined.

The bulk composition of the ore is about 20 percent barite, 60 percent carbonate minerals (calcite, dolomite, ankerite, and siderite), 10 percent rare-earth-bearing fluocarbonate minerals (chiefly bastnaesite), and 10 percent quartz and silicates (Olson and others, 1954, p. 29–30). This composition indicates that the deposits are of low grade with respect to barite as compared to commercial deposits elsewhere, but the barite can be recovered as a byproduct in milling of the ore for the valuable rare-earth minerals (Zadra and others, 1952). The reserves are very large.

Olson and others (1954, p. 1) conclude that

> The carbonate rock might have had a sedimentary origin in the Precambrian gneissic complex as limestone or evaporite, subsequently modified and squeezed into discordance with the foliation of the metamorphic rocks. A magmatic origin of the rare-earth-bearing carbonate rock by differentiation of an alkaline magma from shonkinite to syenite to granite, with a carbonate-rich end-product containing the rare elements, is in harmony with the field relations. This late differentiate might have been introduced either as a relatively concentrated magmatic fluid, highly charged with volatile constituents such as carbon dioxide, sulfur, and fluorine, or as a dilute hydrothermal fluid.

CENTRAL DISTRICT, MISSOURI

The Central district extends over parts of 12 counties, but the principal mines are in Cole, Moniteau, Miller, and Morgan Counties, Mo. This is the only district in the United States where circle deposits have been of commercial importance. This particular kind of breccia deposit is found in collapse structures in the Gasconade, Roubidoux, and Jefferson City formations of Ordovician age. According to Mather (1947, p. 45–47), the collapse structures containing the ore deposits are bell-, flask-, or cone-shaped in vertical section with the apex up, and approximately circular in plan. The ore deposits are generally small; the largest are 200 to 250 feet in diameter. The depths of the deposits are generally unknown because most mining operations have ceased before reaching the bottom; one deposit was worked to a depth of 125 feet.

The minerals of circle deposits are chiefly barite with accessory galena, sphalerite, chalcopyrite, and calcite. The galena and lesser amounts of sphalerite are irregularly distributed, although galena is generally more abundant near the walls. After the minerals were deposited, the remaining pores were filled with red "tallow" clay believed by Mather (1947, p. 47) to have been deposited from quiescent ground water.

The grade of barite ore in these deposits varies greatly and no general figures can be given. Galena and sphalerite are recoverable byproducts from some deposits.

The circle deposits, according to Mather (1947, p. 98–99), probably formed by the enlargement of solution channels through caving of large volumes of roof and wall rocks. The caving extended upward until the roof attained the character of a stable arch, thus producing a cone- or bell-shaped enclosure filled with broken rock. Solution of the debris continued during the formation of the structure. The minerals were deposited after the structure was stabilized as shown by the fact that the minerals are not brecciated. Barite cemented the rock fragments; the filling of the voids by barite probably prevented further solution of the walls and rock debris and strengthened the structure against further collapse.

The weathering of some circle deposits has resulted in the formation of commercially valuable residual deposits.

HANSONBURG DISTRICT, NEW MEXICO

Much of this information is from a report by Kottlowski (1953). Commercial deposits of barite, fluorite, and galena occur in limestones in the Hansonburg district of the Oscura Mountains, a fault block range, on the east side of an intermontane valley known as the Jornada del Muerto in Socorro County, N. Mex. The west face of the range is a steep fault-line escarpment; the east slope is a rolling dissected upland. The western boundary fault, known as the Oscura fault, strikes N. 15° E. The throw of the fault decreases from south to north and dies out in the Oscura anticline. About 1 mile east of the Oscura fault is another north-trending fault, with a throw of about 550 feet. Minor faults and joints are parallel to the major faults. The ore deposits of the district are associated with two sets of fractures that strike within N. 25° E. to N. 25° W.

According to Kottlowski (1953, p. 3), rocks of Precambrian, Pennsylvanian, Permian, middle Tertiary(?), and Quaternary age crop out in or near the Oscura Range. The rock of Precambrian age, a pink leucogranite, is unconformably overlain by gray limestone, green sandstones, and shales of Pennsylvanian age. Red sandstones and shales of

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Permian age rest disconformably upon the older rocks. The Paleozoic rocks are intruded by sills and dikes of middle Tertiary monzonite or diorite. Alluvium of Quaternary age blankets most of the valleys.

The ore deposits on the Mex Tex property, 28 miles east of San Antonio, N. Mex., appear to be typical of those in the Oscura Mountains. The deposit was mined in 1954 for galena and barite. The principal ore minerals are barite (about 30–55 percent), fluorite (about 12–23 percent), and argentiferous galena (about 3–5 percent). Euhedral crystals of galena and white or blue to green fluorite, as much as 4 inches across, and tabular crystals of white to cream barite 6 to 8 inches long are common. Calcite and quartz are the chief gangue minerals. Quartz forms dense masses in the silicified host rocks, large crystals with the ore minerals, and drusy coatings on other minerals in vugs. Accessory minerals include small amounts of primary copper minerals and secondary copper and lead minerals. Much of the ore is banded and vuggy. The vugs, a few inches to several feet wide, are filled mostly with euhedral barite and some euhedral fluorite and galena.

The ore bodies are localized (1) in broad fracture zones in massive limestones, (2) along small hinge faults where brecciation and sheeting of massive beds of limestone have been extensive, and (3) in solution cavities. Silicification of the host rocks occurred along the fractures, but large-scale replacement of the wall rocks by silica, barite, fluorite, or galena has not been seen. If the silicification preceded the deposition of the ore minerals, as suggested by Lasky (1932, p. 68), then the wall rocks were partly sealed off, and replacement by the ore minerals was largely prevented.

The ore deposits of the Mex Tex property occur chiefly in the Council Spring limestone of Thompson (1942) and in the lower part of the Burrego formation of Thompson (1942), both of Pennsylvanian age. Ore also occurs in the upper massive limestones of the Coane and Storey formations of Thompson (1942) and in the Moya formation of Thompson (1942), all of Pennsylvanian age. Massive beds of noncherty limestone appear to be the best host rocks because they were shattered by the faults, whereas the less massive beds folded or broke sharply.

Kottlowski (1953, p. 8–9) concludes that ore deposits of moderate size and value occur in the Hansonburg district. The type of mineralization suggests that no large bedded replacements occur at depth, although the lower part of the Pennsylvanian section is exposed only at the base of the mountain front. This means that possible replacement deposits in the cherty lower part of the Madera limestone are buried 500 to 1,000 feet in most of the area. The lack of widespread shale beds to form impermeable roofs over favorable cherty limestones suggests that such bedded deposits do not occur. Thus, the future of the district probably lies in the discovery of more of the scattered, irregular, elongated bodies now being mined. Surface exploration for exposed ore, silicified zones, and fractured zones near the major faults provides the most promising means of finding new deposits.

KINGS CREEK DISTRICT, SOUTH CAROLINA

The barite deposits of the Kings Creek district are in a belt a few miles wide in York and Cherokee Counties. The deposits occur in the socalled Carolina barite belt that extends for about 20 miles from Crowders Mountain, 4 miles east of Kings Mountain in adjacent North Carolina, southwestward to near the junction of South Carolina Highways 103 and 105, about 5 miles east of Gaffney, S. C.

According to Van Horn, Le Grand, and McMurray (1949), the barite occurs in discontinuous veins and replacement masses in a quartz-sericite schist along the contact between the Battleground schist and the Bessemer granite, both of Precambrian age. The width of outcrop of the sericite schist containing barite ranges from a few feet to more than 1,100 feet. The zone of schist and barite generally strikes N. 45° E. and dips 60° SE. Local folds disturb this trend only slightly between the various deposits.

The barite of the veins is white to rose, is massive, granular, or coarsely crystalline, and occurs locally in a system of veins that are en echelon along the strike and dip of the schist. Some veins, however, cut across the foliation of the host rock. The maximum width of the veins is 8 feet, and the average about 18 inches. The contacts between the veins and the schist are rather distinct, although some fragments of sericite schist are included in the outer parts of the veins.

Minerals associated with the barite veins in the Carolina belt are galena, sphalerite, and calcite in the area around Crowders Mountain, and various sulfides of iron and copper near Kings Creek, S. C. Other minerals occurring with the barite are tourmaline, magnetite, and chlorite.

Much of the wall rock near the veins contains barite as disseminated fragments or aggregates ranging in size from fine flakes to clots an inch or more long. Near the veins these partly replaced rocks contain as much as 20 percent barite. The content of barite diminishes away from the veins in an irregular manner. Barite of this disseminated type has not been mined.

Studies of thin sections reported by Van Horn, Le Grand, and McMurray (1949, p. 8) indicate that the barite replaces quartz and sericite and also occurs as interstitial filling in the sericite schist.

They believe that the barite is younger than the last regional metamorphism and occurs as the result of hydrothermal replacement.

DEL RIO DISTRICT, TENNESSEE

The Del Rio district in southeastern Cocke County, Tenn., is about 19 miles long and has a maximum width of 7 miles. It trends northeast. Ferguson and Jewell (1951), who have described in detail the geology and ore deposits of the district, estimate that 55,000 tons of barite have been produced from about 12 mines and prospects.

The rocks of the area are the Snowbird formation and the Sandsuck shale of Precambrian(?) age, and the clastic rocks of the Unicoi, Hampton, and Erwin formations, the Shady dolomite, and the Rome formation—all of Early Cambrian age (Ferguson and Jewell, 1951, p. 12). These rocks occur in two overthrust sheets that have been pushed from the southeast into their present positions: the Brushy Mountain sheet overrode the Del Rio sheet.

Two principal deposits of barite occur along or near fault planes. Small but comparatively high-grade deposits (Moccasin Gap type of Ferguson and Jewell, 1951, p. 47) are localized along a bedding-plane fault at the base of a quartzite bed 50 feet thick that dips 50° southeast. The quartzite has been named the Moccasin Gap member of the Unicoi formation by Ferguson and Jewell (1951, p. 22). The zone of extensive shearing and brecciation, which is as much as 7 feet thick, served as a channel for the ascending hydrothermal solutions. This fault zone is well exposed at the Moccasin Gap, Darky Tom, and East Meyer mines.

The mineral assemblage generally consists of ankerite, dolomite, barite, quartz, and pyrite. White, glassy, coarsely crystalline barite occurs in pods and veinlets in the ankerite-rich parts of the fault zone, and to a lesser extent in the lower part of the quartzite hanging wall. Most of the mining has been done where the fault zone is deeply weathered and the ankerite has been leached, leaving fragments of barite in red-brown sandy clay.

Large low-grade deposits of the Williams type of Ferguson and Jewell (1951, p. 47) occur in a shear zone at the base of the upper thrust sheet in the pink arkosic to quartzitic Snowbird formation. The shear zone is as much as 9 feet thick and contains quartz, hematite, barite, fluorite, pyrite, and traces of several copper minerals, all of which have a platy appearance inherited from the previously mylonitized host rocks. The most abundant mineral is quartz discolored by blue-black hematite; locally, as at the Williams mine, the shear zone is composed largely of fine-grained dense barite with lesser amounts of the aforementioned minerals. The average composition of the Williams ore body is reported to be 75 percent barite and nearly 20 percent fluorite (Ferguson and Jewell, 1951, p. 195). The ore body is an elongate lens 3 to 14 feet thick striking N. 65° E. and dipping about 25° south.

The mineral composition of the deposits in the eastern and western parts of the Del Rio district differs so markedly as to suggest a mineral zoning regardless of whether the deposits are of the Williams or Moccasin Gap type. Sericite, specularite, fluorite, and traces of copper are characteristic of the barite deposits in the eastern part of the district; abundant ankerite, little sericite and fluorite, and no specularite are characteristic of the deposits in the western part of the district. Ferguson and Jewell (1951, p. 95) interpret the presence of the higher temperature suites of minerals in the eastern part of the district as an indication that the mineralizing solutions came from an igneous source to the east of the area.

Field and laboratory investigations led Ferguson and Jewell (1951, p. 94) to conclude that the mineralization probably occurred "in the closing stages of the Appalachian revolution in the late Paleozoic but after major tectonic deformation had ceased and after considerable erosion had taken place."

The major thrust faults of the district might be examined carefully for other deposits of barite or for extensions of known ore bodies of the Williams type. Deposits of the Moccasin Gap type might be found by examining the base of the Moccasin Gap quartzite. Ore bodies of this kind generally contain ankerite and crop out as brown-stained ledges or form red-brown soils that are distinctive even where no rock crops out. These veins might be capped at the surface by protruding silicified or jasperoid-limonite ledges.

MIDDLE TENNESSEE DISTRICT

Veins containing barite are widely distributed in the limestones of Ordovician age that crop out on a structural arch in middle Tennessee (Jewell, 1947). The arch trends northeast and is about 100 miles long and 50 miles wide. Most of the veins are in the Carters limestone, but some veins also are in the overlying and underlying limy rocks. The limestones are locally sandy, shaly, or dolomitic. Most of the deposits are within 20 miles of the junction of DeKalb, Smith, and Wilson Counties, but others are in Rutherford, Cannon, Williamson, Trousdale, and Putnam Counties.

According to Jewell (1947), the veins of the Middle Tennessee area occur along northeast-trending faults that generally are not persistent along strike and have a throw of not more than a few tens of feet. The faults are nearly vertical. A few have been traced about 3 miles, but most are much shorter. The displacement is mostly horizontal, or nearly so. The faults are marked by polished walls, zones of breccia 5 to 6 feet wide, and greatly fractured zones as much as 20 feet wide. The mineralized parts of the faults are generally less than 3 feet wide. Faults trending northwest are not mineralized and are considered to postdate the mineralized northeast-trending faults.

The vein minerals generally cement fault-breccia and fractured zones, although some filling of fissures and replacement of limestone fragments has occurred. The veins pinch and swell within short distances both laterally and vertically. Veins 2 feet wide pinch to 2 inches within about 12 feet and then widen again within the same distance. The contacts of the veins with the walls are sharp. Replacement of the limestone has been confined to fragments in the fault zones. Deep alteration of the wall rocks apparently did not occur, and no lateral extensions of the veins as blanket veins or bedded replacement deposits have been reported (Jewell, 1947, p. 19).

Banding parallel to the walls of the veins and concentric bands around fragments in the breccia are common. These bands, as many as a dozen over a distance of a few inches, are locally asymmetrical.

The amounts of the chief minerals barite, fluorite, and calcite, vary greatly from vein to vein and place to place within each vein. Seven chemical analyses of vein material given by Jewell (1947, p. 21) indicate that the content of barite and fluorite is as great as 78 and 86 percent, respectively. Galena and sphalerite are widely distributed in the veins but occur in small amounts, generally under 5 percent. Galena is most common where fluorite is abundant; sphalerite is most common where calcite is abundant. Quartz, dolomite, pyrite, and chalcopyrite occur locally.

The upper parts of the veins are considerably weathered. Calcite and limestone fragments have been leached, leaving a porous mass of barite and fluorite containing molds of the dissolved fragments. Calamine and limonite occur as alteration products. The ultimate result of weathering is soil with lumps of white porous barite and limonite.

Jewell (1947, p. 28) considers the veins to be of the telethermal type originating from hydrothermal solutions in post-Carboniferous time.

BEDDED DEPOSITS

Bedded deposits of massive barite are being mined in Arkansas, Nevada, and Idaho, but several deposits also have been worked in California. The commercial bedded deposits occur almost exclusively in rocks of late Paleozoic age, although some deposits in Nevada occur also in rocks of Ordovician age. The large number of bedded deposits in host rocks of late Paleozoic age in widely separated regions is notable, even if the association is purely coincidental.

Sequences of sedimentary rocks having barite-rich beds or groups of barite-rich beds may contain many rock types including conglomerate, sandstone, shale, and limestone. The shale and limestone sequences contain most of the deposits. The individual beds of barite are generally light to dark gray and range in thickness from a few inches to about 10 feet.

The barite-rich beds may have sharp contacts with adjacent layers having little or no barite. Laterally, the barite-rich layers may pinch out abruptly or the content of barite may gradually diminish. Vertically, the abundance of barite-rich beds may gradually diminish, forming a gradational contact between the deposit and barren rock, or the abundance of barite-rich layers may end abruptly whether or not there is a change in lithology. Most bedded deposits of barite may thus be regarded as barite-rich zones in a sequence of layered rocks. The deposits are generally lenticular. The thickness may be as great as 200 feet, the length 1 mile, and the width one-half mile. Gradational contacts appear commonly in the bedded deposits of Nevada. The ore zone at Magnet Cove, Hot Spring County, Arkansas, has a sharp contact with a soft black shaly bed at its base; the upper contact is gradational to barren rock.

Barite in bedded deposits is generally extremely fine grained and accompanied by quartz and chert; pyrite and secondary iron oxides; dolomite, calcite, siderite, witherite, and strontianite; and clay minerals. The barite of many bedded deposits is fetid and gray, probably from included organic matter. Most of the carbonate minerals cannot be identified in the hand specimen. Witherite appears as an accessory mineral more commonly in the bedded than in the vein deposits. The only commercial witherite mined in the United States occurred in the bedded deposit near El Portal, Mariposa County, Calif.

The grade of ore varies from bed to bed, and may be as high as 90 percent barite. Rock containing 30 percent barite or having a specific gravity of 3.2 is considered the minimum grade for beneficiation by flotation methods.

Sedimentary rocks that contain disseminated barite as oolites, pistolites, nodules, rosettes, "dollars," euhedral to subhedral crystals, and irregular masses are widespread especially in rocks of Permian age in Oklahoma and Texas. The concentrations of barite are small and the grade of these concentrations is generally much less than 50 percent barite. Barite in most of these occurrences is regarded as of mineralogic rather than commercial interest.

Bedded deposits of barite as cement and concretions in the Trinity formation of Cretaceous age in Sevier and Howard Counties, Ark., are being explored.

Evidence for the origin of the bedded deposits of massive and disseminated barite is conflicting and suggests that the barite might have originated either as a primary deposit within the sedimentary rocks or as a secondary deposit formed in the host rocks as a result of replacement by aqueous solutions.

REPRESENTATIVE DISTRICTS AND DEPOSITS

MAZARN BASIN REGION, ARKANSAS

Bedded deposits of barite are in a synclinorium in the southern part of the Ouachita Mountains. The synclinorium is a topographic depression known as the Mazarn basin that is about 10 miles wide and 60 miles long in parts of Saline, Garland, Hot Spring, Pike, Polk, and Montgomery Counties. Bedded deposits of barite are exposed principally at the east and west ends of the structure. The large Magnet Cove deposit, the only one worked in 1954, is at the east end of the basin in the synclinal valley of Chamberlain Creek, about 10 miles northwest of Malvern, Hot Spring County. Geologically similar deposits not yet exploited are in the west end of the basin in Montgomery, Pike, and Polk Counties. Some of the deposits in the Mazarn basin have been described by Parks (1932), McElwaine (1946a, 1946b), and Jones (1948).

The deposits of the Mazarn basin occur principally near the base of the Stanley shale of Mississippian and Pennsylvanian age, but a few deposits occur near the middle of the Arkansas novaculite of Devonian and Mississippian age. Most of the barite has been found in the Mississipian part of the Stanley shale. The beds of barite have the appearance of dense, fine-grained limestone; individual beds are light to dark gray when unweathered and generally range from less than one inch to two feet in thickness. Intercalated with the barite are light and dark beds of shale and sandstone ranging in thickness from that of a knife-blade to 20 inches. Many joint surfaces in these beds are coated with barite crystals.

The barite beds near the surface are soft, earthy, and friable but below the zone of weathering the beds are dense and tough. The barite beds generally are crossed by irregular veinlets less than 0.2 inch wide of pink hematite, formed by the oxidation of pyrite, an accessory mineral in the barite-bearing rocks.

The Magnet Cove deposit, Hot Spring County, is typical of bedded deposits in the Mazarn basin. It occurs in the west-trending asymmetrical syncline that is nearly 2 miles long from its tight closure on the east to its truncation on the west by the alkali-rich rocks of the Magnet Cove intrusive body. The north limb of the syncline dips about 40° south and the south limb is nearly vertical; the structure plunges west about 15°.

The ore body is at least three-quarters of a mile long and approximately 60 feet thick. It contains all grades of ore as well as some layers and lenses of barren rock. The barite beds range in specific gravity from 3.2, considered the cutoff point for commercial ore in 1954, to 4.0, with an average of 3.7 (Parks, 1932, p. 22). A soft fissile black shale forms the footwall of the ore-bearing sequence and also separates the rest of the Stanley shale from the underlying Hot Springs sandstone and Arkansas novaculite. The barite content of the Stanley shale decreases irregularly above the richest part of the sequence with the result that the deposit has no distinct hanging wall.

Barite ore in the richest zone contains more than 70 percent $BaSO_4$. The associated minerals are quartz (the most abundant impurity in the ore), various carbonate minerals, pyrite, and iron oxides. The carbonate minerals include calcite and bromlite (a carbonate of barium, strontium, and calcium). Pyrite generally does not exceed 3 percent of the mine-run ore. Iron oxides color some of the layers and fill minute fractures in the rocks. These minerals are separated from the barite by froth flotation.

The ore body near Magnet Cove is worked by the Baroid Sales Division of the National Lead Company and the Magnet Cove Barium Company, a subsidiary of Dresser Industries. The Baroid Sales Division is mining entirely by open-pit methods on the shallower east end of the ore body. The Magnet Cove Barium Company is mining entirely underground on the deeper west end of the body.

Parks (1932, p. 41) deemed the deposit at Magnet Cove of replacement origin. He suggested that the barium was carried in solution from the parent rocks of the Magnet Cove intrusive body of probable Mesozoic age. These solutions permeated the Stanley shale and migrated up the plunge of the syncline. The barium was precipitated as the sulfate by chemical action or a decrease in temperature or pressure, or some combination of these factors. Pyrite crystals were emplaced more or less parallel to the bedding. Surface waters subsequently penetrated the rocks, partly altering the pyrite to iron oxides.

Ten specimens of igneous rock collected from the Magnet Cove complex by Mr. Ralph Erickson and recently analyzed by the U. S. Geological Survey contained 0.06–1.52 percent BaO. Five of the specimens, including some of the most common rocks in the complex, contained nearly 0.3 percent BaO. One sample of feldspar contained about 2.5 percent BaO. These analyses seem to support Parks' conclusion.

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The origin of the deposits in Montgomery and adjacent counties could only be speculated upon because these deposits have not been studied in detail. Alkalic igneous rocks similar to those at Magnet Cove, however, do not crop out.

NORTH-CENTRAL NEVADA

Bedded deposits of barite are abundant in north-central Nevada in a belt about 20 by 100 miles in Lander, Eureka, and Elko Counties, Nevada. The geology of these barite deposits in northern Nevada has been reviewed briefly by Gianella (1940). More than 25 mines and prospects have yielded ore or show promise of being commercially exploitable, especially for barite of the grade used in drilling-mud. Production from this area placed Nevada third in the rank of barite-producing States for 1954.

Most of the barite mining in 1954 was done in the larger bedded deposits of the Shoshone Range near Battle Mountain (table 10, Nevada 5 and 9). The range is a fault-block mountain trending north, with a steep west face and a gentle east face. The barite is interlayered with sandstones, shales, and limestones of Devonian or possibly Triassic age (Keith Ketner, oral communication). The sedimentary rocks and the barite deposits follow the general structural pattern of the range, although locally the structure is greatly complicated by faults.

Beds or zones of dense, fine-grained, gray to black, fetid barite ore containing as much as 97 percent $BaSO_4$ are generally 4 to 8 feet thick and have sharp contacts with interlayer lower grade ore (80 percent or less $BaSO_4$) or barren rock. The barite occurs in belts as long as one-half mile and one-fourth to one-half mile wide. Silicification along certain layers, faults, and fractures has caused considerable irregularity in grade of ore over short distances. Some disseminated chert, pyrite, trace amounts of other metallic sulfides, and accessory amounts of witherite are associated with many of the deposits.

Other bedded deposits of barite occur in the Paleozoic rocks of north-central Nevada and appear to be very similar to those of the Shoshone Range.

HAILEY DISTRICT, IDAHO

The Sun Valley mine (Bonnie and Barium Sulphate claims) in sec. 31, T. 3 N., R. 17 E., is near Hailey, Blaine County. The deposit is on the ridge between Ajax Creek and the north fork of Deer Creek, and has yielded most of the barite produced in Idaho. The barite occurs in lenticular masses in the Wood River formation of Pennsylvanian age. The attitude of the barite follows the regional structural trend which strikes about N. 50° W. and dips 50° SW. This trend is locally distorted by faults, one of which apparently forms the northeast boundary of the deposit. The exposed area of the deposit is about 2,000 feet by 200 feet.

The barite seems to be a replacement of sandstone, argillite, and limestone. Silicification has occurred in the rocks near the faults and fractures; the grade of barite improves away from the silicified zones. The best grade of ore is 84 to 88 percent barite (Kiilsgaard, 1950, p. 60), but this ore is mixed with leaner ore necessitating selective mining. Some of the ore is iron stained; it generally has a higher specific gravity than the unstained ore.

EL PORTAL, CALIFORNIA

The deposit at El Portal, Mariposa County, Calif., has yielded about 75 percent of the barite mined in the State and most of the witherite mined in the United States. This deposit, idle since 1948, has been described by Harding (1941) and Fitch (1931). The barite and witherite replace limestone associated with the slate, phyllite, and schist of the Calaveras formation of late Paleozoic age. The ore occurs in two distinct belts about 1,200 feet apart. Each belt strikes north and dips east. The lenses of ore, as much as 20 feet thick and 100 to 200 feet long, have sharp contacts with the enclosing isoclinally folded limestone and metasedimentary rocks.

The composition of the ore is 85 percent barite, 2 to 3 percent witherite, 0.5 percent pyrite, and 12 to 13 percent silica (Julihn and Horton, 1940, p. 169). Much of the ore is banded and retains the structure of the original rocks.

The deposit is cut by the west-flowing Merced River; both parts of the deposit have been mined. The deposit is truncated on the north by a small boss of granodiorite. The limestone adjacent to the granodiorite has been altered to calc-silicate rocks by contact metamorphism. The barium might have been derived from solutions emanating from the Sierra Nevada batholith.

Another deposit similar to the one at El Portal and on the same structural trend occurs several miles to the south on the Egenhoff property in sec. 17, T. 4 S., R. 20 E. The area is mountainous and quite inaccessible.

RESIDUAL DEPOSITS

Residual barite deposits occur in unconsolidated material and are formed from the weathering of pre-existing deposits. Following Hull's usage (1920, p. 14), the restriction of weathering "in place" is omitted from the definition so as to include accumulations in alluvium and colluvium that might supplement the deposits formed in place. Stream and frost action, soil creep, and gully wash are the principal agents in what might be called a secondary accumulation in alluvium and colluvium. Many residual deposits have commercial or potential commercial value. They are particularly abundant in the Eastern and Midwestern States, especially Virginia, Alabama, Georgia, Tennessee, and Missouri, where the deposits are in the residuum of sedimentary rocks, especially the readily soluble limestones and dolomites of Cambrian and Ordovician age.

Most of the residual barite is white, and translucent to opaque; it occurs in mammillary, fibrous, or dense fine-grained masses. Subhedral to euhedral crystals also occur. The surface of the barite is pitted and stained with clay. Some masses or crystals are covered with quartz crystals. Residual barite derived from circle or solution channel deposits forms dense white masses with rough to rounded surfaces. Pieces of barite containing molds of dissolved fragments of wall rock have been found. Pyrite, galena, and sphalerite occur in or on some barite, and locally lead or zinc may be byproducts of barite mining. Chert and jasperoid also are abundant in many deposits. Undissolved rock fragments and red, yellow, or brown clay make up the rest of the deposit.

The barite masses of residual deposits range from microscopic particles to irregular boulders weighing hundreds of pounds. Most masses, however, range from 1 to 6 inches in the greatest dimension.

The grade of ore in residual deposits varies greatly because of the nature of the original deposit and the degree of concentration of barite in the residuum. Many residual deposits contain an average of 12 to 20 percent barite but may contain more than 50 percent barite. Many miners of residual deposits express the grade of ore in pounds of barite recovered per cubic yard of residuum processed at washer plants. In 1954 the operators considered the recovery of 150 pounds of barite per cubic yard of residuum processed to be the minimum grade for a profitable operation. Deposits formed on gentle slopes generally are of higher grade than those formed on the hilltops; this is especially true of the deposits in Georgia and Missouri. The probable reason is that more clay was washed away on the slopes during the formation of the deposit, resulting in greater concentration of the barite per unit volume.

The size and shape of the residual deposits vary greatly. Some of the larger deposits mined in Missouri, Georgia, and Tennessee extended over several hundred acres and contained many thousands of tons of barite. The shape of most residual ore bodies is dependent upon the shape of the original deposit.

Residual deposits from solution channels tend to be elongate. Those derived from the circle deposits of Missouri are generally circular, although they probably cover an area larger than that of the original deposit, and are among the richest residual deposits known.

Deposits derived from veins are generally elongate, as are those derived from the weathering of mineralized fault zones. In some areas it is impossible to distinguish the original type of deposit. Barite from these deposits locally contains inclusions of pyrite, galena, and sphalerite. Some deposits also contain mineralized fragments of chert.

Residual deposits derived from bedded or replacement deposits commonly are large. In general, fragments from beds of fine-grained barite are angular. Barite from incompletely replaced beds is porous. Barite in residual concentrations derived from beds containing oolites, pisolites, rosettes, and disseminated crystals of barite would probably retain enough of their characteristics to make the origin of the deposit readily identifiable. Concentrations of these latter kinds of barite occur in Oklahoma, but few of them are currently regarded as commercial.

The depth of residual deposits varies according to local conditions. Some residual deposits in Georgia terminate at the contact with bedrock as deep as 150 feet beneath the surface; other deposits in Missouri terminate on bedrock at 10 to 15 feet beneath the surface. The contact of the residual barite and clay with bedrock generally is very irregular. Pillars or ribs of bedrock protruding into, and even through, the residuum are common in many residual deposits. Ribs are prominently exposed at the Ballard (Krebs) mine in Monroe County, Tenn. The barite may be randomly distributed throughout the residuum but is concentrated in many deposits near the contact of the residuum with the underlying bedrock. The general relations of residual deposits to bedrock are shown in figure 3.

The occurrence of large boulders of barite is an important feature of residual deposits. In few instances does bedrock exposed at many mines or elsewhere in the mining districts rarely contain veins more than a few inches thick. The relation of thin veins in bedrock to boulders several feet in diameter and weighing hundreds of pounds in the residuum is not clear. Some of these large boulders might have come from the weathering of thick veins or bedded deposits. Perhaps some factors bearing upon the solubility and redeposition of barite are unknown. Many problems in the geochemistry of weathering and the accumulation of residual deposits need further investigation.

REPRESENTATIVE DISTRICTS

WASHINGTON COUNTY DISTRICT, MISSOURI

The Washington County district, Missouri, about 50 miles southwest of St. Louis, includes also parts of St. Francois, Jefferson, and

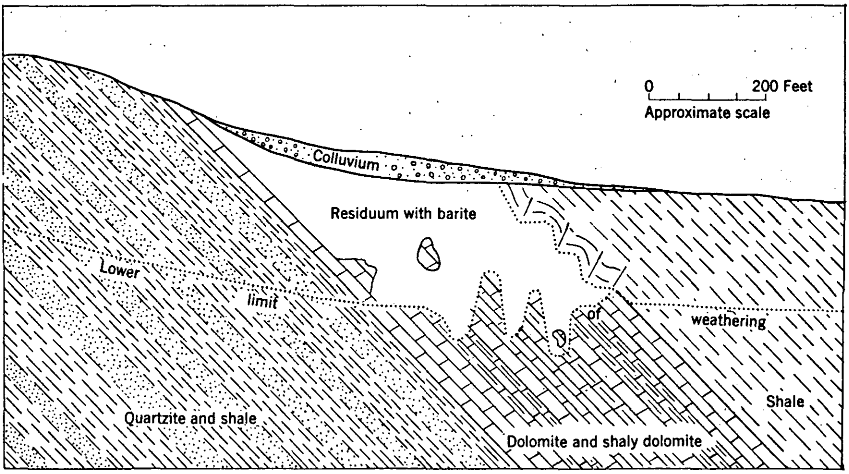


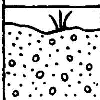
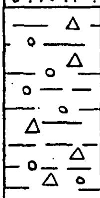
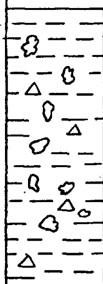
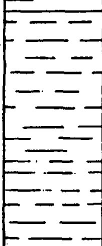
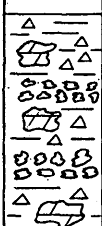
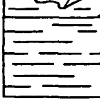
FIGURE 3.—Relations of residual deposits to bedrock in Cartersville, Ga.

Franklin Counties. The barite occurs chiefly in residual clay derived from the underlying Potosi and Eminence dolomites of Late Cambrian age. The red residual clay is plastic and free of grit and ranges in thickness from 1 to 50 feet, with an average of 10 to 15 feet.

Most of the barite is opaque and pure white on fresh surfaces, although the outside generally is covered by a thin film of limonite that is removable by washing. Some lumps composed of tabular crystals are friable; the sharp edges can be crumbled and broken off by hand. Hard transparent or translucent crystals of barite are rare. The barite fragments range from particles of clay size to masses weighing several hundred pounds. Most of the fragments are between one-half inch and six inches across. Many of the larger lumps have cavities lined with limonite scale one thirty-second inch to one-sixteenth inch thick. This limonite clings to the barite, even though the wash process, in contrast to the limonite films previously mentioned, and is the chief source of iron in the final washed product. The barite of these deposits also is associated with chert, chalcedony, drusy quartz, and lesser amounts of sphalerite, galena, pyrite, and marcasite.

Many of the deposits are as large as 100 acres, and as thick as 4 to 30 feet. The best deposits occur on the slopes of hills where the barite may be partly concentrated by removal of the clay during the course of weathering. Few large, rich deposits are found on the hilltops or in the valleys. In places the barite is uniformly distributed through the clay but generally it is concentrated in layers.

The concentrations are 10 to 20 feet wide and several hundred feet long. A typical profile in the residual soil of Washington County given by Weigel (1929, p. 12) is reproduced in figure 4.

Section	Unit	Minimum thickness, (feet)	Maximum thickness, (feet)
	Surface soil		1.5
	Chert, gravel, and clay	1.5	2
	Clay, barite, chert and quartz; barite in small fragments, not over 2 inches	2.5	4
	Red clay, dark, practically barren	3	4
	Red clay, large chert and dolomite boulders, and large masses of barite, locally in almost continuous layers 4 to 6 inches thick and several square feet in horizontal extent	1	2.5
	Red clay, practically barren; depth to bedrock not exposed		

After Weigel, 1929, p 12

FIGURE 4.—Generalized profile in the residual deposits of barite in Washington County, Mo.

Some deposits contain as much as 20 to 25 percent barite. According to Weigel (1929, p. 12), some deposits averaged less than 10 percent barite.

Production of barite from bedrock in the Washington County district has been negligible because the few veins and stringers of barite observed are too narrow, generally less than one inch across, and too discontinuous to be mined profitably.

SWEETWATER DISTRICT, TENNESSEE

The Sweetwater district in parts of McMinn, Monroe, and Loudon Counties has yielded most of the barite mined in Tennessee. The geology and ore deposits of this district have been described by Gordon (1918), Laurence(1939), and Gildersleeve (1946). The barite occurs with fluorite and pyrite in veins or shatter zones in the upper part of the Knox group of Cambrian and Ordovician age and is concentrated in the overlying residual clays. Only the residual deposits have been exploited commercially. The best of these are in clays derived from the limestone member at the base of the Kingsport formation. Some deposits are in the residuum of Mascot dolomite above the Kingsport and some also are in residuum of the Longview dolomite below the Kingsport.

The residual deposits occur along three narrow parallel northeast-trending belts separated by barren zones. The three belts are on fault blocks bounded by southeast-dipping thrust faults (Rodgers, 1952). The regional strike of the rocks is N. 50° E. and the dip is 10° to 20° southeast. Workable residual bodies of ore occur at irregular intervals along the three belts that are 100 to 300 feet wide. The eastern belt has yielded the most ore, chiefly from the Ballard (Krebs) and Stevens mines in the southwesternmost 5 miles of the belt, south of Sweetwater. This belt is about 20 miles long, where the middle and western belts probably are about 40 miles long. Some of the larger residual deposits extended over 10 to 12 acres and were worked to bedrock at a depth of 125 feet.

A layer of red clay as much as 6 feet thick covers the barite-rich clays at some places. Barite occurs as fragments and boulders as large as 1 ton. The amount of chert associated with the barite deposits is least in the eastern belt and increases in both the middle and western belts. The chert is almost black when fresh, but weathers to gray or white. Primary pyrite is altered to iron oxides in the residual deposits. Fluorite is generally absent.

CARTERSVILLE DISTRICT, GEORGIA

The residual barite deposits at Cartersville, Bartow County, Georgia, have been studied in detail by Hull (1920) and most recently by

Kesler (1949, 1950) who reports that the productive part of the district, containing about 35 mines, has a length of 4.5 miles with a northerly trend and a width of about 2 miles. The ore deposits of the district are associated with rocks of Early Cambrian age—the Weisner, the Shady, and the Rome formations—listed in ascending order.

The Weisner formation, in the Cartersville district, is more than 1,000 feet thick and consists chiefly of micaceous shale with many intercalcated layers of quartzite, a few beds of conglomerate, metasiltstone and crystalline limestone. The rocks of this formation are resistant to weathering and therefore crop out on the ridges. Nearly all of the ridges are asymmetric anticlines.

The Shady formation, a discontinuous unit between the Weisner and Rome formations attains a maximum thickness of 30 feet. It consists of a sequence of beds of siliceous specular hematite and thin beds of dolomite that are fossiliferous at places. In the zone of weathering the dolomite is leached and the hematite is altered to ocherous and umberous clays in which the original bedding planes are preserved; locally they have been distorted by slumping. This feature of weathering of the Shady formation is in marked contrast to the weathered Rome formation where the original structures generally have not been preserved.

According to Kesler (1950, p. 12) the Rome formation in the Cartersville district has two members; one contains crystalline carbonate rocks and the other metashale. The carbonate rocks are largely dolomite and are 500 to 1,200 feet thick. A few pinnacles and boulders of dolomite remain in the baritic residual clays over the dolomite. The residual clay is derived not only from the insoluble residue of the dolomite but also from the constituents of the former overlying shales. All of the residual material from the shale and dolomite has been thoroughly mixed by slumping into caverns and sinkholes. The clays derived from the Rome formation occur on the slopes of the ridges and parts of the adjacent valleys. These clays are yellow to brown, tough, and are over 100 feet thick in many places. The clay weighs about 140 pounds per cubic foot in place.

On the lower slopes of the ridges the residual clays containing the barite generally are covered by a mantle of red clay that averages 20 to 50 feet in thickness and contrasts markedly with the color of the clays underneath. This colluvial clay is extremely ferruginous and, because of its position above the barite-rich clays, makes prospecting for barite more complicated. The relations of the Cambrian rocks and the clays are shown in figure 3.

The residual clay that forms the matrix for the barite also contains other hard fragmental materials, the most common of which are angular pieces of jasperoid stained yellow by ferric hydroxide. Kesler (1949, p. 372) reports that thin sections of jasperoid show inclusions of fine-grained dolomite and have relict textures and structures of dolomite. Residual clay on lower slopes of the ridges also contains some boulders of Weisner formation which crops out farther up the slopes. Flakes and pieces of partly hydrated specularite from the Shady formation also are mixed with the residuum and are the chief source of the iron that contaminates the barite ore.

The barite of the residual deposits is similar to that exposed in the scattered and irregular veins in the dolomite. The fragments are irregular and range from a fraction of an inch to about 4 feet in diameter, although the average is probably less than 6 inches. The fragments are generally aggregates of coarse white to blue-white crystals that also contain small amounts of quartz and sulfides. The sulfide minerals are pyrite, galena, sphalerite, chalcopyrite, and tennantite, all of which have been destroyed largely by weathering. All of these, except pyrite, occur in amounts so small that they can be found only by microscopic examination. The pyrite weathers to limonite that occurs as films on, or cavity fillings in, the barite, or even as large discrete masses a foot across.

The content of barite in the residuum varies greatly, and no established minimum average grade for profitable operation can be given because of such factors as accessibility of the deposit, length of haul to the mill, amount of overburden, and method of concentration. Averages of recoverable barite from large deposits ranged from 11.8 to 17.5 percent of the material moved (Kesler, 1950, p. 51–52). Most of the richest and easiest to mine deposits have been exploited; these mines yielded one long ton of barite for 2.9 to 4.6 cubic yards of residuum in place. These figures include the stripping of the overburden. In the remaining deposits the concentration ratio is five or more cubic yards for each ton of concentrates. This ratio does not include overburden to be stripped.

Kesler (1949, p. 372) reports that the barite and other minerals originally were deposited in and near faults in the dolomite near the close of deformation in late Carboniferous time. The barite deposits are associated with three differently oriented fracture sets striking N. 25° E. to N. 25° W., N. 65° W., and N. 55° E. Some dolomite and vein carbonate in the fractures were replaced by silica after deposition of the barite. Brecciated barite commonly is included in the veins and silicified wall rock, thereby indicating that movement along the faults continued after the emplacement of the barite.

BARITE DEPOSITS IN THE UNITED STATES

Table 10 lists most of the barite deposits in the United States, summarizes their geology, and cites literature containing further information. Additional literature describing these deposits is listed in the annotated bibliography of barite deposits in the United States (Dean and Brobst, 1955). The number of each deposit in the listings by State on table 10 corresponds to the number for each district, mine, or prospect in the various states on the index map (plate 1).

MINING AND BENEFICIATION

Vein and bedded deposits can be mined either by open-pit or underground methods, depending on local conditions.

Some beneficiation of ore from vein and bedded deposits by gravity or flotation, or both, is usually necessary. Gravity separation of barite from other materials entails crushing, washing, jigging, and perhaps tabling. This process may then be followed by flotation for the recovery of fine barite.

Ore from the bedded deposit at Magnet Cove, Ark., is finely ground so that the material will pass through a screen of 325 mesh before going to the flotation cells. This process recovers 90 percent of the barite in a product with a specific gravity of 4.4 that is 98 percent barite.

Residual deposits generally are mined by power shovels in open pits after overburden has been removed. The mining of shallow deposits, as in Missouri, caused some land utilization problems. The stripping of top soil and the digging of pits rendered land unfit for further use. Some rehabilitation has been practiced.

The ore from residual deposits is commonly beneficiated in simple log-washer and jig plants, with or without tabling. The use of log washers and jig combinations in many plants results in the recovery of 80 percent of the barite. When shake tables are added to the circuit, the recovery can be increased to about 90 percent. Cleaned crude ore from residual deposits generally consists of fragments of barite one-half to three-quarters of an inch in diameter.

Technical information about the processes of beneficiation and the results obtainable by different methods are available in the literature (Fine and Kennedy, 1948; Frommer and Fine, 1952; O'Meara and Coe, 1936; Santmyers, 1930; Harness and Barsigian, 1946; Zadra and others, 1952; Ralston, 1938).

EXPLORATION

Many of the barite companies are engaged in active programs of exploration for new deposits. Methods of exploration vary, depending

TABLE 10.—*Barite deposits in the United States*

No. (by States) on plate 1	District, mine, or prospect	Mode of occurrence	Host rock	Remarks	Reference
Alabama					
1	Sinks district, Bibb County	Residual	Newala limestone of Ordovician age.	Deposits in residual clay overlying bedrock containing thin veins of barite.	Adams and Jones (1940).
2	Longview-Saginaw district, Shelby County.	do	do	do	Do.
3	Vincent-Harpersville-Wilsonville district, Shelby County.	do	do	do	Do.
4	Leeds, Jefferson County	do	do	do	Do.
5	Beaver Creek Valley, St. Clair County, and Greens Valley, Etowah County.	do	do	do	Do.
6	Angel Station district, Calhoun County.	do	Chepultepec dolomite of Early Ordovician and Copper Ridge dolomite of Late Cambrian age.	do	Do.
7	Southern Cleburne County	Veins	Ashland mica schist of Precambrian age.		Do.
8	Southeastern Cherokee County	do	Weisner formation of Cambrian age.	One prospect	Do.
Arizona					
1	Macco (Christman, Ariz. Barite Company) mine, Maricopa County.	Veins 5 to 20 feet wide along fault zone.	Granite of Precambrian age. Conglomerate, basalt, dacite, and rhyolite of Tertiary age.	Deposit being mined for barite in 1954.	Wilson and Roseveare (1949).
2	Castle Dome district, Yuma County.	Veins	Shales, impure limestone of Cretaceous age, and dioritic and rhyolitic dikes of post-Cretaceous age.	Barite gangue with argentiferous galena and fluorite.	Wilson (1933).
3	Ernest Hall property, Yuma County.	do		In Cottonwood Pass, near Salome, yielded several carloads in 1938. No other data.	Wilson and Roseveare (1949).
4	McCracken lead mine, Mohave County.	Two veins 6 to 20 feet wide.	Metamorphic complex of Precambrian age. Intrusive igneous rocks of Tertiary age.	Barite with quartz, carbonates, and galena.	Bancroft (1911).
5	Neversweat district, Yuma County.	Vein in brecciated fault zone.	Schist of Precambrian to Mesozoic age.	Crystalline barite with massive gypsum in a vein with silver at the Nottbusch or Silver Prince mine.	Wilson (1933).

6	Renner mine, Yuma County	Vein in fault zone	Gneiss of Precambrian to Mesozoic age.	Generally less than 2 feet thick but several thousand feet long. Barite as white to pink radiating crystals. Mined in open cut.	Do.
7	Sheep Tanks district, Yuma County.	Veins in fault breccia	Volcanic rocks of Tertiary age	Barite gangue with gold, silver, and lead.	Do.
8	Silver district, Yuma County	Veins in fault zones	do	Barite gangue with base metal sulfides.	Do.
9	Silver Belt mine, Yavapai County	Vein, 15 to 20 feet wide	Amphibole schist of Precambrian age.	Barite and ankerite with some argentiferous galena and sphalerite.	Lindgren (1926).
			Arkansas		
1	Bear Creek prospect, Pike County	Residual	Stanley shale of Mississippian and Pennsylvanian age.	Covered by reservoir of Narrows dam on Little Missouri River.	Jones (1948).
2	Bee Mountain, Boar Tusk Mountain; and Two Mile Creek prospects, Polk County.	Bedded	Arkansas novaculite of Devonian Mississippian age.		Do.
3	Boone Springs Creek, Fancy Hill, Gap Mountain, Polk Creek Mountain, and Sulphur Mountain prospects, Montgomery County.	do	Arkansas novaculite of Devonian and Mississippian age and Stanley shale of Mississippian and Pennsylvanian age.		Do.
4	Cossatot River prospect, Polk County.	do	Arkansas novaculite of Devonian and Mississippian age.		Do.
5	Magnet Cove deposit, Hot Spring County	do	Stanley shale of Mississippian and Pennsylvanian age.	One of the largest deposits in the United States.	McElwaine (1946); Parks (1932).
6	Mill Creek prospect Pike County; and Pigeon Roost Mountain deposit, Montgomery County.	do	do		Jones (1948).
7	Viles Creek prospect, Polk County	do	Arkansas novaculite of Devonian and Mississippian age and Stanley shale of Mississippian and Pennsylvanian age.	Barite occurs between the two formations.	Do.

TABLE 10.—*Barite deposits in the United States*—Continued

No. (by States) on plate 1	District, mine, or prospect	Mode of occurrence	Host rock	Remarks	Reference
California					
1	Afterthought prospects and Austin quarry, Shasta County.	Veins	Basic igneous rocks of Tertiary age.	Veins a few inches of 8 feet wide.	Averill (1939).
2	Almanor district, Plumas County.	Bedded	Quartzite and limestone in the Calaveras formation of late Paleozoic age.	Cameron, Savercool, and Synthetic Iron Color Company mines. Work ceased in the district in 1953.	Averill and others (1951).
3	Barite Nos. 1 and 2 claims (Noble prospect on Beegum Creek), Shasta County.	Veins		Deposit possibly truncated by fault or slide at depth. Barite 5 feet wide in cut.	Bradley (1930).
4	Barstow area (Ball, Barium Queen, Big Medicine, Lead Mountain, and Silver Spar mines), San Bernardino County.	do	Metamorphic rocks of Pre-Cretaceous age and sedimentary and volcanic rocks of Tertiary age.	The veins follow faults	Durrell (1954); Wright and others (1953).
5	Bidwell ranch prospect and Exposed Treasure Nos. 1 and 2 claims, Shasta County.	do	Diorite of Tertiary(?) age	Was not considered commercial in 1939.	Averill (1939); Bradley (1930).
6	Democrat mine, Nevada County	Bedded replacement body		Incomplete data. The mine has yielded commercial ore.	Bradley (1930); Logan (1941).
7	El Portal and Egenhoff mines, Mariposa County.	Bedded	Slate, phyllite, and schist of the Calaveras formation of late Paleozoic age.	The mine at El Portal had yielded 75 percent of the barite mined in California until its closing in 1948. The Egenhoff mine is in inaccessible mountain country.	Fitch (1931).
8	Gabilan (Fremont) Peak deposit, Monterey County.	do	Silicified limestone with dolomite	Age of host rocks not given. No shipments since 1920.	Bradley (1930).
9	Glidden Co. (Loftus) deposit, Shasta County.	do	Slate and limestone of Devonian or Carboniferous age.		Averill (1939).
10	Gunter Canyon deposit, Inyo County.	Veins	Slate and schist of Cambrian age		Bradley (1930).
11	Hansen barite mine, San Bernardino County.	do	Sedimentary and volcanic rocks of Tertiary age.	Ore is associated with faults	Durrell (1954).
12	LaBrea deposit (Eagle mine), Santa Barbara County.	Vein	Sandstone	Age of host rock not given. A vein 25 feet wide pinched out 30 feet from the surface.	Bradley (1930).
13	Liscom Hill, Humboldt County	do		No other geologic data available	Do.
14	Mountain Pass deposits, San Bernardino County.	Veins	Metamorphic and igneous rocks of Precambrian age.	This district has a large potential to produce barite as a coproduct of mining for the rare-earth minerals.	Olson and others (1954); Zadra, Engel, and Shedd (1952).

15	Poso Baryta deposit, Tulare County.	do	Quartz diorite of Jurassic age	Vein outcrops are 10 to 70 feet wide and average 20 feet. Outcrops traced continuously over 4,000 feet.	Tucker and Sampson (1938).
16	Red Hill deposit, Orange County	do	Sandstone of Tertiary age	Barite with cinnabar	Bradley (1930).
17	San Dimas Canyon deposit, Los Angeles County.	Bedded		On the west side of the canyon 8 miles northwest of the town of San Dimas.	Winston (1949); Bradley (1930).
18	Spanish mine, Nevada County	do	Slate of the Calaveras formation of late Paleozoic age.	Two beds of barite about 4 feet thick occur 25 to 30 feet apart, stratigraphically.	Logan (1941).
19	Warm Springs Canyon deposit, Inyo County.	Vein		Outcrop 6 to 8 feet wide. Discovered in 1937.	Tucker and Sampson (1938).
			Colorado		
1	Hartsel, Park County	Veins 1 to 2 feet wide and layers 2 inches to 3 feet thick.	Limestone in the Maroon formation of Permian and Pennsylvanian age.		Howland (1936).
2	Wet Mountains, Custer County	Veins in shear zones	Complex of igneous and metamorphic rocks of Precambrian age.	Red to white barite occurs with thorite. Barite might be a coproduct.	Christman and others (1953).
3	Sunshine Canyon deposit, Boulder County.	Vein	Granite of Precambrian age	Barite mined in 1916	Argall (1949).
	Other areas			Barite is gangue in many veins mined for base and precious metals; in tungsten veins, Boulder County; with gypsum in limestone, Park County.	Do.
				Occurrences are reported in Lake, Las Animas, Ouray, Pueblo, Grand, Gunnison, Mesa, and San Miguel Counties.	Larrabee and others (1947); Vanderwilt (1947).
			Connecticut		
1	Cheshire, New Haven County	Veins	Sandstone and arkose of Triassic age.	Jinny Hill mine closed in 1878 after yielding 160,000 tons of barite.	Harte (1945); Hill (1917)

TABLE 10.—*Barite deposits in the United States*—Continued

No. (by States) on plate 1	District, mine, or prospect	Mode of occurrence	Host rock	Remarks	Reference
			Georgia		
1	Kingston prospects, Bartow County, and Bass Ferry prospects, Floyd County.	Residual	Knox dolomite of Cambrian and Ordovician age.	Probably small deposits	Hull (1920).
2	Cartersville district, Bartow County.	do	Weisner formation, and (A) Shady dolomite and (B) dolomite of Rome formation, all of Cambrian age.	Large commercial deposits. Different terms for same host rocks (A) Hull (1920), (B) Kesler (1950) Kesler's work is the newest detailed study of the district.	Hull (1920); Kesler (1950).
3	Eton district, Murray County, and Ruralvale deposit, Whitfield County.	do	Conasauga limestone of Cambrian age and the Knox dolomite of Cambrian and Ordovician age.	District is 3.5 miles long, 0.5 mile wide. Small deposits.	Hull (1920).
4	Plainville area, Floyd and Gordon Counties.	do	Conasauga limestone of Cambrian age.	Small deposits of good ore	Do.
5	Stilesboro prospect, Bartow County.	do	Knox dolomite of Cambrian and Ordovician age.	Small accumulations	Do.
6	Waleska deposit, Cherokee County.	Bedded replacement	Quartzite in Ocoee series of Precambrian(?) age.	Ore, in place, is sharply defined lens or layer.	Do.
			Idaho		
1	Meyers Cove, Lemhi County	Veins with fluorite and stibnite.	Volcanic rocks of Permian and Tertiary age.	Barite might be a coproduct of mining for fluorite.	Cox (1954).
2	Sun Valley mine, Blaine County	Bedded	Sandstone, shale, and limestone of Wood River formation of Pennsylvanian age.	This mine has yielded most of the barite in Idaho.	Kiilsgaard (1950).
			Illinois		
1	Kentucky-Illinois fluorspar dist., Pope and Hardin Counties, Ill.	Veins and bedding-replacement deposits associated with faults.	Limestones of Mississippian age	Fluorspar is of commercial values; barite might be a coproduct in some deposits.	Bastin (1931); Williams and Duncan (1955).

			Kentucky		
1	Central district, (Anderson, Bourbon, Boyle, Clark, Fayette, Franklin, Garrard, Harrison, Henry, Jessamine, Lincoln, Madison, Mercer, Owen, Scott, and Woodford Counties).	Steeply dipping veins and fault breccia fillings with barite, fluorite, calcite, sphalerite, and galena.	Limestones, shales, and sandstones of Ordovician age.	Replacement of wall rocks is of minor importance. Faults are post-Pennsylvanian and pre-Late Tertiary.	Robinson (1931).
2	Western Kentucky fluorspar district, (Crittenden, Caldwell, and Livingston Counties).	Vein and bedded replacement deposits associated with faults.	Limestones, shales, and sandstones of Mississippian age.	"Barite is common in a few veins but is very rare in most" (Williams and Duncan, 1955, p. 5). Fluorspar is of commercial value. Many authors contributed to Bull. 1012, published in 6 chapters.	U. S. Geol. Survey Bull. 1012 (see Williams and Duncan, 1955).
			Maryland		
1	Johnsville mine, Frederick County	Bedded lens	Limestone of the Loudon formation of Cambrian age.	Reported as the only mine operated for barite in the State.	Ostrander (1942).
2	Saûble quarry, Frederick County	Veins	do	Veins of barite exposed in a limestone quarry.	Watson and Grasty (1915).
			Missouri		
1	Central district, mostly in Cole, Miller, Moniteau, and Morgan Counties.	Residual and vein (circle) deposits.	Gasconade and Jefferson City dolomites and the Roubidoux formation of Ordovician age, and the Burlington limestone of Mississippian age.	Circle (see text) and residual deposits are commercially important. District includes parts of 16 counties.	Mather (1946, 1947).
2	Graniteville occurrence, Iron County.	Vein	Granite of Precambrian age		Tarr (1932).
3	Houston mine, Texas County	Cement in collapse breccia	Jefferson City dolomite of Ordovician age.	Blue barite in an isolated deposit worked during 1941 and 1942.	Kidwell (1946).
4	Southeastern (or Washington County) district Franklin, Jefferson, St. Francois, and Washington Counties.	Residual	Potosi and Eminence dolomites of Cambrian age.	One of the most important barite mining areas of the United States.	Dake (1930); Tarr (1918, 1919, 1932).

TABLE 10.—*Barite deposits in the United States*—Continued

No. (by States) on plate 1	District, mine, or prospect	Mode of occurrence	Host rock	Remarks	Reference
Montana					
1	Greenough area, Missoula County	Vein	Missoula group of Precambrian age and intrusive igneous rocks of late Mesozoic or Tertiary age.	F and S mine in operation during 1954. Barite used in oil industry.	Anonymous (1953).
2	Patte Canyon and Rattlesnake Creek, Missoula County.	Veins with specular hematite.	Missoula group of Precambrian age.	Regarded by Rowe as of possible commercial value.	Rowe (1928).
	Other occurrences			Near Ekalaka, Custer County; Wibaux County; and Dawson County.	Rowe (1908).
				In Musselshell, Pondera, Madison, Phillips Counties, and Glacier National Park.	Knechtel and others (1948).
				Minor occurrences near Dillon, Beaverhead County; Bernice, Jefferson County; Red Lodge, Carbon County; and near Libby, Lincoln County.	
Nevada					
1	Austin (Reese River district), Lander County.	Veins	Monzonite of Jurassic(?) age		Vanderburg (1939); Ross (1953).
2	Contact deposit, Elko County				Gianella (1940, 1941).
3	Eagleville district deposit, Churchhill County.	Vein	Altered volcanic rocks of Tertiary(?) age.	Barite occurs with silver and gold.	Do.
4	Ellendale deposit, Nye County				Stoddard (1932).
5	Hilltop district, Lander County, (Bateman and Lewis Canyons deposits and Starr Grove mine).	Bedded and vein	Limestones and shales of Devonian(?) or Triassic(?) age.	Some igneous intrusive and extrusive rocks in the area. Some of the barite deposits are in rocks of Devonian(?) or Triassic(?) age according to Keith Ketner (oral communication).	Gianella (1940, 1941).
6	Lone Mountain deposit, Esmeralda County.	Vein	Dolomite, limestone, and shale of Paleozoic age.	Near Tonopah	Hill (1917).
7	Lynn district (Boulder Flat, Simon Creek, Rossi mine), Eureka County.	Veins	Limestone and shale of Carboniferous age.		Gianella (1940, 1941).

8	Maggie Creek deposit, Eureka County.	Vein	Shale of Carboniferous(?) age	Vein 10 feet wide. Deposit explored to depth of 75 feet.	Vanderburg (1939).
9	Mountain Springs, Nevada, Valley View, and Greystone barite mines, Lander County.	Bedded	Chert and banded shale of Devonian(?) or Triassic(?) age.	Greystone and Mountain Springs deposits being mined in 1958.	Gianella (1940, 1941).
10	Pine Valley deposit, Elko County	Vein	Limestone of Paleozoic(?) age		Do.
			New Mexico		
1	American fluorspar group, Socorro County.	Vein	Limestone of the Madera formation of Pennsylvanian age.	Barite occurs with calcite, quartz, galena, and fluorite.	Clippinger (1949).
2	Derry district, Sierra County	do			Northrop (1944).
3	Bear Canyon district, Devils Canyon, and White Spar mines, Dona Ana County.	Bedded	Fusselman limestone, brucite-serpentine marble in Fusselman limestone of Silurian age and the El Paso limestone of Ordovician age.	Marble is result of contact metamorphism by quartz monzonite of Tertiary age.	Dunham (1935); Clippinger (1949).
4	Dewey mine, Socorro County	Vein	Gneiss of Precambrian age	Barite occurs with galena, fluorite, and quartz.	Clippinger (1949).
5	Gallinas district, prospects, Lincoln County.	Veins	Quartzitic sandstone, siltstone and limestone of the Yeso formation of Permian age and sills and dikes of Tertiary age intrude the sedimentary rocks.	Veins with barite, fluorite, quartz, and calcite occur in fault zones.	Rothrock and others (1946).
6	Gonzales prospect, Socorro County.	do	Granite of Precambrian age and sedimentary rocks of the Magdalena group of Pennsylvanian and Permian age.	Barite occurs with fluorite and quartz in veins and breccia in a fault zone between the older and younger rocks.	Clippinger (1949).
7	Hansonburg district, Socorro County.	do	Limestone, shale, and sandstone of the Magdalena group of Pennsylvanian and Permian age and sedimentary rocks of Permian intruded by igneous rocks of middle Tertiary(?) age.	Barite occurs with fluorite, quartz, galena, and calcite along faults. Mining for barite and galena was in progress in 1954.	Clippinger (1949); Kottlowski (1953).
8	Palm Park mine, Dona Ana County.	do	Brecciated rhyolite sill of Tertiary age.	Barite occurs with fluorite and quartz in a brecciated sill intruded along the bedding contact of limestone and shale.	Clippinger (1949).
9	Tonuco Mountain deposits, Dona Ana County.	do	Metamorphic and igneous rocks of Precambrian age.	Barite, fluorite, and quartz fill fissures.	Do.
10	Vincent Moore claim, Torrance County.	Vein	Limestone	A vein of barite 6 to 10 feet wide 7 miles south of Barton.	Do.

TABLE 10.—*Barite deposits in the United States*—Continued

No. (by States) on plate 1	District, mine, or prospect	Mode of occurrence	Host rock	Remarks	Reference
North Carolina					
1	Hillsboro district, Orange County.	Veins	Metamorphosed tuff of Precambrian age.		Stuckey and Davis (1935).
2	Hot Springs district, Madison County.	Veins and lenses in breccia zones along 2 major faults.	Snowbird formation of Precambrian(?) age and Max Patch granite of Precambrian age.	Five mines yielded most of the barite, but other prospects might be valuable mining properties.	Stuckey (1942); Oriel (1950).
3	Kings Mountain-Gaffney district, Gaston and Cleveland Counties, N. C., and York and Cherokee Counties, S. C.	Veins	Bessemer granite and Battleground schist of Precambrian age.	Barite in a contact zone between the granite and schist. Most of this district is in South Carolina.	Van Horn, LeGrand, and McMurray (1949).
Oklahoma					
1	Cache prospect, Comanche County.	Residual	Shale of Permian age	Possibly other small deposits derived fron thin veins in bedrock.	Ham and Merritt (1944).
2	Manitou prospect, Tillman County.	do	do	Possibly other small deposits derived from thin vein in bedrock.	Do.
3	Mill Creek (Thompson ranch prospect), Johnston County.	do	Arbuckle limestone of Cambrian and Ordovician age.	Twenty tons of barite has been recovered from this deposit.	Do.
4	Watson prospects, McCurtain County.	Veins with sphalerite and galena.	Quartzite in the Stanley shale of Mississippian and Pennsylvanian age.	No indication of large quantities of barite.	Do.
	Other occurrences			In Murray, Coal. Garvin, Cleveland, Noble, Lincoln, Stephens, Cotton, Comanche, Tillman, Kiowa, McClain, Logan, Okfuskee, Oklahoma, Pottawatomie Counties. Residual concentrations of barite rosettes probably form only small scattered deposits	Do.

		Pennsylvania			
1	Buckmanville deposit, Bucks County.	Vein		Decomposed diabase occurs in matrix of barite and quartz. Yielded some commercial barite.	Stone (1939).
2	Chambersburg deposits, Franklin County.	Residual	Limestone of Cambrian and Ordovician age.	Veins and cement in breccia. Deposits are residual concentrates from weathering of these structures.	Do.
3	Fort Littleton deposit, Fulton County.	do	Limestone of Cambrian and Ordovician age?		Do.
4	Waynesboro deposits, Franklin County.	do	Limestone of Cambrian age	Barite cements breccia; deposits are residual concentrates from these structures.	Watson and Grasty (1915).
		South Carolina			
3	Kings Creek area, York and Cherokee County (part of Kings Mountain-Gaffney district, N. C. and S. C.).	Veins	Bessemer granite and Battleground schist of Precambrian age.	Barite in a contact zone between the granite and schist.	Van Horn, LeGrand, McMurray (1949).
		Tennessee			
1	Del Rio district, Cocke County	Veins	Snowbird formation of Precambrian age and the Unicoi formation of Cambrian age.	Barite deposits are of 2 types: A. Replacement of microscopically granulated, sheared, brecciated gouge in thrust faults; B. Filling and replacement of zones less intensely sheared, or along tension fractures and bedding planes and in porous beds.	Ferguson and Jewell (1951).
2	Fall Branch district, Greene, Sullivan, and Washington Counties.	Residual	Knox group of Cambrian and Ordovician age.	Dark, fetid barite	Laurence (1938); Rankin and others (1938).
3	Greene County area	do	do	Four deposits worked prior to 1920.	Gordon (1920).
4	Lost Creek district, Union County	do	Murfreesboro limestone of Ordovician age.	A small deposit of white barite worked in 1938.	Gildersleeve (1946).
5	Middle Tennessee area (Cannon, DeKalb, Putnam, Rutherford, Smith, Trousdale, Wilson, and Williamson Counties).	Veins	Carters limestone and other limestones of Ordovician age.	Veins containing barite, fluorite, calcite with sulfides of lead, zinc, copper and iron ore associated with fault zones.	Jewell (1947).
6	Pall Mall district, Fentress County.	Residual	Warsaw limestone of Mississippian age.	Barite in all workings is in one bed 10 to 30 feet thick underlain by sticky green clay.	Rankin and others (1938).
7	Sweetwater district, McMinn, Monroe, and Loudon Counties.	do	Knox group of Cambrian and Ordovician age.	Deposits occur in 3 narrow belts bordered by thrust faults.	Gordon (1918); Laurence (1939); Rankin and others (1938).

TABLE 10.—*Barite deposits in the United States*—Continued

No. (by States) on plate 1	District, mine, or prospect	Mode of occurrence	Host rock	Remarks	Reference
			Texas		
1	Freeman ranch deposit, Llano County.	Veins	Metamorphic rocks of Precambrian age.	Deposits seem small	Zapp (1941).
2	Henry Mills ranch deposit, Valverde County.	Veins and fillings in caverns.	Limestone of Edwards limestone of Cretaceous age.	Exploration work indicates that the deposits in this area might be larger than first reported (Evans, 1946).	Evans (1946).
3	Seven Heart Gap area, Culberson County.	Beds and veins	Limestone in the Delaware Mountain group of Permian age.	Sixteen occurrences in area reported possibly commercial.	Do.
4	Van Horn area, Culberson County	Veins	Limestones of Early Paleozoic age.		Do.
	Other areas			Other occurrences listed by Evans	Do.
			Utah		
1	Cottonwood-American Fork district (Pacific mine), Salt Lake County.	Veins	Quartzite of Cambrian age	Barite is gangue in veins with galena and pyrite. Some barite possibly commercial.	Butler and Loughlin (1916).
2	Argenta district, Morgan County	Bedded	Limestone of Cambrian age	Barite with some sulfides of iron and lead. Deposits are 10 miles north of Petersen.	Hill (1917).
3	Wasatch Range near Ogden, Morgan County.	Veins	Granite gneiss of Precambrian age.	Barite and fluorite with sulfides	Do.
			Virginia		
1	Bedford County area	Veins and tabular bodies associated with faults.	Marshall granite of Precambrian age.		Edmundson (1938).
2	Campbell-Pittsylvania Counties area.	Vein and residual deposits	Cockeysville marble and other metamorphic rocks of Precambrian age.		Edmundson (1938); Espenshade (1952).
3	Fauquier County area	Veins and fault breccia	Bull Run shales of Roberts (1923), of Triassic age.	No mining since 1903	Edmundson (1938).
4	Grayson County area	Residual and vein deposits in fault zones and fractures parallel to the foliation of enclosing metamorphic rocks.	Grayson granodiorite gneiss of Precambrian age.		Do.

5	Roanoke-Botetourt Counties area	Residual	Beekmantown limestone of Ordovician age.	Only residual deposits worked commercially.	Edmundson (1938); Espenshade (1952).
6	Russell, Tazewell, and Smyth Counties area.	Residual, vein and replacement bodies localized along bedding planes, fractures, or breccia zones.	do	do	Edmundson (1938).
			Washington		
1	Maple Creek prospect, Mason County.	A lens with manganese silicate.	Volcanic rocks and red limestone and argillite of Eocene age.	Barite is a large part of this deposit and is widely distributed in small quantities elsewhere in the region.	Park (1942).
2	Northern Stevens County	Veins	Sedimentary rocks of Paleozoic age, and intrusive igneous rocks of Mesozoic age, and volcanic rocks of Miocene age.	Many veins follow shear zones	Valentine (1949).
3	Springdale area, Stevens County	do	do		Do.
4	Other occurrences			Other occurrences and deposits of possible commercial value in Okanogan, Ferry, and Pend Oreille Counties.	
			Wisconsin		
1	Cuba City area, Lafayette County	Veins	The Galena dolomite, Decorah shale and Plattville limestone of Ordovician age.	Barite is gangue in lead-zinc deposits. Barite might be a coproduct of metal mining. A few veins might contain enough barite to be mined for that alone.	Agnew, Flint, and Crumpton (1954).

upon the type of deposit and its geologic setting. Vein and bedded types of deposits can be explored by the usual methods of digging pits and trenches, and of drilling. Residual deposits generally are explored by test pits a few feet in diameter, dug according to a grid pattern to give as complete coverage of the area as deemed desirable. One company in Missouri used a grid system with holes no farther apart than 400 feet. Shallow residual deposits may be tested by driving a steel rod down through the clay to bed rock, where possible, and then examining the rod. Chert and bedrock containing quartz may scratch the rod, but barite streaks adhere to it. Rotary drilling also has proved to be a successful method of prospecting for barite deposits in residual clays (Kesler, 1949).

Uhley and Sharon (1954) have reported on gravimetric prospecting for residual deposits in Missouri. The results of the gravity survey were checked by test pits, and it was found that ore bodies near the surface could be discovered and outlined by this method. Tonnage calculations based on the test-pit data indicated that the margin of error was as great as 35 percent.

RESOURCES OF THE UNITED STATES

Knowledge of domestic resources of barite is incomplete. Barite deposits in many States have been studied and described by State geological surveys and Federal agencies. Most of the State publications describe the general geologic features of the deposits and present details on selected deposits, but few contain statistical information on the resources. Some of the studies by the U. S. Geological Survey and the U. S. Bureau of Mines have included estimates of resources in certain mining districts. Active exploration programs by the major barite-mining companies are continually resulting in the discovery and evaluation of new deposits, but rarely do these data become a matter of public record.

With the information so generously made available by industrial and governmental organizations, enough is known about the larger mining districts to permit estimation of the probable order of magnitude of the demonstrated reserves and inferred reserves of barite in the United States. These estimates are listed on table 11.

As the term is used on table 11, demonstrated reserves are those that can be exploited under present technologic and economic conditions. The inferred reserves are the amounts of potential ore that await more favorable economic conditions or new techniques of mining and beneficiation. The sum of the demonstrated and inferred reserves is the equal of the total resources. These definitions are discussed in detail by Blondel and Lasky (1956).

The figures (table 11) on demonstrated reserves and inferred re-

TABLE 11.—*Estimated resources of barite in the United States, 1958*

Area	Demonstrated reserves of ore (millions of short tons)	Inferred reserves of ore (millions of short tons)	Grade	Maximum depth (feet)	Remarks
Western States:					
California	25	150+	Resources are mostly 20 to 25 percent barite.	300	Most of the resources are in vein deposits containing 5 to 10 percent rare-earth minerals in the Mountain Pass area, San Bernardino County. Barite is not recovered there now. Statistics from Olson and others (1954, p. 64). Inferred reserves also include barite in other deposits widely distributed in the State.
Nevada	10	20+	Demonstrated reserves are 50 to 90 percent barite. Inferred reserves include all grades.	300	Favorable geologic environment for bedded deposits is widespread in north-central Nevada. Some barite can be produced as a byproduct of metal mining.
Other Western States	2	Large	Resources are mostly less than 50 percent barite.	500	Tonnage in inferred reserves probably much greater. Insufficient data available for accurate estimation of resources. Deposits of all types. Some production as byproduct of metal mining. Area includes Arizona, Colorado, Idaho, Montana, New Mexico, Utah, and Washington. Widely distributed deposits.
Midwestern States:					
Arkansas	16	30+	Much of demonstrated reserves are 50 to 80 percent barite. Inferred reserves include some material with less than 50 percent barite.	500	Favorable geological environments for bedded deposits in western and southwestern Arkansas.
Missouri	200	100+	Resources include much ore with about 10 percent barite.	50	Most of the resources are in the residual deposits of Washington County. The resources of the small scattered deposits of Central Missouri are small compared to those of Washington County.
Other Midwestern States.	----------	----------	Most resources are less than 50 percent barite.	----------	Data are insufficient for estimation of resources. Area includes Wisconsin, Oklahoma, and Texas.
Eastern States:					
Georgia, Tennessee, North Carolina, and South Carolina.	32	65+	Most resources are less than 50 percent barite.	250	Deposits chiefly of vein and residual types.
Other Eastern States	----------	----------	Most deposits are less than 50 percent barite.	----------	Data are insufficient for estimation of resources. Mostly vein and residual deposits. Area includes Alabama, Kentucky, Virginia, and Maryland. A few deposits in the Middle Atlantic and New England States.
TOTAL	285	365+			The total demonstrated reserves contain about 46 million tons of barite. The total inferred reserves probably contain more than 67 million tons of barite.

serves are conservative estimates of the amounts of ore available in each State or group of States as of 1958.

The demonstrated reserves of barite ore in the United States are estimated to be about 285 million tons, containing about 46 million tons of barite. The inferred reserves are large, more than 365 million tons of material, probably containing about 67 million tons of barite.

The greatest demonstrated reserves of ore are in the residual deposits of Missouri and the southern Appalachian States. These deposits contain about 50 percent of the barite estimated in the demonstrated reserve of 46 million tons of barite. The remaining 50 percent is probably evenly divided between the bedded deposits of Arkansas and Nevada and the deposits of California and the other Western States.

In addition to the great inferred reserves of the residual deposits of Missouri, important inferred reserves are in the widely scattered vein and bedded deposits of the Western and Midwestern States. As demand increases and beneficiation methods improve, these types of deposits should become more important commercially than those residual deposits that contain less than 10 percent barite.

WESTERN STATES

The major part of the resources of the Western States is in vein and bedded deposits in California and Nevada.

The largest part of the barite resources of California is in the rare-earth deposits at Mountain Pass, San Bernardino County. Olson (Olson and others, 1954, p. 64) estimates that the deposits contain 25 to 100 million tons of rock containing 20 to 25 percent barite and 5 to 10 percent rare earths. No barite was being recovered from this deposit in 1954, but a barite product suitable for drilling mud might be produced (Zadra and others, 1952). The mill dump may in the future be a source of barite.

Nevada contains sizeable demonstrated reserves of relatively high-grade ore, containing more than 75 percent $BaSO_4$. The geologic environment is favorable for the discovery of more good deposits in the north-central part of the State. Prospecting has been done only within 500 feet of the surface, and then only in a few areas. Only ores containing more than 50 percent barite are now mined. Total inferred reserves in the State are large; the estimated 20 million tons of barite ore is considered conservative.

Other western states, including Arizona, Colorado, Idaho, Montana, New Mexico, Utah and Washington, apparently do not have large demonstrated reserves individually, but their inferred reserves may be great, especially considering the potential recovery of barite as a byproduct of fluorspar and metal mining. Most of the deposits contain less than 50 percent barite. Many individual deposits appear to be small or discontinuous along faults, fractures, and solution channels, but the possible aggregate tonnages might be great. Continued prospecting should be fruitful.

MIDWESTERN STATES

In the Midwestern States, the demonstrated reserves are chiefly in the residual deposits of Missouri and the bedded deposits of Arkansas. Most of the demonstrated reserves in Missouri are centralized in Washington County, where large areas of residual soil contain deposits that probably average 10 percent barite. These deposits are and have been of great value.

The inferred reserves of Washington County are also large, although most of this tonnage contains an average of perhaps 5 percent barite. Material containing less than 50 percent but more than 5 percent barite in many other areas probably would be worked first. Thus when the richest residual deposits are exhausted, a significant change in economics must occur before barite from very low grade residual deposits can be competitive with barite from deposits elsewhere having a grade 2 to 3 times higher.

The resources of barite in Washington County include the tailings ponds at the former sites of log washers. Tests run by the Missouri Geological Survey indicated that the tailings nearest some of the washers contain at least 5 percent and as much as 35 percent barite (G. A. Muilenburg, oral communication). Barite in these tailings ranges from fragments about three-quarters inch in diameter to particles of clay size.

The central district of Missouri, chiefly in Cole, Moniteau, Miller, and Morgan Counties, contains some residual and breccia deposits of barite that can be classified as demonstrated and inferred reserves. The aggregate tonnage is possibly great, but the individual deposits are scattered and small compared to those in Washington County.

A large part of the resources of barite in Arkansas is concentrated in bedded deposits near the base of the Stanley shale of Mississippian and Pennsylvanian age in the Mazarn basin. Large areas in the western part of the basin where the Stanley shale crops out are favorable for the discovery of bedded deposits similar to the one at Magnet Cove. Deposits in the Trinity formation of Cretaceous age may increase the resources of Arkansas by a large factor.

The deposits of Oklahoma, Texas, and Wisconsin are not well enough known for estimation of demonstrated and inferred reserves. Many small deposits and occurrences of barite of all types are reported in Oklahoma and Texas. In Wisconsin, barite occurs with lead and zinc ores.

EASTERN STATES

In the Eastern States the greatest part of the resources occur in the southern Appalachian region. Results of geologic investigation of the deposits in Tennessee, Georgia, North Carolina, and South Carolina has indicated that these States contain most of the demonstrated reserves and probably also most of the inferred reserves in the East.

Alabama, Virginia, and Kentucky contain scattered deposits of barite, few of which have been worked since 1940. The deposits in Alabama and Virginia are generally of the residual type; those in Kentucky are of the vein type. Most of the deposits in all three States appear to be small.

FOREIGN RESOURCES

Commercial deposits of barite are distributed widely around the world. In 1956 the world production amounted to about 3 million short tons, of which over 1 million were mined in the United States. Other producers of more than 100,000 tons were Canada, Mexico, West Germany, Italy, and Soviet Russia. Nations producing from 25,000 to 100,000 tons included United Kingdom, France, East Germany, Greece, Yugoslavia, Algeria, French Morocco, and Peru. Nations producing from 10,000 to 25,000 tons include Japan, Argentina, and Brazil.

Most of the imports to the United States in 1956, came from Canada (240,650 short tons), Mexico (204,354 short tons), Yugoslavia (42,815 short tons), Italy (26,599 short tons), Greece (22,365 short tons), Brazil (16,069 short tons), and Peru (30,305 short tons). Barite from most other producing nations was not competitive in the United States during 1956. World resources of barite are sufficiently well distributed so that the United States probably will not supply large markets abroad.

OUTLOOK FOR FUTURE SUPPLY

Information available about the barite reserves in the United States (table 11) indicates that, with present markets and technology, the mining industry can continue to supply barite at the current rate of about 1 million tons annually, for at least 40 years. At expanded rates of production the demonstrated reserves, of course, will be mined sooner, but new deposits probably will be discovered to replace some of the reserves used.

Domestic production can be augmented by foreign supplies available in many parts of the world. The deposits of nearby Canada and Mexico and others in Argentina, Colombia, Brazil, and Peru are of strategic importance to the United States and all of the western hemisphere should the need for hemisphere self-sufficiency arise.

As technology advances and it becomes possible to utilize lower grade ores of all types, much of the material now classed as inferred reserves can be reclassified as demonstrated reserves. The long-range outlook, therefore, appears favorable for the continued life of a barite industry in the United States.

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