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MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN 1928

BY

PHILIP S. SMITH AND OTHERS

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By PHILIP S. SMITH [1]

INTRODUCTION

For many years the mineral industry has been one of the main contributors to the development of Alaska, if not the main industry. To assist in fostering this industry the Federal Government through the Geological Survey has for 30 years paid considerable attention to the problems relating to the industry and, by means of its studies of the distribution, character, origin, and extent of ore deposits, has kept those interested in mining developments informed of the facts of significance to the prospector, the miner, or the business man. One of the phases of these investigations that has obvious value is an annual record of the kinds and quantity of mineral produced, as such a record furnishes measures of the size and trend of the industry. It is to supply this information that the Geological Survey collects annually records of the production of all mineral commodities and makes these records available through annual reports, of which this one is the twenty-fifth.[2]

The collection of the data necessary for these annual statements is by no means a simple matter, because the great size of the Territory, the diversity of its mineral products, and the large numbers but small size of many of the enterprises make it impracticable to gather all the desired information at first hand. The information must therefore be obtained from many sources, which necessarily vary in reliability and completeness. Among the most reliable sources are the field engineers, geologists, and topographers of the Geological Survey engaged in Alaskan surveys, who acquire much accurate information regarding the mineral production of the regions

[1] The statistics in this chapter have been compiled largely by Miss L. H. Stone.

[2] The other volumes of this series, commencing with that for 1904, are Bulletins 259, 284, 314, 345, 379, 442, 480, 520, 542, 592, 622, 642, 662, 692, 712, 714, 722, 739, 755, 773, 783, 792, 797, 810.

in which they work, or more general information by contact with miners and operators in the course of their travels to and from the field. Members of other Government organizations—for instance, the Bureau of Mines, the Bureau of the Mint, and the Customs Service—in the course of their regular duties collect many data which are extremely valuable in these studies and the use of which avoids unnecessary duplication in the collection of records. Most of the banks, express companies, and other business organizations in Alaska collect for their own use data regarding mineral commodities of their particular districts. Some of these data are extremely pertinent to the general inquiry conducted by the Geological Survey, and through the cordial cooperation of many of these companies important facts have been made available to the Geological Survey for its information but not for publication, as their disclosure would reveal confidential facts. Most of the larger Alaskan newspapers as well as certain papers published in the States that feature Alaskan matters are courteously sent by their publishers to the Geological Survey, and from these and the technical and scientific periodicals are gleaned many items regarding new developments. In addition to all these sources the Geological Survey each year sends out hundreds of schedules—one to every person or company known to be engaged in mining. On these schedules are a number of questions regarding the mining developments and production of each individual property during the year. These schedules when properly filled out by the operators of course constitute a most authoritative record. Unfortunately, however, not all of them are returned by the operators, and even some of the operators who return them have not all the specific data desired or misunderstand the inquiries or reply in such a manner that the answers may not be correctly interpreted when the schedules are edited. It is a gratifying evidence of the general appreciation of these annual summaries that so many of the operators cooperate fully and cordially with the Geological Survey by furnishing the information called for on the schedules as well as volunteering much other pertinent information.

It is evident that with such a mass of information available the resulting report should correctly and adequately reflect the actual conditions, and every effort is made to see that this result is attained so far as possible. Unfortunately, however, there are many causes of inaccuracy. For instance, the same term may be differently interpreted by different persons, so that answers to the same question are not always made from the same viewpoint. To the lode miner the value of the production from his mine will probably mean tons of ore mined times the assay value of its metallic contents. To others knowing the inevitable loss that occurs in the metallurgical or milling treatment of this ore the value of the production will probably mean value of the metal recovered. To still others it may mean the amount they received from the bank for their product after deducting assaying and handling charges, insurance, etc., or it may mean the amount the local trader paid for their gold, even though that amount may have a wholly fictitious relation to its mint value. So far as possible these various standards have been reconciled to the single one represented by the value of the metal recovered, as shown generally for placer or lode gold by bank assays or receipts without deductions. Many of the mineral products, however, are not disposed of during the year in which they are produced at the mine, so that for these the only accurate record available is the gross quantity produced and its approximate metal tenor. This condition is especially common for the larger lode mines, where production of ore may continue up to the last day of the year, but the ore thus produced may not reach the mill, smelter, or mint until many months later. This same condition also occurs to a lesser degree with some of the placer product. It is readily evident that there will always be differences between the quantities of metals reported by different agencies, though on the whole many of these differences tend to offset one another. Thus for a mine that has been in operation for some time at approximately the same rate, its production that did not reach the mill, smelter, or mint during the current year is usually about balanced by its similar production during the last part of the preceding year, which is reported by the mint or smelter during the current year.

Another element that creates some inaccuracy or misconception is the fact that the price of all mineral commodities except gold fluctuates considerably during the year. All the reports do not give the value of the production on a single consistent basis, so that many must be edited to bring them to an approximately common standard. For this reason the average prices of the several mineral commodities for the year as determined by the Bureau of Mines are used instead of the prices actually received by the producer. Although it is recognized that this arbitrary method of computation results in obscuring the amount actually received by the individual mines, it probably does not introduce any considerable error in the totals, inasmuch as higher prices received by the more shrewdly or efficiently administered mines are about balanced by the lower prices received by less fortunate ones.

It is the constant aim of the compilers to make these annual summaries of mineral production as accurate and adequate as possible. The Geological Survey therefore bespeaks the continued cooperation of all persons concerned in the mineral industry and urges them to communicate any pertinent information that may lead to this desired end. It should be emphasized that all information regarding individual properties is regarded as strictly confidential. The Geological Survey will not use any data that are furnished in any way to disclose the production of individual plants nor allow access to its records in any way that will be disadvantageous to either the individuals who furnish the information or those to whom the data relate. So scrupulously is this policy followed that it has been necessary to combine or group together certain districts or products so that the production of an individual may not be disclosed. In order to fulfill this obligation it has even been necessary to adopt certain rather artificial and unnatural groups, as, for instance, the "miscellaneous mineral products," which include petroleum, quicksilver, stone or marble, tin, and other materials produced in small quantity or by only one producer, whose output would otherwise be obvious.

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of Nome; A. V. Cordovado, of Deering; A. S. Tucker, of Bluff; Goldsmith Dredging Co., of Solomon; Robert Benson, of Kougarok; T. P. Roust, of Candle; Wallace L. Johnson, of Council; Arthur W. Johnson, of Haycock; Lewis Lloyd and James C. Cross, of Shungnak; and R. S. Hall, of Wainwright.

MINERAL PRODUCTION

GENERAL FEATURES

The total value of the mineral production of Alaska in 1928 was $14,061,000. This was furnished by a number of mineral products, of which the most valuable were gold and copper. The total was about a third of a million dollars less than in the preceding year, but this decrease amounts to less than 2½ per cent of the total value in 1927, so that, in a broad way, it is evident that the amount of money won from the Alaska mines in 1928 showed no marked change from that of the preceding year. Viewed in more detail, however, there were decided changes in the value of the individual mineral commodities. For instance, the amount of copper produced was only about 75 per cent of the amount produced in 1927, and its value was a million and a quarter dollars less. On the other hand, the value of the gold produced in 1928 was over $900,000 more than in 1927, and the amount of coal produced in 1928 was greater than ever before in the history of Alaska coal mining. These and other facts relating to the individual metals and mineral products are discussed in more detail in the pages of this report devoted to the different products.

On the whole the market prices for many of the metals that enter most largely into Alaska's metal production were better than for the preceding year. This statement of course does not apply to gold, for its price is constant. According to the Bureau of Mines, which computes the average price of metals for each year, silver brought 58.5 cents an ounce in 1928, against 56.7 cents in 1927, and copper brought 14.4 cents a pound in 1928, against 13.1 cents in 1927. Some of the metals that enter in smaller amounts into the total mineral production, however, brought a lower price in 1928 than in the preceding year. Thus, according to the Bureau of Mines, the average selling price of lead in 1928 was 5.8 cents a pound, as against 6.3 cents in 1927; the price of tin was 50.46 cents a pound, against 64.37 cents in 1927; and the price of platinum was $75 an ounce, against $85 in 1927. The net results of the fluctuation in prices was to increase materially the value of the output in 1928, the increase of 1.3 cents a pound for copper affording an increased income of half a million dollars over what would have been received if the price of copper for 1927 had prevailed during 1928.

Although there was no outstanding new development during the year, the general tone of the mining industry appeared encouraging. Several of the projects that before had been in preparatory stages came into production. The most noteworthy of these was the starting of dredging on the properties of the Fairbanks Exploration Co. in the Fairbanks district. This project had been in a development stage for a number of years, and many million dollars had been expended in prospecting the ground and installing the required mining equipment, so that the end of this preparatory period and the beginning of real production marks an event of great significance. It was not only in actual production, however, that the season of 1928 appeared encouraging, but rather in the greater interest in mining that appears to have been taken by many people who during the last decade at least had shown little activity in mining ventures. Throughout the Territory were heard rumors of renewed interest in mining projects. Doubtless many of these projects are destined to be dropped before they have progressed far, but some of them are likely to be carefully examined and, if undertaken, have excellent chances of being productive. In fact, the present tendency among even the most primitive prospectors seems to be to test the ground more adequately before commitment rather than after difficulties arise. At some of the larger mines the application of most advanced engineering procedure has made them outstanding examples of efficient and economical operation. Even the ordinary traveler in Alaska becomes aware of an undercurrent of new interest in mining. Almost every passenger vessel bound to or from Alaska carries engineers, promoters, or capitalists who are engaged on some mining mission, and most of them are interested in large-scale enterprises requiring considerable outlay rather than in the hand-to-mouth operations that were so characteristic of the past. Out in the hills prospectors are still all too scarce, but even there they are beginning to be somewhat more numerous than in the last few years, though it is still difficult for them to accumulate enough money to finance a prospecting trip, and many of the good prospectors must eke out their slender funds by devoting most of their time to trapping or some other work that will bring an immediate return. The encouragement given to prospectors by the payment from the treasury of the Territory of certain of their expenses incident to transportation is said to have shown beneficial results, though the law has been in effect only since April, 1927, and the official in charge of this work states in his report [3] that "sufficient data are not yet in

[3] Report on cooperation between the Territory of Alaska and the United States in making mining investigations and in the inspection of mines for the biennium ending Mar. 31, 1929, p. 29, Juneau, 1929.

hand to form a comprehensive basis for judging the results achieved."

General conditions affecting transportation throughout the Territory showed continued improvement. The officials of the Alaska Railroad displayed new interest in trying to make the services of the railroad meet the needs of mining operations adjacent to its route. The officials of the Alaska Road Commission have mapped out a broad program for road development and made notable progress on many of the projects that were in course of construction that will be of service in developing the mineral resources of the country. One of the outstanding results was the building of the highway linking Circle with Fairbanks, whereby automobiles can make the trip between the two places in only a few hours. Airplane travel is growing increasingly common, and prospectors and miners are now using this means of transportation to reach remote parts of the Territory that were almost inaccessible by other means. The remarkable records of the Alaska pilots in reaching their destinations with sureness and safety have given a great impetus to airplane travel, and its speed makes it more economical than many of the usual methods.

The accompanying table shows the value of the mineral output of Alaska for each year from 1880, the first year for which records are available, to and including 1928; also the distribution of the total value among the metals and minerals that contributed to it. The total value for this period is nearly $600,000,000, about five-eighths of which has been afforded by gold and more than 95 per cent by gold and copper together.

Value of total mineral production of Alaska, 1880–1928

By years:		By years—Continued.	
1880	[4] $6, 826	1893	$1, 104, 982
1881	[4] 15, 000	1894	1, 339, 332
1882	[4] 23, 000	1895	2, 588, 832
1883	[4] 67, 146	1896	2, 885, 029
1884	[4] 72, 000	1897	2, 539, 294
1885	[4] 425, 000	1898	2, 329, 016
1886	[4] 540, 000	1899	5, 425, 262
1887	[4] 657, 000	1900	7, 995, 209
1888	[4] 667, 181	1901	7, 306, 381
1889	[4] 847, 490	1902	8, 475, 813
1890	[4] 873, 276	1903	9, 088, 564
1891	1, 014, 211	1904	9, 627, 495
1892	1, 019, 493	1905	16, 490, 720

[4] $37,205 for coal produced prior to 1890 should be distributed among these years, but data are not available for this purpose, and the entire value of that coal has been credited to 1890.

By years—Continued.

1906	$23, 501, 770
1907	20, 840, 571
1908	20, 092, 501
1909	21, 140, 810
1910	16, 875, 226
1911	20, 720, 480
1912	22, 581, 943
1913	19, 547, 292
1914	19, 109, 731
1915	32, 790, 344
1916	48, 386, 508
1917	40, 694, 804
1918	28, 218, 935
1919	19, 626, 824
1920	23, 330, 586
1921	16, 994, 302
1922	19, 420, 121
1923	20, 330, 643
1924	17, 457, 333
1925	18, 220, 692

By years—Continued.

1926	$17, 664, 800
1927	14, 404, 000
1928	14, 061, 000
	599, 435, 000

By substances:

Gold	373, 080, 000
Copper	200, 878, 000
Silver	11, 486, 000
Coal	6, 214, 000
Tin	1, 048, 000
Lead	1, 440, 000
Marble and other products (including platinum metals)	5, 289, 000
	599, 435, 000

In Figure 1 is shown graphically the curve of total mineral production for each year from 1890 to 1928. From this curve it will be evident that for more than 20 years, except for the inflation marked by the years of the World War, the annual mineral production for Alaska has ranged between $14,000,000 and $23,000,000. In this period the value for 1928 was the least since 1904, but there is as yet no evidence that a permanent waning of the industry as a whole is in progress, and the mining of certain of the metals is undoubtedly on the increase.

Mineral output of Alaska, 1928 and 1927

	1928		1927		Increase or decrease, 1928	
	Quantity	Value	Quantity	Value	Quantity	Value
Gold fine ounces	331, 140	$6, 845, 000	286, 720	$5, 927, 000	+44, 420	+$918, 000
Copper pounds	41, 421, 000	5, 965, 000	55, 343, 000	7, 250, 000	−13, 922, 000	−1, 285, 000
Silver fine ounces	454, 700	266, 000	627, 800	356, 000	−173, 100	−90, 000
Coal short tons	126, 100	662, 000	104, 300	548, 000	+21, 800	+114, 000
Tin, metallic do	41. 0	41, 000	26. 7	34, 000	+14. 3	+7, 000
Lead do	1, 019	118, 000	1, 008.	127, 000	+11	−9, 000
Miscellaneous mineral products, including petroleum, platinum, metals, marble, gypsum, etc		164, 000		162, 000		+2, 000
		14, 061, 000		14, 404, 000		−343, 000

An analysis of the production of minerals for the year 1928 is given in the above table, from which it will be seen that the value of the gold and copper together amounted to about 91 per cent

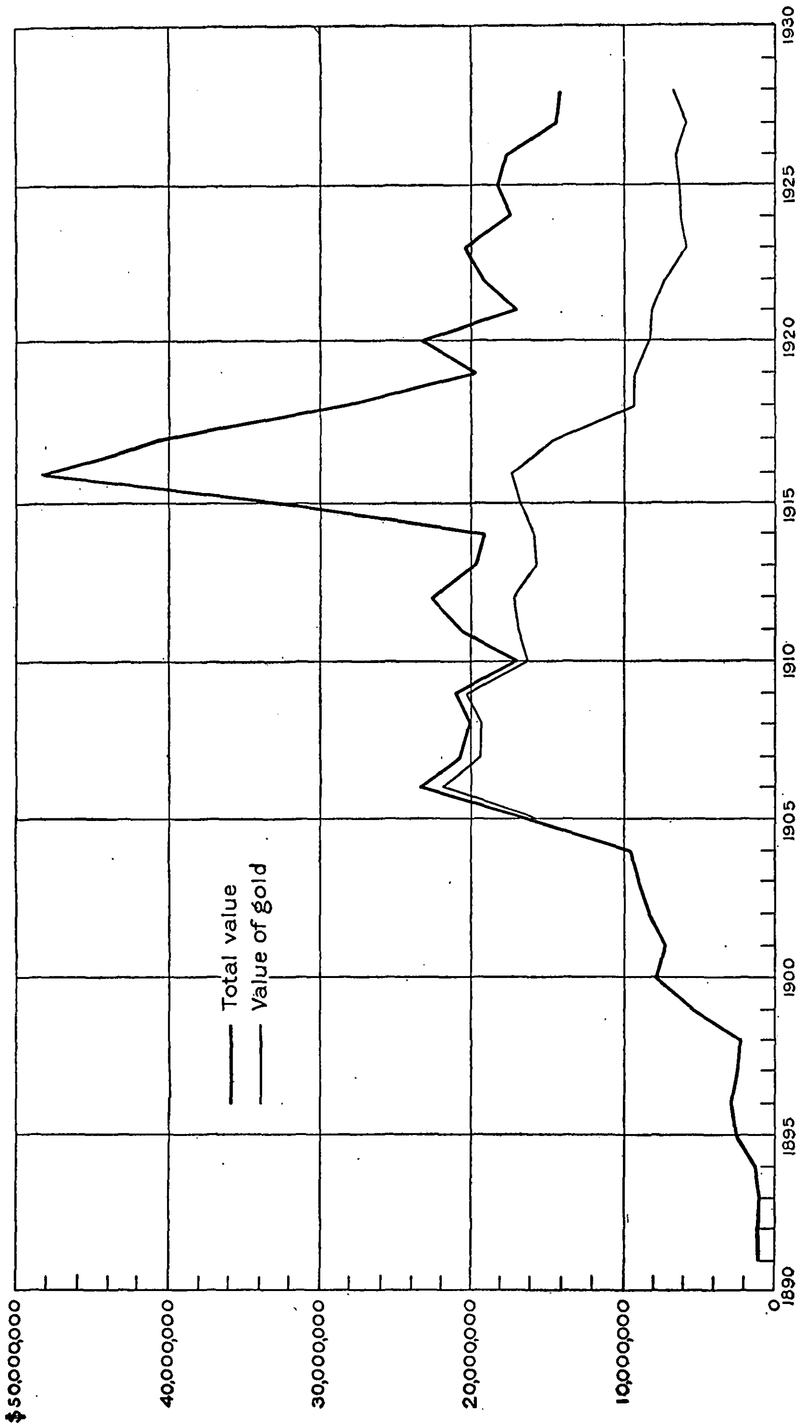


FIGURE 1.—Trends of mineral production of Alaska, 1890–1928

of the total and that of the gold to about 49 per cent. Each mineral product is discussed in more detail in the following pages, where are set down such facts as are available regarding the amount of each product, the places from which it comes, and new developments.

GOLD

TOTAL PRODUCTION

The total value of gold produced from Alaska mines in 1928 was $6,845,000, as contrasted with $5,927,000 in 1927, an increase of $918,000. The general trend of gold mining in Alaska since 1890 is graphically represented by one of the curves on Figure 1. From 1890 to 1904 the curve for the value of the gold production practically coincides with the curve for the value of the total mineral production of Alaska and marks a fairly even upward trend. From 1904 to 1906 there was an abrupt increase in the value of the gold, marking the boom periods of many of the placer camps. From the peak of gold production in 1906 there was a gradual decline for the next 10 years, and during the period of the war there followed a rather rapid decrease to less than $10,000,000 a year. After 1922 the gold production was fairly uniform and was between about $6,000,000 and $7,000,000 a year; the largest amount was produced in 1928.

There are two principal types of deposits from which the gold is recovered—lodes and placers. The lodes are the mineralized veins or masses of ore in the country rock that were in general formed through deep-seated geologic processes and represent material in place. The placers are deposits of sand and gravel which have been worn from the hard rocks in their general vicinity and in which the loose grains of gold or other valuable minerals have been more or less concentrated by surficial geologic processes that were effective because of some distinctive physical or chemical property of the material thus concentrated.

The following table shows the amount and value of the gold produced annually for the last 13 years, the total amount that has been produced since gold mining began in the Territory in 1880, and the value of the gold that has been derived from each of the two principal types of gold mines. Of the $373,000,000 worth of gold that has been produced from Alaska mines, $250,000,000, or 67 per cent, has come from placers and $123,000,000, or 33 per cent, from lodes. The relation between these two sources of gold in the past has varied widely. Thus up to 1898 the lode production was greater than that from the placers. Then ensued a period of more than 20 years when the placer production far exceeded that from the lodes. Since 1919 the production from each source has been approximately the same. There is reason to believe that in the future the production from lodes is more likely to show an increase than that from placers. There is nothing in the record to indicate that the peak of lode-gold production has yet been reached.

Gold and silver produced in Alaska, 1880–1928

Year	Gold		Silver		Value of gold by sources	
	Fine ounces	Value	Fine ounces	Value	Placer mines	Lode mines
1880–1915	12, 592, 121	$260, 302, 243	4, 923, 198	$2, 821, 911	$185, 200, 444	$75, 101, 799
1916	834, 068	17, 241, 713	1, 379, 171	907, 495	11, 140, 000	6, 101, 713
1917	709, 049	14, 657, 353	1, 239, 150	1, 021, 060	9, 810, 000	4, 847, 353
1918	458, 641	9, 480, 952	847, 789	847, 789	5, 900, 000	3, 580, 952
1919	455, 984	9, 426, 032	629, 708	705, 708	4, 970, 000	4, 456, 032
1920	404, 683	8, 365, 560	953, 546	1, 039, 364	3, 873, 000	4, 492, 560
1921	390, 558	8, 073, 540	761, 085	761, 085	4, 226, 000	3, 847, 540
1922	359, 057	7, 422, 367	729, 945	729, 945	4, 395, 000	3, 027, 367
1923	289, 539	5, 985, 314	814, 649	668, 012	3, 608, 500	2, 376, 814
1924	304, 072	6, 285, 724	669, 641	448, 659	3, 564, 000	2, 721, 724
1925	307, 679	6, 360, 281	698, 259	482, 495	3, 223, 000	3, 137, 281
1926	324, 450	6, 707, 000	690, 000	430, 500	3, 769, 000	2, 938, 000
1927	286, 720	5, 927, 000	627, 800	356, 000	2, 982, 000	2, 945, 000
1928	331, 140	6, 845, 000	454, 700	266, 000	3, 347, 000	3, 498, 000
	18, 048, 760	373, 080, 000	15, 418, 700	11, 486, 000	250, 008, 000	123, 072, 000

In the foregoing table the amount of silver produced by Alaska mines has also been given, though a detailed discussion of the source of the silver minerals is given on a later page. All gold that is found in nature, either in lodes or in placers, contains some silver. Furthermore, many lodes contain more than one valuable mineral constituent, so that even those lodes that are principally valuable for their gold content may derive considerable additional return from the sale of the silver, copper, lead, or other subordinate minerals, and doubtless some of the operating mines could not be worked at a profit except for the additional value of those other minerals. It is therefore not practicable, except through an undesirably minute classification, to tabulate in detail all the sources of gold-bearing material. In the following table, which lists the sources from which gold was produced in 1928, all the ores from lode mines that yielded gold have been segregated from those that carry copper, and the gold recovered from placers is stated separately. No gold is recovered from the ores here classed as principally valuable for their copper content, though these are the ores that are the source of most of the silver that is recovered. The absence of any appreciable quantity of gold in the ores from which most of the Alaska copper is produced is a noteworthy but as yet unexplained feature.

Gold and silver produced in Alaska, 1928, by sources

Source	Gold		Silver	
	Fine ounces	Value	Fine ounces	Value
Gold ores (3,736,500 tons)	169, 220	3, 498, 000	80, 340	47, 000
Copper ores			350, 430	205, 000
Placers	161, 920	3, 347, 000	23, 930	14, 000
	331, 140	6, 845, 000	454, 700	266, 000

GOLD LODES

As has been stated, $3,498,000 in gold was produced from Alaska lode mines in 1928. This was approximately 51 per cent of the entire gold production of the Territory for that year. It was recovered from widely distributed mines, but more than 93 per cent came from southeastern Alaska, as shown in the following table.

Gold and silver produced from gold-lode mines in Alaska in 1928 by districts

District	Ore mined (short tons)	Gold		Silver	
		Fine ounces	Value	Fine ounces	Value
Southeastern Alaska	3, 720, 000	157, 575	$3, 257, 200	78, 900	$46, 158
Willow Creek	6, 000	5, 030	104, 000	190	112
Fairbanks district	5, 500	4, 010	82, 900	780	456
Other districts	5, 000	2, 605	53, 900	470	274
	3, 736, 500	169, 220	3, 498, 000	80, 340	47, 000

Of the Alaska lode gold mines the properties of the Alaska Juneau Gold Mining Co. in southeastern Alaska are by far the largest, and that company alone produced nearly 90 per cent of the total lode-gold output of the Territory in 1928. The magnitude of this company's mining operations is set forth in the company's published report to its stockholders, from which the following statements are abstracted. The total rock mined and trammed to the mill in 1928 was 3,718,140 tons, or an average of 10,186 tons a day. Of this amount 1,922,949 tons of coarse tailings were rejected and 1,795,191 tons were fine milled. The average gold content of all the material mined was $1.11 a ton. The amount of gold in that part of the rock which was rejected was about 21 cents a ton and the value of the gold content of the rock that was further treated was about $2.07 a ton. Of this content gold worth 32 cents was lost during the treatment, $1.34 was recovered as bullion, and 41 cents was recovered in the concentrates which were subsequently smelted. The following table, compiled from the published reports of the Alaska Juneau

Gold Mining Co., summarizes the mining record of this company since the beginning of its operations in 1893:

Production of Alaska Juneau mine, 1893–1928

Year	Ore (tons)			Metals recovered			
	Total	Fine milled	Coarse tailings rejected	Gold	Silver (ounces)	Lead (pounds)	Total value
1893–1913	507, 254	330, 278	176, 976	$707, 730	Lost in tailing.		$707, 730
1914–1915	242, 328	239, 918	2, 410	251, 655	6, 192	117, 031	261, 326
1916	180, 113	180, 113		115, 022	2, 844	61, 068	121, 378
1917	677, 410	677, 410		429, 262	12, 248	296, 179	460, 666
1918	592, 218	574, 285	17, 933	430, 124	11, 828	273, 297	459, 445
1919	692, 895	616, 302	76, 593	499, 002	16, 431	359, 762	542, 714
1920	942, 870	637, 321	305, 549	732, 870	23, 348	487, 574	791, 389
1921	1, 613, 600	904, 323	709, 277	969, 703	40, 619	550, 913	1, 035, 251
1922	2, 310, 550	1, 108, 559	1, 201, 991	1, 296, 157	49, 404	687, 315	1, 388, 679
1923	2, 476, 240	1, 134, 759	1, 341, 481	1, 427, 199	41, 876	755, 423	1, 514, 774
1924	3, 068, 190	1, 367, 528	1, 700, 662	1, 907, 374	63, 191	1, 256, 857	2, 055, 782
1925	2, 481, 780	1, 537, 884	1, 943, 896	2, 030, 067	55, 971	1, 288, 974	2, 184, 384
1926	3, 829, 700	1, 649, 678	2, 180, 022	1, 931, 052	52, 333	1, 300, 915	2, 067, 836
1927	4, 267, 810	1, 839, 695	2, 428, 115	2, 328, 540	61, 232	1, 513, 306	2, 463, 262
1928	3, 718, 140	1, 795, 191	1, 922, 949	3, 142, 808	77, 491	2, 038, 655	3, 316, 019
	28, 601, 098	14, 593, 244	14, 017, 854	18, 198, 565	515, 109	10, 987, 269	19, 370, 637

This record is especially impressive for the last few years, when operating costs have been successively reduced, until now they stand at so low a figure as to compel the highest admiration for the mining administration that has developed such efficient operation. For 1928 the cost of mining is stated by the company to have been 29.66 cents for each ton of ore trammed to the mill, the cost of milling was 22.85 cents, and all other operating and marketing costs and expenses, including interest, amounted to 10.31 cents, making the entire cost for each ton of ore trammed only 62.82 cents. During the year not only have the mining and milling costs been kept at a low figure but the tenor of the ore handled has been much higher. As a result the value of the gold recovered from each ton of rock mined in 1928 was 84 cents, as against 55 cents in 1927 and 50 cents in 1926; in fact, the tenor of the ore was the highest since 1915—that is, during the entire period of enlarged operations by this company. In addition to its usual mining activities this company during the year successfully negotiated the acquisition, by the issuance of stock, of all the physical properties in Alaska of the Alaska Treadwell Gold Mining Co., the Alaska Mexican Gold Mining Co., and the Alaska United Gold Mining Co., most of which are on Douglas Island a short distance west of Juneau. As a result of this transaction the company acquired, among other things, three hydroelectric power plants. The company also took an active part in prospecting and development work in the Taku region, where promising lead-zinc-gold-silver deposits have been discovered. Some of these claims lie in British Columbia, but others are in the United States. At the end of 1928 development work on these claims had not proceeded far enough to allow any definite statement of their true character, but the indications were regarded as distinctly favorable for disclosing ore bodies of value.

The next most productive gold mines in southeastern Alaska were the Hirst-Chichagof and those of the Apex-El Nido Mining Co. The Hirst-Chichagof mine is near the head of Mine Bay, on the west coast of Chichagof Island about 60 miles northwest of Sitka. No noteworthy new developments were reported as having been made on the property during the year, and work appears to have been carried on at approximately the same rate as heretofore. The Apex-El Nido mines are in the northern part of Chichagof Island, on the south side of Lisianski Inlet about 5 miles southeast of its junction with Lisianski Strait. Work on this property was suspended late in June, and the manager, who was in poor health, went to the States. Later in the season engineers were sent to make a thorough examination of the property, but no report of the results of these studies has been made public, and no information is available as to when mining operations will be resumed. In this same general region, at the head of Klag Bay, is the property of the Chichagoff Mines, which has long been one of the well-known mines of the Territory. At this mine practically only development work was in progress, so that its gold production was much less than usual. This company has recently been undergoing refinancing and reorganization, as a result of which increased output is to be expected as soon as the necessary changes have been effected. No detailed statements, as to its plans, however, have been given out by the company. Elsewhere on Chichagof Island there are a number of small gold-lode properties on which some prospecting and development work was carried on, but none of them is reported to have made any material production during the year.

In the Funter Bay region, on Admiralty Island, development work was continued at the Admiralty-Alaska Gold Mining Co.'s mine and the Williams mine. At the first-named about 5,400 feet of diamond drilling was done with the view of determining the extent and size of the mineralization. The results of this work, together with the reports of several mining engineers who made a careful examination of the property, were sufficiently encouraging for the management to plan an extensive development program. Reports were current that steps were being taken to reopen the old Jualin mine, to the north of Juneau in the Berners Bay region, and that negotiations were in progress looking toward resumption of work at the near-by Kensington mine, but no production of gold from either of these properties was made in 1928. Near Windham Bay, south of Juneau, the Jacob Marty Mines has continued development work on a number of claims but has not yet reached an operating stage.

The Hyder district, at the head of Portland Canal, in southeastern Alaska, was the scene of continued prospecting during the year, but very little gold was produced from any of its mines. The geology and mineral resources of this region have recently been fully described by Buddington,[5] and his account of the individual properties and of the district as a whole encourages prospecting there. During 1928 the greatest amount of development work was done on claims of the Mountainview Gold Mining Co. on Fish Creek, about 6 miles north of Hyder. Several thousand feet of development work has already been done, and the results are said to be encouraging, though the only production has been a few tons shipped to outside smelters for test runs. The ore in addition to gold carries lead, silver, and some copper. Shortage of funds necessitated cessation of the work late in the year, but this was regarded as only temporary. In the vicinity of the Mountainview property some prospecting and development work was in progress on the claims belonging to the Titan Mining Co. Throughout the year the Riverside mine, which in earlier years had been the most productive mine in the Hyder camp, was idle, owing, it is stated, to difficulties in management. No statement has been given out as to when mining is likely to be resumed there. Farther north, in the Texas Creek region, prospecting and search for workable ore deposits has been continued with reported encouraging results, though no shipments of ore or bullion were made.

In the Ketchikan district gold lodes have long been recognized and in the past have yielded considerable gold, though recently most of them have been inactive. In 1928 the most productive gold mine in the district was that of the Kassan Gold Mining Co. near Hollis, on Prince of Wales Island. This mine has been developed to a depth of about 600 feet and several levels turned off. The general gold tenor of the ore is rather low, so that unless mining is done on a large scale the margin of profit is likely to be small. Considerable graphite occurs with the ore, and this makes recovery of the gold on ordinary plates difficult. In fact, the plates become dirty so quickly that lately their use has been discontinued, and it is the practice to send the finely crushed ore directly to Wilfley tables, where concentration is effected; the middlings after further grinding are passed through flotation cells, where the mineral they contain is recovered. Power is obtained by means of a 100-horsepower Diesel

[5] Buddington, A. F., Geology of Hyder and vicinity, southeastern Alaska: U. S. Geol. Survey Bull. 807, 124 pp., maps, 1929.

engine burning distillate, which costs at the property about 6½ cents a gallon. An attempt to acquire hydroelectric power by developing the Karta River has been unsuccessful, as that stream is required for other purposes. On Helm Bay north of Ketchikan a little gold-lode mining was done in 1928 on the Gold Standard property. At this place a small 5-stamp mill operated by local water power was in use part of the summer, and the material passing over the plates was concentrated on a table, the concentrates being shipped to Tacoma for treatment at a smelter. A little other prospecting is in progress in the vicinity of Helm Bay, and it is reported that during 1928 several of the old mines and prospects were thoroughly sampled by a capable mining engineer, evidently with the view of reopening them if they proved suitable. The results of this investigation have not been made public. A little work was also done on one of the old properties near Dolomi, on Prince of Wales Island, and a small amount of gold produced. Some work was also started at the Peerless mine, on Thorne Arm, but it was discontinued early in the season. No work was reported to have been in progress at the mine of the Alaska Palladium Co. on Kasaan Peninsula, though rumors were current that developments might be resumed in the near future.

The Willow Creek district north of the head of Cook Inlet was the second most productive gold-lode camp in the Territory in 1928. Its production, however, was somewhat less than in 1927, owing largely to cessation of productive work on some of the properties pending reorganizations and the laying out of new plans for their development. The largest producers of lode gold in this region are the Willow Creek Mines, the Golden Bear Mining Co., the Marion-Twin Gold Mining Co., the Fern Gold Mining Co., and the Mabel mine. The Lucky Shot and War Baby mines of the Willow Creek Mines were operated during much of the year under lease by a group of miners, as that system has proved effective heretofore in the operation of the Gold Bullion mine of the same company. Unfortunately, in November, when work for the season had practically ceased, the mill at the Lucky Shot mine caught fire and was completely destroyed. Plans were immediately made to rebuild the mill, and material for the new structure was arriving on the ground during the winter and was being freighted to the mill site, so as to be on hand early in the open season of 1929. At the other properties much of the season of 1928 was spent in development work, both in the mines and in the mills, and the results of this work should be reflected by increased production later. No new discoveries of moment were made, but throughout the camp revival of activity was evident.

In the Fairbanks region gold-lode mining was continued in 1928, in both the Ester Dome and Pedro Dome areas, on a somewhat larger scale than in the preceding year, though at several of the mills the operations were hampered by shortage of water. In the vicinity of Ester Dome, which lies northwest of Fairbanks, the principal producing properties were the Mohawk and Elmes mines, on the northeastern slopes of the dome, and the Eva Quartz Co. and First Chance properties, on the Ester Creek side. Reports were current late in the season that an English company had taken up its options on the old Ryan lode, on the eastern flanks of the dome, and would press development work actively next season. In the vicinity of Pedro Dome the greatest gold-lode production was reported from the Crites & Feldmann mine and the McCarty mine, both in the valley of Fairbanks Creek; from the property of Heath & Kearns, on Dome Creek; and from the Wyoming mine of the Wackwitz Bros., on Bedrock Creek, a tributary of Cleary Creek. The Crites & Feldmann mine has long been the principal producer in this region, and work there continued at practically the same rate as heretofore. The Heath & Kearns mine is being developed on the Soo claim, formerly part of the property earlier exploited by Spaulding. The McCarty mine is near the summit of the ridge at the head of Fairbanks Creek, where showings of especially rich quartz float had been found the year before. At the Wyoming mine considerable new underground developments had been made and some new surface construction done during the year. In the valley of Bedrock Creek, on the old Rhoads-Hall property, now known as the Cleary Hills Mines, a new shaft had been sunk and other underground work done but no production of gold reported. Several other small operations that were merely in a prospecting stage were also reported to have had some work done on them during the year.

Among the gold-lode producing districts grouped in the table on page 12 under the heading "Other districts," the most productive are the mines and prospects on Kenai Peninsula—including the Nuka Bay region, the region south of Hope, and the hills north of Girdwood—and in the Kuskokwim region at the old Pearson & Strand mine, on a tributary of Nixon Fork. In the Nuka Bay region the greatest amount of gold was recovered from the Babcock & Downey property. Work at the Alaska Hills mine closed early owing to a slide which destroyed several of the buildings. Some work was done on gold-lode claims on each side of the Alaska Hills mine. Two prospectors were driving short tunnels to disclose the geologic conditions at a property on the right arm of Nuka Bay, and two or three other prospectors were looking for opportunities to locate promising ground in the district.

In the vicinity of Girdwood prospecting and development work has been in progress at several places near the head of Crow Creek, and a small amount of lode gold was produced. The most active work is reported to have been done on the old Monarch group of claims; on the old Jewell claims, to the south; and on the Gunnysack group of claims, to the south of the Jewell, but small amounts of prospecting were also done at several other places in that region. Farther south on Kenai Peninsula proper the Lucky Strike mine, on Palmer Creek, was again in operation, and the owners reported that recent developments had disclosed ore that appeared to be better than the ordinary run which had lately been produced. In addition to the gold recovered on the plates at this mill some concentrates were produced and shipped to a smelter in the States for treatment. Several small lode-gold prospects, at which some work was done during the season, were also reported at a number of points near the Alaska Railroad, notably at mile 20, mile 40, and mile 43½. At several other places lode prospecting was in progress, but so far as known it amounted to little more than the annual assessment work required by law.

In the Kuskokwim Valley the only lode-gold production reported came from the old Pearson & Strand mine, operated by Charles Mespelt, on Ruby Creek, in the Nixon Fork district. No details regarding the recent developments at this mine are available, but apparently more work was done in 1928 than during the last few years. In connection with this general region it may be of interest to record the fact that according to the published annual report of the Alaska Treadwell Gold Mining Co. for 1928, that company during the year wrote off the last of the item for its earlier expenditures for developing a property in this region, though it had discontinued work at that place several years before.

In addition to the operations in these various districts and camps from which some lode gold was produced in 1928, there was renewed activity in prospecting for gold lodes and rehabilitating some of the mines that had been idle for several years at other places in Alaska. In the vicinity of Valdez and at other points on Prince William Sound a good deal of interest was displayed in revived activities at several of the old properties. According to local reports a new mill was being constructed at the Ethel mine, development was in progress at the Little Giant mine, a new lease had been taken on the Ramsay-Rutherford property, and late in the year the old Granite mine was acquired by a company that proposed to reopen it. Prospecting for lodes was continued in the Tiekel region, and the finds are reported to have been encouraging. During the driving of the tunnel for the Eklutna power development a quartz vein was cut that was said to carry gold, but further examination failed to indicate that it had commercial value. No new developments were reported on the lodes in the Valdez Creek region. In the Nome region further development work was carried on at the Hed & Strand mine, but this property has not yet reached a productive stage. A little search for gold lodes was carried on at a few other points in Seward Peninsula but appears not to have disclosed workable deposits.

GOLD PLACERS

GENERAL CONDITIONS

Placer mining in Alaska in 1928 returned gold worth more than a third of a million dollars in excess of the amount produced in 1927, and on the whole the industry seemed to be in a flourishing condition for still further increase in the near future.

The annual production of placer gold and certain other data relating to Alaska's gold production are graphically represented in Figure 2. From this diagram may be traced the changes that have taken place in the industry. Thus in no year from the beginning of the industry in 1880 to 1898 did the production of placer gold amount to as much as $1,000,000, and the average during that period was less than $280,000. In 1899 there was a sudden increase, marking the discoveries of Nome and some of the camps in the upper Yukon Valley, which were soon followed by the discovery of Fairbanks and many of the other camps of the interior, resulting in a golden period that lasted through 1916, during which the annual yield of placer gold averaged more than $10,000,000 and in 1906 reached the peak of nearly $19,000,000. In 1918, after the entry of the United States into the World War, placer production dropped to less than $5,000,000, and in the 10 years since that time it has fluctuated between that amount and $3,000,000.

The increased production of placer gold in 1928 is to be attributed to the generally favorable weather that prevailed in most of the placer districts of the Territory and to the coming into production of some of the large enterprises that had been in the course of development during preceding years. The success of so many of the placer operations depends on adequate water supply that weather conditions which afford abundant rainfall are regarded by the placer miners as especially desirable. During the open season of 1928, throughout most of interior Alaska in which the placer camps are situated, there was fairly abundant rainfall in the early months and again late in the fall, though the middle of the season was rather dry. The break-up of the streams in the spring and their freezing up in the fall occurred at about the same dates as usual, so that the length of the mining season was about normal.

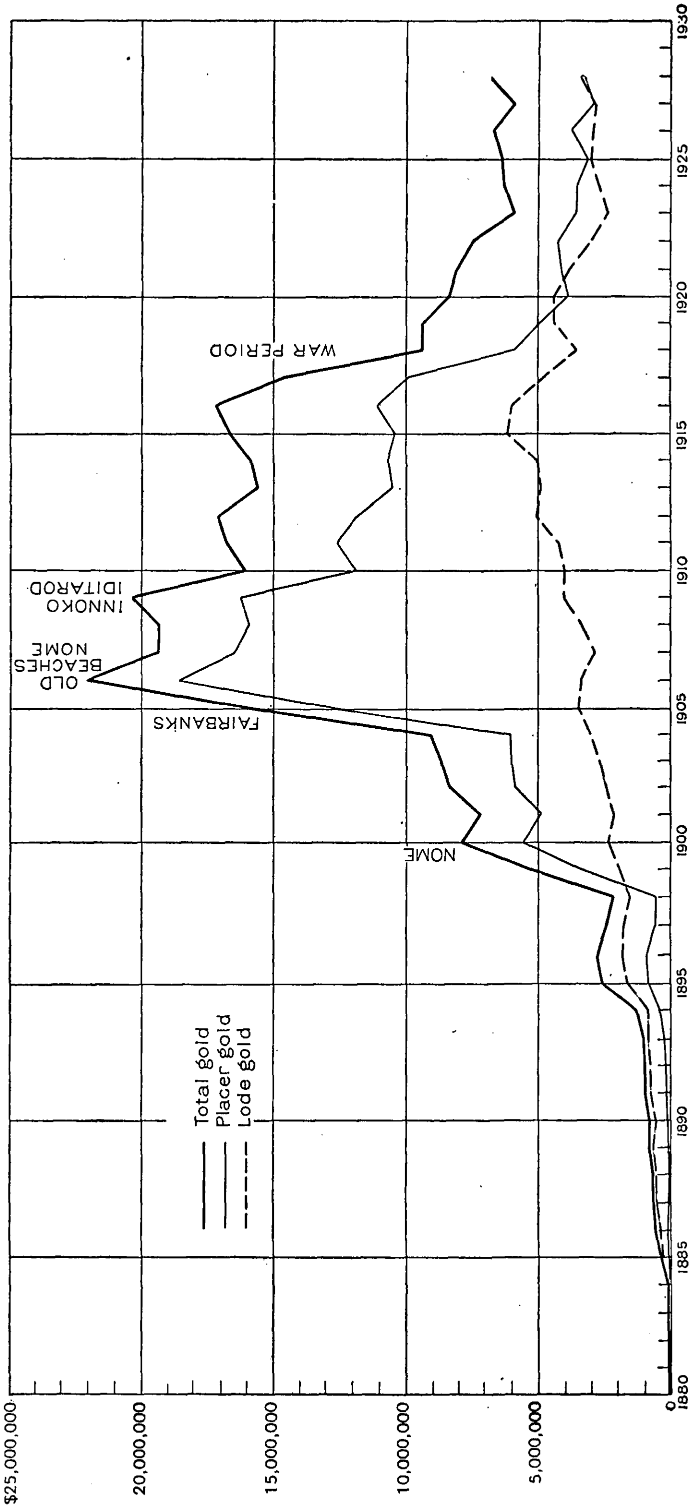


FIGURE 2.—Trends of total value of gold production of Alaska, 1880–1928, and proportion of gold derived from lodes and placers

The principal increase in placer-mining operations was the beginning of actual mining on the big dredging enterprise in the Fairbanks district that has been in course of development by the Fairbanks Exploration Co. for several years. Two large dredges that were built during the winter of 1927–28 started digging early in the season, and a smaller dredge was built during the summer and was in operation during the last months of the season. Several dredges that had been constructed by other companies during 1927 but had been completed so late in that season that they had mined only a short time were able to operate throughout much of the season of 1928. These larger well-managed enterprises not only contributed notably to the direct output of gold during the current year but are of even greater significance in assuring continued activity in placer mining. They also have many indirect effects in stimulating the industry, for they afford employment whereby prospectors can accumulate funds with which to do prospecting on their own account during the off season, and by their demonstration of sound engineering practice they afford excellent training to prospectors in efficient methods of conducting various phases of mining, some of which can be effectively employed by individuals on personal holdings. On the whole, however, the lessons taught by these larger enterprises tend to dissuade the prospector from searching for small tracts that can be mined by one or two men, so that much of the search that is now being made, even by individual prospectors, is directed to the discovery of large tracts that can be mined only by well-financed companies. This in a way is unfortunate, for it is difficult for the individual to prospect a large tract adequately, and a large company that might undertake the development of such a tract, realizing the large amount that it must spend in preliminary investigation, is seldom willing to meet the price asked by the prospector. In other words, many of the prospectors are spending their time searching for a thing which, if found, will be difficult to dispose of at a high price. On the other hand, however, there is an increasing interest on the part of capitalists in large properties that hold promise of being profitably mined, so that the prospector can usually dispose of his finds provided the price he asks is in accord with the showings. It is believed that there are still large tracts of Alaska which have not yet been thoroughly prospected or adequately examined for large-scale placer operations. Most of these areas do not appear to give promise of holding bonanza deposits that can be won cheaply. There are, however, extensive areas in which, it is confidently believed, large, well-organized, and well-managed companies will find placers that can be mined profitably for many years.

At the present time wages appear to be relatively higher and costs lower in the States than in Alaska, so that incentive for a new generation of prospectors to come to Alaska and take part in the search for new placers is lacking. This condition, however, is not regarded as permanent, and when conditions change so that active prospecting is renewed in the Territory the opportunities that still await the earnest worker will probably prove to be very great.

PRODUCTION BY DISTRICTS

From the description already given as to the methods used in collecting and interpreting the information that forms the basis of this report it is probably evident that it is more difficult to obtain accurate facts regarding the production of placer gold than regarding any of the other items. This is due to the great number of small producers, who are widely scattered and many of whom are in the most remote parts of the Territory. The gold they produce frequently passes through many hands before it finally reaches a mint or assay office, so that a single lot is difficult to trace. It may appear in the reports of the individual and then lose its identity by being lumped with other gold by the storekeeper who took it in exchange for supplies, and still further consolidated by the bank, perhaps in some distant district, to which it was sent by the merchant, and its course perhaps still further obscured by being shipped to another bank before being turned in to the mint. Every reasonable effort has been made to check the information from different sources and to adjust discrepancies so far as possible. As a result it is believed that the figures given for the total placer production are in accord with the actual facts. The distribution of this total among the different districts, however, is open to much more serious errors, as gold produced in one district, unless reported to the Geological Survey by the original producer, may be credited to some other district through which it passed in the course of trade. For instance, in 1928 a small amount of gold that was evidently mined in Alaska was nearly excluded in this tabulation because it had been credited to Oregon through being turned in by a resident of that State. In spite of the possibility of some error in the distribution of placer gold among the different districts, the following table has been prepared to show the comparative standing of the different districts as accurately as possible. The greatest amount came from the Yukon Basin and the next largest from Seward Peninsula. Placer mining in each of the main regions will be discussed in some detail in the following pages, and the more notable events of the year will be recorded for each region.

Value of placer gold produced in Alaska in 1928 and 1927

Region	1928	1927	Decrease or increase, 1928
Southeastern Alaska	$9,800	$20,000	−$10,200
Copper River region	110,000	89,000	+21,000
Cook Inlet and Susitna region	72,800	66,000	+6,800
Yukon Basin	1,876,500	1,282,000	+594,500
Kuskokwim region	217,500	151,000	+66,500
Seward Peninsula	1,056,300	1,365,000	−308,700
Kobuk region	4,100	9,000	−4,900
	3,347,000	2,982,000	+365,000

SOUTHEASTERN ALASKA

Although southeastern Alaska is rich in gold lodes, its placers are of relatively small extent and yield only a little gold, because throughout most of the region the topography is mountainous, with precipitous slopes leading down from the crests of the ridges to the ocean waters or to the valley floors and affording little or no lodgment for detrital material. Furthermore, so much of the region was occupied in the recent past by glaciers that there is an almost complete lack of deposits produced through the long-continued sorting action that is so essential for the formation of rich placers. Even along the coast there are almost no beaches where concentration has long been effective. In the lowlands along the larger streams, in some of which great amounts of detrital material have been dumped by past processes, sorting action conducive to the formation of rich placers has been relatively slight, and much of the material handled by the streams has not been subjected to weathering and similar processes which unlock the mineral grains of different kinds and thus promote separation through physical differences. There is therefore small likelihood that southeastern Alaska as a whole holds much promise as a placer region, though in a few places where special geologic conditions prevail there is a prospect of finding placers of local value.

In 1928 there were two main tracts in southeastern Alaska from which some placer gold was recovered. These were the Porcupine River district and the Yakataga district. The principal work in the Porcupine River district was done on claims of the Porcupine Mining Co., where 35 men are said to have been employed throughout the open season in development work on a large hydraulic enterprise that has been going through the preparatory stage for the last two years. Much of the preliminary work is now reported to have been completed, so that another year productive operations can be carried on more continuously. Two or three smaller camps were also engaged in placer mining in the district, but their efforts were largely directed to prospecting, and their output of gold was small.

In the Yakataga district the placers are all of the beach type, occurring in the stretch of coast where sorting by the ocean is effective. Their position exposes the workings to the waves of the Pacific, so that except under favorable weather conditions they can not be mined, and even then the use of extensive mechanical appliances is precluded. As a result only two or three small camps of two men or so each are engaged in mining, and though the amount of gold they produce is small, relatively to the size and expense of the operations it is large. Mining on the coast has been carried on at about the same scale as in 1928 for several years.

The only other place in southeastern Alaska at which some production of placer gold was reported in 1928 was on Montana Creek, a tributary of the Eagle River, a short distance north of Juneau. Four men were employed at this place, but most of their time was spent in preparatory work, so that they produced only a little gold.

COPPER RIVER REGION

In the Copper River Valley there are three principal areas that yield placer gold, though there are a few small camps widely scattered throughout the river basin. These principal areas, named in order of their production, are the Nizina, Chistochina, and Nelchina districts. As will be noted from the table on page 23 the value of the placer gold produced from the Copper River districts was $21,000 greater in 1928 than in 1927. In the Nizina district the bulk of the placer gold came from the properties of the Chititu Mines, on Chititu and Rex Creeks, and from the Nicolai Placer Mines, on Dan Creek. At both these properties the season of 1928 was reported to have been especially favorable, although mining operations were somewhat hampered by low water in the early part of the season and some damage was done by high water late in the season. About 35 men were employed at these two properties, and there were about four others engaged in prospecting work on their own account in the district.

In the Chistochina district the Slate Creek Mining Co. on Slate Creek was the only operator that reported any noteworthy production and was the only one in this district that did more than prospecting work. Owing to favorable conditions as regards water supply the output of placer gold from this district was considerably more in 1928 than in 1927, when mining was much hampered by shortage of water. In the Nelchina district all the mining was done by a few small camps consisting of only two or three men each, and the total production amounted to only a few thousand dollars.

During the open season the Alaska Road Commission did considerable work on the trail that leads from the Chickaloon branch of the Alaska Railroad to Caribou Creek, which will be of much assistance in making the Nelchina district more accessible.

COOK INLET-SUSITNA REGION

In the Cook Inlet-Susitna region, as that term is used in this report, are included the placer camps in Kenai Peninsula and adjacent country, the Yentna-Cache Creek district, and the Valdez Creek district near the head of the Susitna River. In the past many of these camps have been highly productive, though lately their output of gold has decreased and only a few score miners are now at work, where formerly there were hundreds. Owing to more favorable weather conditions in 1928 the output of placer gold from this region showed an increase of about $6,800 above that reported in 1927 and was approximately $72,800.

In the Yentna-Cache Creek district no new discoveries of moment were reported. As in the past, the greatest amount of mining was done on Cache Creek and its tributaries. The dredge, which had been in successful operation here for several years but which was damaged in 1926 and put out of commission, still continued to stand idle. The largest single operation in the district was that of J. C. Murray, of Cache Creek, who hydraulicked considerable ground on both sides of the creek and is also reported to have found good showings of gold in some of the bench ground that was prospected. On Falls Creek, a tributary of Cache Creek, W. H. Nagley and associates did considerable work, and on Thunder Creek, also a tributary of Cache Creek, one small camp is reported. On Peters Creek four different camps, comprising a total of eight men, were engaged in placer mining. Mining camps of one to three men each were also reported as active on Bird, Poorman, and Willow Creeks, which are tributary to Peters Creek. North of Peters Creek, in the valley of the Tokichitna River, some prospecting and development work was reported to be in progress, but no specific information is available as to the amount of gold obtained, though it was probably small. In the Fairview district, which lies to the southwest of the Cache Creek district, four separate camps, consisting of a total of about half a dozen prospectors, took out a little placer gold. Work there, however, appears to have been little more than prospecting, and the only definite report of production received by the Geological Survey came from one outfit on Notobac Creek.

The producing placer camps in the Kenai Peninsula region are mostly situated in the vicinity of Hope, Sunrise, and Girdwood. All of these are small operations, the largest yielding only a few thousand dollars a year and some of them only a few hundred dollars. In the valley of Resurrection Creek, the stream which enters Turnagain Arm near Hope, the only mining that was reported to have continued throughout the season was at the St. Louis Mining & Trading Co.'s property, where hydraulicking was done by a force of about six men. On the Mathieson ground on the same stream work is said to have been discontinued early in the season, owing to difficulties with the long ditch. On Sixmile Creek, near Sunrise, a small amount of placer gold was produced by two prospectors. On Canyon Creek, which joins East Fork from the west to form Sixmile Creek, several outfits were mining during the season. Tolsen, Plowman, Miller, and Davies, who had leased ground from the Canyon Creek Development Co., report a reasonably satisfactory season. There were two small camps on Mills Creek, farther up the Canyon Creek Valley, and also two small camps on Lynx Creek, a tributary of East Fork. North of Turnagain Arm in the valley of Crow Creek, a tributary of Glacier Creek about 5 miles northeast of Girdwood, some placer gold was mined at the property of Holmgren & Erickson.

In the Valdez Creek region, which lies some 125 miles north of Anchorage, near the head of the Susitna River and about 40 miles in an air line east of the main line of the Alaska Railroad, prospecting for both lodes and placers has been going on for many years. No new finds were reported to have been made during 1928, but the returns to the few placer operators who were in the district appear to have been satisfactory. The supply of water was abundant through the open season, and as a result the output from that district was somewhat larger than it has been during recent years. The largest amount of gold came from hydraulic operations near the main stream and from some of the bench ground, especially on the left bank of Valdez Creek. A little of this ground was also worked by drift mining. Some gold was also recovered from the placers on Lucky Creek, a tributary of Valdez Creek. Twelve men appear to be the total number of miners engaged in productive work in the Valdez Creek district during the year.

YUKON REGION

The Yukon Valley embraces a tremendous extent of territory, and scattered through it from one end to the other are many placer-gold camps. In the past gold has been reported from almost every stream in the entire basin, though the quantities in some have been so small as to be of no possible commercial interest. For convenience of description in this report all the producing placer camps in this vast area have been grouped into 17 more or less distinct tracts that are here called districts. It should be noted that the boundaries of these districts are by no means well defined and do not necessarily correspond with any of the legal subdivisions such as the precincts or recording districts. In the main the names here given to these districts have been chosen from some of the more prominent features occurring in them. The main purpose of this grouping is to combine areas having in general similar interests and similar conditions and to separate those that are dissimilar. This results in throwing some large tracts together and in splitting up some other parts of the valley into a number of small districts. In some places the boundaries of the different districts almost overlap; in others the boundaries of one district lie far from those of its nearest neighbor.

The gross output of placer gold from all the camps in the Yukon Valley in 1928 was worth $1,876,500, an increase of almost $600,000 over the corresponding figure for 1927. The increase is largely attributable to the starting of actual dredging work on the property of the Fairbanks Exploration Co., in the Fairbanks district, but was in no small measure due to the generally favorable weather conditions and fairly abundant water supply in 1928, whereas in 1927 the season was especially dry and opened late and closed early. In the following table the districts are arranged in order of their placer production in 1928, and for comparison the production from the same districts in 1927 is given. The total is believed to be correct as stated, but the distribution of this total among the districts is open to uncertainty, owing to the great number of small producers, their wide distribution, and the failure of some of them to supply the essential information. However, every precaution has been taken to guard against errors and to keep the estimates in accord with all the available facts, so that the figures stated are regarded for all practical purposes as accurate.

Value of placer gold produced in Yukon Basin, 1928 and 1927, by districts

District	1928	1927	District	1928	1927
Fairbanks and Richardson	$947, 500	$350, 000	Ruby	$21, 800	$52, 000
Iditarod	296, 200	150, 000	Eagle	16, 500	19, 000
Tolovana	151, 000	151, 000	Chisana	16, 000	15, 000
Innoko	113, 200	244, 000	Kantishna and Bonnifield	11, 800	12, 000
Circle	80, 500	72, 000	Rampart	7, 500	10, 000
Fortymile	79, 100	37, 000	Marshall	3, 500	9, 000
Hot Springs	77, 000	75, 000			
Koyukuk and Chandalar	54, 900	86, 000		1, 876, 500	1, 282, 000

In the foregoing table two small districts, the Richardson and Chandalar, have been grouped with the near-by larger districts, Fairbanks and Koyukuk, respectively, and two small districts, the Kantishna and Bonnifield, have been combined. These combinations have been made principally to avoid disclosing confidential information regarding individual production from some of the small districts, where the bulk of the placer gold has come from only one or two mines. None of these small districts produced as much as $10,000, and some of them only a few thousand dollars. The combinations that have been made do not affect the relative standing of the larger districts to which the smaller ones have been added.

The region adjacent to Fairbanks has long been and still is the main placer district in interior Alaska. The greatest amount of placer gold was produced by the dredges of the Fairbanks Exploration Co., on Chatanika River and Goldstream; the Fairbanks Gold Dredging Co., on Fairbanks Creek; the Tanana Valley Gold Dredge Co., on Fish Creek; and the Chatham Gold Dredging Co., on Chatham Creek, a tributary of Cleary Creek. Considerable placer gold was also recovered by hydraulic or open-cut methods, and a little by drift mining. The placer gold recovered by other methods than dredging came principally from Ester, Pedro, Dome, and Big Chena Creeks, the upper Chatanika River, and their tributaries. Several thousand dollars' worth of placer gold, in addition to that produced by the dredges, came from placers on Fairbanks and Fish Creeks. There were also smaller camps in the valleys of several of the other streams whose production, though individually only a few hundred or a few thousand dollars, yet in the aggregate swelled the total production for the district.

By far the most outstanding event in the Fairbanks district was the completion of three of the dredges of the Fairbanks Exploration Co. on Goldstream and at Chatanika. The building of two of the larger dredges was carried on throughout the winter, so that they were completed and in operation early in the season. The third dredge, a smaller one, was erected during the summer near Gilmore and started digging early in September. To supply power for these dredges and for the other activities of the company, a large power plant, utilizing coal from the Nenana field, was built and put into successful operation. The long ditch, with necessary siphons, which was undertaken to bring water from the valley of the upper Chatanika River, was completed, and water was turned into successive sections of it until by fall all parts as far as Goldstream had been tested. As with all new ditch construction in interior Alaska difficulties were experienced in making certain sections water-tight, and doubtless as the ground settles the ditch will require considerable attention for some time, but except in a few places no serious trouble was encountered or expected. Extensive thawing by cold water was carried on in the areas where dredging will be done, and similar work that had been undertaken in the earlier years at the places where the present dredges are installed had prepared the ground so that it was in condition to be mined. The whole development has been carefully planned, thoroughly analyzed, and efficiently conducted so that little of its success has been left to chance. Intensive study has been made of many of the technical problems involved—for instance, the efficacy of thawing ground with cold water—and the conclusions reached will be of great practical interest to engineers when the final results are made public.

In the ill-defined district east of Fairbanks, here called the Richardson district from the principal settlement in it and including the old camp known as Tenderfoot, the Big Delta and Jarvis Creek area, south of the Tanana, and parts of the Goodpaster and Salcha Valleys, to the northeast and northwest, about 25 men were doing a little placer-gold mining or prospecting. The output of this entire district amounted to only a few thousand dollars in gold. The most productive operation was that of W. F. Puntila, on Tenderfoot Creek. One smaller camp was also mining farther up the valley. Two small camps worked on Democrat Creek, a tributary of Banner Creek, and one prospector was reported to have taken out a little gold on Buckeye Creek, also a tributary of Banner Creek. No details are available regarding the placer-mining operations on the other creeks here included in the Richardson district, and except in the vicinity of Jarvis Creek the work was practically only development work. In the vicinity of Jarvis Creek, however, three to five prospectors were at work and reported a small production of gold.

The output of placer gold from the Iditarod district in 1928 showed a very great increase over the amount attributed to that district in 1927. This increase was largely due to the much greater output of gold by the two dredges. It was also due to the much more plentiful supply of water in 1928 than in 1927, so that many of the smaller plants could be operated more continuously and efficiently. The high stage of water was also advantageous for the freighting of supplies and thus reduced the long delays that have been so vexatious in the past. Continued activity in road building by the Alaska Road Commission in this district is likewise facilitating the movement of freight and encouraging development. One of the largest camps in the district is that of the Black Bear Mining Co., on Chicken Creek, where a dozen or more men were employed throughout the season. Several camps were reported on Willow Creek, the largest of which are one maintained by Frank Manley and one by Joseph Loranger. In addition to the dredges several small parties of miners were at work on Flat Creek and its tributaries. Several camps were also mining on Otter Creek and its tributaries above Flat Creek. The largest of these, that of Peter Miskovitch, was mining with a hydraulic elevator and employed four men. Many of the smaller operators in the Iditarod district do not report fully to the Geological Survey the results of their work, so that the available information as to the recent mining developments is not as accurate as that from most of the other placer camps.

In the Tolovana district, with which is included Nome Creek, a tributary of Beaver Creek, the greatest amount of gold was produced by the dredge on Nome Creek. The output of gold by this dredge was considerably more than in 1927, and operating conditions were being improved. At the other placer mines in the district, however, there was a decrease in the amount of gold produced, so that the net result so far as the records of the Geological Survey show was identical in 1928 and 1927. Exclusive of the gold mined by the dredge about equal amounts of gold are recovered by drift mining and by hydraulic or open-cut methods. Most of the larger producing mines are on Livengood Creek and its tributaries, Lillian, Ruth, and Amy Creeks. Some placer gold was also recovered from the Tolovana River and its tributaries east of Livengood Creek. Among these tributary streams the most productive were Olive and Ester Creeks, which join the Tolovana from the north, and Wilbur Creek, which enters it from the south. Even under the best ordinary conditions the water supply of the camps in the Tolovana district is small, and some of the gold-bearing gravel mined by drifting in the winter of 1926–27 was not sluiced until 1928. Under these conditions the gold recovered from this gravel in 1928 has been included in the production of that year. The Livengood area continues to be handicapped by lack of good freighting facilities. Although it is only a few score miles distant from some of the good roads of the Fairbanks district, there is no road connection, and most of the freight bound for the camps must be taken by small boats up the Tolovana River, a stream of nearly endless meanders, full of snags, and involving much rehandling of cargo. For the transportation of persons and small articles from these camps to or from Fairbanks airplanes have been advantageously used.

Reports from the Innoko district indicate that in 1928 its production of placer gold showed a greater decrease than that of any of the other districts in the Yukon Valley. This decrease was largely due to the great falling off in the production from the dredges on Yankee and Ganes Creeks. Not only was the production from the individual dredges less in 1928 but only two dredges were in operation, against three in 1927. The dredge of the Innoko

Dredging Co. on Ganes Creek was mining for only about 35 days, owing to shortage of wood for fuel. At the property of the Flume Dredge Co. much of the season was spent in reconstructing the dredge on Little Creek and in operating the dredge on Yankee Creek. Much of the material for the construction work was delayed so that the work was not completed until too late in the season to warrant mining this year, but the dredge was in good shape to put in a full season in 1929. In connection with these dredging operations an extensive equipment for cold-water thawing was installed. Mining other than dredging was done on Ganes Creek by two small camps; on Little Creek by two camps, the larger of which was that of N. J. Vibe; on Spruce Creek by two of moderate size; and on Ophir Creek by three, the largest of which was that of Collins & Hand. In the Cripple Creek Valley there were three producing camps, the largest of which was that of Wilson & Hand. The records indicate that between 40 and 50 men were employed at the producing mines in the Innoko district, but in addition there were probably a few individuals in scattered localities whose efforts were directed only toward prospecting. Extension of the road up Little Creek is said to have progressed satisfactorily, and during the year an additional stretch of about 1½ miles was completed.

The production of placer gold from the Circle district in 1928 was somewhat more than in 1927, although much less than in the immediately preceding years, when the dredge of the Berry Dredging Co. was in operation. In 1928 the largest output of gold came from properties of the Berry Holding Co. on Independence, Mastodon, and Eagle Creeks, where hydraulic plants were operated. Among the other mines in the district that produced some placer gold may be mentioned those of J. A. Anderson and August Erickson, both on Mastodon Creek; of Nicholas Knutson, on Deadwood Creek; and of J. F. Kelley, on Miller Creek. In addition to these larger producers there were a dozen or more 1-man camps widely scattered through the district that produced a few hundred dollars' worth of placer gold each. No noteworthy new discoveries were reported to have been made during the year, but there was a general undercurrent of optimism that seemed encouraging. This spirit seems to have been fostered by the completion of the highway from Fairbanks to Circle, which should be instrumental in opening up the district and stimulating development, for this road joins the formerly remote town of Circle with Fairbanks by less than a day's automobile travel.

Placer mining in the Fortymile district yielded much more gold in 1928 than in 1927. In the main this increase was due to the much more abundant water supply, so that all the mines were able to handle a large volume of gravel and to operate more continuously. The largest mine in the district is that of the Walker Fork Gold Corporation, which is on Walker Fork and operates a dragline scraper. During the year the Alaska Consolidated Gold Corporation acquired extensive holdings on Dome and Chicken Creeks and plans to carry on large-scale hydraulic mining. The principal other streams from which placer gold was obtained are Chicken Creek and vicinity, Jack Wade Creek and vicinity, the Fortymile River, Franklin Gulch, and Napoleon Creek. On and near Chicken Creek were 5 hydraulic mines, 2 shoveling-in operations, and 4 camps engaged in prospecting. On and near Jack Wade Creek eight camps had been engaged in drift mining during the winter. In addition, two hydraulic plants, those of Charles Martin and of Patterson & Olsen, were mining during the summer, and two or three individuals were prospecting. On the Fortymile River six small camps were carrying on open-cut work on bars in the river. On Franklin Gulch three groups of miners were mining placer gravel by open-cut methods. The only work that was reported to have been in progress during the year on Napoleon Gulch was ground sluicing and stripping preparatory to undertaking hydraulic mining in the near future.

The value of the placer gold produced in the Hot Springs district in 1928 was practically the same as in 1927, though the source of the gold differed greatly in the two years. Thus in 1928 the gold came largely from the dredge of the American Creek Dredging Co. and the production from the mines of other kinds was rather small, whereas in 1927 the dredge was not completed until late in the season and therefore its output was insignificant, and the output of the mines of other types was correspondingly much greater. Operation of the dredge was somewhat hampered by tracts of frozen ground within the area which the company planned to mine, but on the whole the results for a new undertaking were encouraging. Elsewhere in the American Creek-Tofty-Woodchopper region production from placer mining was almost at a standstill. This was due in a considerable measure to the fact that options on a large tract of the region had been given to an English company that was proposing to build dredges to work the ground and recover the tin and gold it contained, and while this option was in force the local people were more or less marking time, awaiting the company's decision as to its future plans. In the Eureka Creek section of the Hot Springs district the greatest amount of gold was recovered from hydraulic mines of Ed. Ness, Farmer & Jones, and Johnson & Hensley. In addition there were a few smaller camps of only one or two individuals each, and their output amounted to only a few hundred dollars each.

The Koyukuk district, as the term is here used, embraces a very large tract of country and consists of at least three rather widely separated areas in which placer gold has been mined. These subordinate areas are the Indian Creek-Hughes tract, in the central part of the Koyukuk Valley; the Hogatza River and vicinity, somewhat north of Hughes and embracing country north of the Koyukuk River; and the upper Koyukuk area, which includes that part of the Koyukuk Valley lying north and northeast of Bettles and including the country near Wiseman. Mining in the two more southern placer areas was practically negligible, and the Geological Survey has received no specific information regarding work there. Reports from the upper Koyukuk area seem to indicate that many of the miners and prospectors are becoming discouraged by the high cost of living and the difficulties of obtaining the supplies and equipment necessary for development. The Detroit Mining Co., in its exploration of the Hammond River, encountered so many difficulties due to water pressure in its test holes that it was unable to reach bedrock in the main valley and had to discontinue its tests there and transfer its prospecting to the shallower ground. Hydraulicking of certain bench ground along Nolan Creek was considerably hampered by shortage of water, and bedrock had not been reached when freezing weather set in. A slight flurry of excitement was aroused early in the winter of 1927–28, when a considerable quantity of gold was panned in the channel of the Bettles River while the water was at an exceptionally low stage, just prior to the freeze-up. Several attempts to prospect this point further during the summer of 1928 were unsuccessful, owing to the miners' inability to handle the large volume of water then carried by the river, and further attempts were postponed until cold weather had reduced the volume of water and permitted freezing down a hole to bedrock. Apparently about equal amounts of gold are recovered in the Koyukuk district from drift mines operated during the winter and from the mines that are operated in the summer. The greatest amount of productive mining is done in the vicinity of Nolan and Smith Creeks, five camps employing a total of 12 men, having been at work there during the winter of 1927–28, and four camps having a total of 9 men during the summer of 1928. In the entire upper Koyukuk tract there were about 50 prospectors and miners.

In the table on page 27 the placer-gold production of the Chandalar district has been combined with that from the Koyukuk. The amount of gold that comes from the Chandalar is much less than comes from the camps in the Koyukuk Valley. So far as reported only two mines in the Chandalar produced more than $1,000 in 1928. These were the property of Carlson, Amero & Buckley on Little

Squaw Creek and that of Newton & Yasuda on Big Creek. Three other small camps are reported to have done some prospecting during the year on Big Squaw, Little Squaw, and Dictator Creeks. No new developments were reported to have resulted from the work of the season.

The greatest amount of gold produced in the Ruby district in 1928 came from mines on Poorman Creek and its tributaries and on Long Creek and its tributary Greenstone Creek, but some placer gold was recovered from Spruce and Trail Creeks, which are tributaries of the Sulatna River to the northeast of the settlement of Poorman and east of the town of Long, respectively. Local reports indicate that some promising placer ground was discovered on Poorman Creek so late in the season that its development had to be postponed until another year. On both Long and Poorman Creeks a great deal of dead work was done during 1928, and this is believed to have made ready much ground to be mined in 1929. In fact, there was a general feeling of optimism in the region that though the production in 1928 was small there should be a material increase in 1929. About 35 miners and prospectors are said to have been at work in the district during the year. Prospecting was continued on Birch and Big Creeks, with the principal object of finding tin ore but incidentally with the hope that the search might disclose profitable gold-placer deposits as well.

Throughout the Eagle district, except on Barney, Nugget, and Broken Neck Creeks, the supply of water for placer mining was rather greater than usual, but there was no marked change in the amount of mining that was carried on. The largest amount of gold was recovered from the properties of the July Creek Mining Co., on Fourth of July Creek; of Froelich, Kummer, Ott & Scheele, on Crooked Creek; of Bryant & Parsons, on Alder Creek; and of Olsen & Johnson and August Fritz, on American Creek. In addition to these larger plants, some work was in progress on Nugget and Barney Creeks and on the bars of the Seventymile River. On Broken Neck Creek most of the season was spent in building a ditch which was completed so as to be available for use next season. On Crooked Creek ditch construction was also in progress and was expected to be finished in 1929 and thereafter be available to increase the amount of placer ground that can be sluiced. No new discoveries of note were reported to have been made in the district during the year.

The Geological Survey has received very little first-hand information regarding mining developments in the Chisana (locally called Shushana) district. Apparently mining was in progress on five properties during the year, and about 11 or 12 men were employed. The water supply of the district is said to have been small, so that sluicing operations were hampered. On Bonanza Creek a channel in the bench on the left bank was discovered, and the heavy overburden was hydraulicked off and the bedrock and pay gravel shoveled into the sluice boxes. Several new automatic-boom dams were built during the season but were not completed in time to be of much use in 1928. Production from the district seems to have been maintained at essentially the same rate as in 1927.

Placer mining in the Bonnifield district was carried on by six or seven small camps, the largest of which employed five men, and was situated on Grubstake Creek, a tributary of the Tatlanika River. The smaller camps were on Marguerite, Platte, Daniels, Moose, and Gold Run Creeks, and the production of gold from none of them exceeded a few hundred dollars. The production from this district has been combined in the table on page 27 with that from the Kantishna district, but it may be stated that the placer gold from the Bonnifield district in 1928 accounts for somewhat more than half of the combined total. In the Kantishna district there were a number of small camps at work on several of the creeks, notably Eureka, Little Moose, Glen, and Glacier Creeks. None of them, however, recovered gold worth more than a thousand dollars, and most of them only a few hundred dollars' worth. All the ground worked is shallow and is mined by simple methods.

Records received by the Geological Survey regarding placer mining in the Rampart district indicate that not more than 10 or 12 camps were active during 1928, and most of these were small 1-man operations that recovered only a few hundred dollars' worth of gold. On Hunter Creek were three or four hydraulic plants; on Idaho Bar between Hunter and Little Minook Creek one man was doing some drift mining; on Little Minook Creek two or three camps were mining by means of open cuts and automatic dams; on Hoosier Creek one camp of two men was preparing to do drift mining during the winter of 1928–29; on Slate Creek one camp was doing open-cut mining; and on Quail Creek there was also one open-cut mine active.

Willow Creek was the source of most of the placer gold that was mined in the Marshall district in 1928. This stream enters the Yukon a few miles upstream from the settlement of Marshall (Fortuna Ledge post office) and heads in hills composed principally of Upper Cretaceous sediments and Paleozoic greenstones and related rocks. Within the hills Willow Creek flows in a narrow-floored valley whose deposits contain many large boulders that interfere seriously with mining. Only a few miners or prospectors still remain in the district, and consequently the work that they can accomplish in thoroughly prospecting this large tract of country is small. Fifty miles northeast of Marshall, in the valley of the Stuyahok River, a tributary of the Bonasila River, one man is said to have done some prospecting during the year, but no report as to the results of that work has been received by the Geological Survey.

KUSKOKWIM REGION

Included in the Kuskokwim region are four principal districts where gold placers were mined in 1928. For convenience of description, they may be called the Mount McKinley, Georgetown, Tuluksak-Aniak, and Goodnews Bay districts. The Mount McKinley district embraces all the eastern part of the Kuskokwim Valley, but the placer mining in it is more or less localized around McGrath, Takotna, and Medfra. The Georgetown district is in the central part of the Kuskokwim Valley, and work there centers more or less closely around the settlement of Georgetown, on the Kuskokwim, about 45 miles in an air line south of Iditarod. The Tuluksak-Aniak district is named from two rivers that traverse parts of it; the Tuluksak enters the Kuskokwim from the south about 30 miles east of the settlement of Bethel, and the Aniak enters the Kuskokwim about 50 miles farther upstream, to the east. Goodnews Bay is a small indentation of the coast on the east side of Kuskokwim Bay, about 125 miles in an air line south of Bethel.

The placer production from the Kuskokwim region showed a marked increase in 1928, largely attributable to the greatly increased output from the dredge of the New York-Alaska Gold Dredging Co., on Bear Creek, in the Tuluksak-Aniak district. Details regarding the work at this mine are not available, but from general sources of information it appears that the operating conditions were especially favorable and that the dredge had a very successful season, although no noteworthy new discoveries were made. It is understood that part of the ground mined last summer by the dredge lay somewhat outside the tract originally considered suitable for dredge mining, so that evidently the original estimates of the company as to minable area were conservative. No other dredges were in operation elsewhere in the Kuskokwim region in 1928. The dredge that for many years has been so productive in the district near McGrath was again idle, as it was in 1927, and apparently no plans are now under consideration for its early reconditioning.

Reports regarding placer mining in the Mount McKinley district are extremely meager, and so far as could be learned most of the work was done by several one or two man camps at widely separated points, most of which, however, are adjacent to McGrath or in the hills north of the Kuskokwim farther upstream, near Medfra. Among the streams from which some placer gold was produced in 1928 may be mentioned Candle, Ruby, Hidden, and Eagle Creeks and Holmes Gulch. Work at these places was done on a somewhat smaller scale than heretofore, and no notable new finds appear to have been made. A Geological Survey party carried on exploratory work in the hills at the head of the Stony River during 1928, but members of that party state that there were no prospectors there. The extent of former glaciation and the general inaccessibility of the region make search for placers there difficult, though the geologist reports certain geologic conditions that are regarded as favorable for mineralization. The vast slightly explored or even totally unexplored area that lies south of the Kuskokwim is regarded as country that well deserves more thorough examination and intelligent prospecting.

Mining in the Georgetown district appears to have been practically restricted to work on Donlin Creek, where two miners operated a small hydraulic plant on bench gravel. In the Tuluksak-Aniak district, in addition to the dredge output, considerable gold was recovered from placers on Marvel Creek, a tributary of the Salmon River, which in turn flows into the Aniak River, and from Canyon Creek, a tributary of the Kwethluk River, on the western slopes of the Kuskokwim Mountains, east of Bethel. The largest camp on Marvel Creek was that operated by Dahl & Wilson on ground owned by L. C. Hess. Five men were employed at this camp, and the reports indicate an especially good season. A few prospectors were reported to have been carrying on a search for placers on several of the streams that head in the general vicinity of Marvel Dome, and there is said to be some revival of interest in prospecting throughout the area, but returns from this work have not yet made any notable increase in the output of placer gold.

In the Goodnews Bay district only four to six men appear to have been engaged in productive placer gold mining in 1928. Their camps were on Butte, Bear, Olympic, and Clara Creeks. This district was the only placer district in Alaska that appears to have been hampered by too much water during the year. Mining and development work on Wattamus Creek, which has long been one of the productive creeks in the district, was suspended because during most of the summer that stream was running bank full. On the Arolic River prospecting with a horse drill to determine the adaptability of placers on that stream for dredging was continued by a small force of miners, but no statement has been made as to the results, and it is not known whether the findings are such as to warrant the construction of a dredge in that area in the near future. There has been considerable interest in placer deposits of platinum in the Goodnews Bay district in 1928, and several men have been engaged in that work. Further notes on this work are given in a later section of this report, which treats of platinum. Except at certain claims on Clara Creek, where several ounces of gold was recovered with the placer platinum, the clean-up from the platinum placers showed only a few almost insignificant flakes of gold.

SEWARD PENINSULA

The production of placer gold from Seward Peninsula camps in 1928 was $1,056,300, or about $300,000 less than in 1927. Much of this decrease was due to the shortening of the dredging season at most of the dredges on the peninsula and a corresponding decrease in their output. For instance, in 1928, the large dredges of the Hammon Consolidated Gold Fields ceased work early in October, whereas in 1927 one of them was mining as late as November 23. The rather widespread early cessation of dredging was not due to adverse weather conditions in 1928, as the records appear to indicate that both the time of opening and freeze-up and the supply of water were normal. In fact, the general reports from Seward Peninsula indicate that the season of 1928 was as good as the normal or even better. The early closing may, however, be traced to the adverse weather conditions of 1927, which prevented many of the dredge operators from preparing enough ground that season to take care of the dredge requirements for 1928.

Approximately $832,000, or nearly 79 per cent of the total gold recovered from Seward Peninsula placers, was mined by dredges, one or more of which were active in practically every one of the larger districts of the peninsula. Additional data regarding dredge mining on Seward Peninsula, as well as in other parts of Alaska, are given in a later section of this report. In the relative order of their output of placer gold in 1928 the mining districts of Seward Peninsula stood as follows: Nome, Fairhaven (including the Candle and Inmachuk districts), Council, Solomon (including the Casadepaga River region), the Koyuk River region, Kougarok, Port Clarence, and Bluff. So much of the placer gold from some of these districts came from only one or two mines that it has not seemed advisable to publish the production of the separate districts, as it might disclose the output of the individual mines. The total placer gold production from the peninsula in 1928 was worth $1,056,300, to which must be added about $6,000 for the silver that is an integral part of the placer gold as it is recovered from the gravel.

The outstanding enterprise in the Nome region, as well as in the whole of Seward Peninsula, continues to be that of the Hammon Consolidated Gold Fields, with its three dredges between Little and Wonder Creeks, its scores of claims, and its extensive ditch lines and other equipment essential for properly conducting its work. The dry weather of 1927 prevented thawing as much ground as was necessary to allow the dredges to operate continuously in 1928. As a result the dredges encountered some frozen ground which could not be mined without subjecting the boats to too much wear and without making mining too expensive, so that for several periods during the season the company was compelled to discontinue the work of one or more of the dredges, and the same condition probably caused the early cessation of work in the fall. The good water conditions of 1928 allowed the thawing of adequate amounts of ground to meet the probable requirements of the season of 1929, so that the outlook for a much larger output of gold during that season was encouraging. As has been pointed out in earlier reports of this series, the sound mining practice and experimental research into new mining problems make the work of this company watched with great interest by all mining engineers who have to contend with northern conditions. It is hoped that the time is not far distant when the company, through its engineers, will publish accounts of some of the technical problems that it has studied and thus make available an authoritative basis of facts regarding methods and costs. Among the matters of wide general interest would be data on adequacy and accuracy of methods of sampling and determining values of frozen and unfrozen placer ground; comparison of estimated and recovered returns from placers mined by dredges, with special reference to different kinds of bedrock and other physical conditions; the distribution of ground temperatures in the Nome placers; and methods, costs, and effectiveness of the different thawing processes that have been tried.

Near Nome two other dredges, those of the Dry Creek Dredging Co. and the Bangor Dredging Co., were active during the year. A dredge formerly operating on the Solomon River was moved to a new site on Osborn Creek, in the Nome district, and was reconstructed but was not in running order in 1928. This dredge will be operated by the Osborn Mining Co., recently organized. Reports also indicate that during the year new equipment was shipped in for the old dredge on Hastings Creek and that active work was under way in preparing this boat for mining on that stream in 1929. In addition to the dredges, small open-cut mines were being developed on several of the creeks adjacent to Nome. Most of these mines employed only a few men; the largest appears to have been that of the Monument Creek Mining Co. on Monument Creek, a tributary of the Snake River, where five to eight men were employed for most of the open season. West of Nome extensive prospecting with a drill has been continued in the coastal-plain region, near the lower part of the Snake River. The results of this work have not been made public, but the accurate determination of the conditions that prevail there will be of great value in interpreting the conditions that prevailed while the coastal-plain deposits were being laid down and may prove to be of considerable economic significance.

The greatest amount of placer gold mined in the Fairhaven district came from three main tracts—Candle Creek, the Inmachuk River, and Bear Creek. Candle Creek is a large tributary of the Kiwalik River from the west, close to the town of Candle. On Candle Creek and its tributaries, Patterson and Jump Creeks, the greatest amount of placer gold was recovered by the dredge of the Keewalik Mining Co. Altogether about six camps, employing a total of about 50 men, were mining on this creek and its tributaries. Farther up the Kiwalik River, on Quartz Creek, which enters from the east, three small camps did a little productive placer mining, and on Gold Run, which enters the Kiwalik River from the west a few miles below Quartz Creek, one miner recovered some gold. In the Inmachuk Valley the principal producer was a hydraulic mine on the main river near the mouth of Arizona Creek. At this property about 24 men were employed throughout the open season, and mining was carried on for 158 days. A little placer mining and prospecting was carried on at other points in the valley of the Inmachuk and its tributaries. Prospecting was continued in search of any auriferous channels that might have been buried under the lava flows which cover large tracts of the country at the heads of the Inmachuk and of the neighboring streams adjacent to Imuruk Lake. This search has been in progress for several years, but no deposits that appear to warrant mining have yet been reported, though indications of placers have been encountered in many of the shafts that have been sunk in the course of this work. The third tract in which placers were mined in the Fairhaven district, that on Bear Creek, lies east of the hills which form the divide between the Buckland and Kiwalik Rivers. Two camps employing a total of about eight men were at work on Bear Creek during 1928 and took out some gold, but no new developments of general significance were reported.

In the Council district, as in the other larger producing districts of Seward Peninsula, most of the placer gold produced in 1928 came from dredges. Two dredges belonging to the Ophir Gold Dredging Co. and the Northern Star Dredging Co. mined on Ophir Creek and report good operating conditions. One hydraulic mine was also being operated on Ophir Creek. The finding of some promising placer ground on one of the benches of Ophir Creek stimulated a good deal of interest in the early part of the season, but it proved not to extend far, so that its volume was rather small. On Crooked

Creek, which is a tributary of Ophir Creek from the west, about 8 miles due north of Council, and on Sweetcake Creek, which is a tributary of Ophir Creek about 4 miles northwest of Council, some prospecting was in progress that yielded small amounts of gold. On Melsing Creek two small camps did a little placer mining. The dredge that was formerly on Basin Creek, a tributary of Melsing Creek, was idle throughout the year. On Rock Creek, which is a tributary of Aggie Creek south of Council, two small groups of prospectors did a little mining. The results are said to have been rather disappointing, as the distribution of the gold in the gravel was very irregular, so that no continuous pay streak could be traced for any distance.

In the valley of a stream that lies about 50 miles east of Council and is far outside the limits of what is really the Council district and outside the area in which placers have been worked in the past, a prospector reports finding little placer gold during the year. This locality is described as on June Creek, a small stream that rises in the conglomerate hills between the Kwik and Tubutulik Rivers.

Only two dredges were engaged in placer mining in the Solomon district in 1928. These were the dredge of the Goldsmith Dredging Co., on the Solomon River near Coal Creek, and that of the Shovel Creek Dredging Co., on Shovel Creek, a tributary of the Solomon River from the west. To these might be added the dredge of the Casadepaga Mining Co., which mined in the main valley of the Casadepaga River near the mouth of Canyon Creek and was practically the only producer of any appreciable amount of gold in the entire Casadepaga region in 1928. Few details regarding mining other than dredging in the Solomon district have been received by the Geological Survey, and the very absence of reports indicates that few mining enterprises were active and that no new finds of significance were made. In the Bluff area, which lies east of Solomon and which for convenience is grouped with that district, only two or three placer mines were operated. The largest amount of placer gold came from a mine on Koyana Creek and one on Swede Gulch, but some was also taken from claims on Daniel, California, and Eldorado Creeks. No work was done in 1928 on the beach claims at Bluff, which had been equipped during an earlier year with a novel scraping plant.

The Koyuk district includes most of southeastern Seward Peninsula and is so named from the principal stream that traverses it. Most of the placer deposits that are mined are on Dime Creek and a few of the other streams in the vicinity of Haycock. Although there is one small dredge in the district, the bulk of its placer gold came from bench and creek placers mined by hydraulic or open-cut methods. Three camps, employing a total of five or six men, were mining during the winter, and seven camps, employing a total of about 20 men, during the summer. All these camps were situated on Dime Creek except three on Sweepstake Creek or its right fork. Work in the valley of Sweepstake Creek was discontinued in the later part of August, and the amount of gold produced from it was correspondingly curtailed.

Placer mining in the Kougarok district, in central Seward Peninsula, was done entirely by hydraulic and open-cut methods. The dredge which had long been active was closed down in 1927 and remained idle throughout 1928, and no plans for operating it again in the near future were reported. Most of the camps in the Kougarok district were small one or two man affairs, and the largest employed only four or five men. Their individual output of gold was small, none reporting a yield of more than a few thousand dollars. These camps were situated not only in the valley of the Kougarok River and its tributaries but also were reported from some of the more remote valleys. One of the most productive was that of the Dick Creek Mining Co. on Dick Creek, which lies north of the Kougarok and flows into the Serpentine River. Another of the more remote camps that had a successful season was one on Humboldt Creek, which lies to the northeast of the Kougarok and is a tributary of the Goodhope River. One of the items of most general interest regarding recent developments in the Kougarok district relates to the recent acquisition of large tracts of presumable placer ground on Coffee Creek, on which extensive drilling tests were made during 1928. If the results of these tests indicate favorable conditions, the owners propose to install a hydraulic plant to handle a considerable volume of material. South of the Kougarok district, in the vicinity of Iron Creek, four men are reported to have done some hydraulic mining during the year. On American Creek, about 8 miles east of Iron Creek, one camp of seven or eight men was busy constructing a ditch to lead water for use in hydraulicking placer ground on that stream. Excessively high water interrupted this work, so that no productive mining was reported to have been done at that place.

In the Port Clarence district a little placer gold was mined on the Bluestone River and some of its tributaries, especially Windy and Gold Run Creeks. A little placer gold was also mined on Coyote Creek, which enters Grantley Harbor about 2 miles east of Teller. No first-hand information is available regarding mining operations in the region north of Teller, but it is currently reported that one camp on the Agiapuk River produced a little placer gold and that there were also one or two prospectors in that region. For the last two years there has been considerable testing of the placer deposits that occur in the valleys of Bluestone River and its tributary, Gold Run, with the aim of determining the practicability of mining this ground with a dredge. This work is being done by the Metalsmith Mines Corporation. No actual construction work was commenced during 1928, but apparently the results of the prospecting were satisfactory, for it is stated by the management that it was the company's intention to place a dredge on the Bluestone River and operate the placer property.

Lying east of Seward Peninsula but more or less closely related to it is the Bonanza district, so named from the small stream in it which has long been known to carry some placer gold. Prospecting has been carried on at a number of places in this general area and for the last two or three years has been especially active in the narrow coastal plain that lies between the waters of Norton Bay and the hills to the east. The bedrock in this part of the area consists mostly of dark slates and sandstones and thus differs markedly from the bedrock throughout most of the placer camps in Seward Peninsula. The history of the coastal plain at this place in the main seems to have been comparable to the history of the coastal plain at Nome and elsewhere in Seward Peninsula, so that prospecting for ancient beaches in this region is well justified. Whether, however, the ancient beaches will prove to be gold bearing depends on the occurrence or lack of mineralization in the material forming this coastal plain and if it occurred, on the effectiveness of any subsequent concentration. The present production from this entire tract amounts at most to only a few thousand dollars a year.

NORTHWESTERN ALASKA

The Kobuk River Valley is the only one in northwestern Alaska that is reported to have been the scene of any placer mining in 1928. In this valley there are two principal areas where placer mining is being done. The western area is near Kiana, and the principal placer tract is in the valley of Squirrel Creek and especially in the valley of its tributary, Klery Creek. The eastern area is in the vicinity of Shungnak, a small settlement about midway between the head and mouth of the Kobuk River. Kiana is about 50 miles in an air line above the mouth of the Kobuk, and Shungnak is about 90 to 100 miles in an air line east of Kiana. Both of these tracts are so remote and so poorly served by any means of regular transportation or communication that their development is much retarded and hampered by high costs, unavoidable delays, and short working season.

In the area near Kiana three men were reported to have done a little prospecting and recovered a small amount of gold from three separate patches of placer ground on Klery Creek and its tributaries. A drill rig that was shipped into this region a few years ago to test some of the bench ground adjacent to Klery Creek was not used, owing to mechanical difficulties with its operation. The proved occurrence of gold in the field is an incentive for further search for workable deposits, but the field of search is so large and the number of prospectors to do that work is so small that progress in really testing out its worth is extremely slow. The present total production of gold from this tract amounts to only little more than a meager grub stake for most of the workers.

In the tract that lies near Shungnak the placer deposits occur in the lowland adjacent to the Kobuk, close to the places where the small streams which debouch from the hills to the north traverse that lowland. The source of the placer gold found in these deposits appears to be local, as in general it is rough and appears to have been transported only a short distance. This conclusion is further supported by the finding of many quartz veins carrying free gold in the metamorphic rocks that form the hills in which these streams rise or which they traverse. In 1928 there were six small camps employing a total of 12 men established on streams in the vicinity of Shungnak. Three of these were on Dahl Creek and one each on Lynx Creek, California Creek, and the Shungnak River. Lynx and California Creeks are tributaries of the Kogoluktuk River, which joins the Kobuk some 3 or 4 miles east of Shungnak, and the Shungnak River enters the Kobuk about 15 miles west of that settlement. The largest camp is that on California Creek, where mining is carried on by hydraulicking. Most of the season, however, was spent in stripping the deposits and getting them ready for mining. On the Shungnak River most of the work was directed toward testing and prospecting the ground to determine the practicability of mining on a large scale by dredging or hydraulicking. No report of the results of these tests has been made public, but it is understood that they were undertaken by a group that is prepared to finance the work adequately and carry it on if the tests prove satisfactory. The prospectors were brought in from Fairbanks by airplane, thus obviating many of the difficulties usually experienced in reaching this out of the way region. In the course of their preliminary investigations they also did some prospecting in the vicinity of Lake Selby and on the Pah River.

Near the head of the Kobuk another group of seven prospectors associated together as the Arctic Prospecting & Developing Co. were brought to Walker Lake by airplane from Fairbanks in April, 1928, and made some investigations in the vicinity of the lake, without, however, engaging in any active mining. Difficulties in sinking test pits, owing to the many large boulders or the amount of water encountered, and finally the smashing up of the plane that later came to replenish their supplies prevented the successful accomplishment of the objects of the enterprise and necessitated return for supplies. Returning again the party spent some time in prospecting in the Alatna Valley, especially in the vicinity of its tributary, the Iniakuk River, and later made another trip to Walker Lake. Miscarriage of plans for supplying the party by the use of airplanes finally necessitated abandoning further work, and the entire party tramped out to Alatna in the middle of winter, arriving there December 22. After a six weeks' wait, the party was brought back to Fairbanks by airplane. No announcement has yet been made as to whether prospecting by the company will be resumed in this district in the near future.

DREDGING

Over 65 per cent of all the placer gold produced in Alaska in 1928 was mined by dredges. The total gold recovered by dredges was $2,185,000, of which the greatest part came from 12 dredges in the Yukon-Tanana region and the rest from 14 dredges in other parts of Alaska, notably Seward Peninsula. This total exceeds by $445,000 the amount recovered by dredges in 1927, and the increase is largely due to the new large dredges installed in the Fairbanks region that began mining in 1928. The accompanying table gives the output of gold by Alaska dredges beginning in 1903, the earliest year for which records are available.

Gold produced by dredge mining in Alaska, 1903–1928

Year	Number of dredges operated	Value of gold output	Gravel handled (cubic yards)	Value of gold recovered per cubic yard
1903–1915		$12, 431, 000		
1916	34	2, 679, 000	3, 900, 000	$0. 69
1917	36	2, 500, 000	3, 700, 000	. 68
1918	28	1, 425, 000	2, 490, 000	. 57
1919	28	1, 360, 000	1, 760, 000	. 77
1920	22	1, 129, 932	1, 633, 861	. 69
1921	24	1, 582, 520	2, 799, 519	. 57
1922	23	1, 767, 753	3, 186, 343	. 55
1923	25	1, 848, 596	4, 645, 053	. 40
1924	27	1, 563, 361	4, 342, 667	. 36
1925	27	1, 572, 312	3, 144, 624	. 50
1926	32	2, 291, 000	5, 730, 000	. 40
1927	28	1, 740, 000	6, 084, 000	. 29
1928	27	2, 185, 000	6, 371, 000	. 34
		36, 076, 000		

The total value of the gold produced by dredges since 1903 is about 14.4 per cent of the total value of gold produced from all kinds of placer mining since 1880, and there has been a constant tendency each year for a greater and greater percentage of the placer production to be mined by dredges. During 1928 the ratio of dredge production to the output from all other kinds of placer mining was about 65 to 35, and there are no signs of a future diminution in dredge mining; in fact, an even higher ratio seems probable.

In the foregoing table the figures given for yardage mined and value of the gold recovered per cubic yard are open to some inaccuracy, because several of the dredge operators have not furnished specific information on those subjects for their individual properties and the figures for these properties have therefore had to be estimated. In making these estimates the following procedure has been adopted to determine the unknown factors: Operators of dredges that produced approximately $1,771,788 in gold, or a little more than 81 per cent of the total mined by dredges, report that that amount came from 5,166,362 yards of gravel. The average yield thus shown is about 34.3 cents in gold to the cubic yard. Applying this average to determine the unreported yardage gives a total of 6,371,000 cubic yards, and this is the figure that has been used in the table. This procedure is obviously open to criticism, because the companies that reported fully the amount of gravel mined were the larger ones, and doubtless they worked ground of a lower tenor than that mined by some of the smaller companies. As a result the average value adopted may be too low and consequently may indicate a larger volume of gravel than was actually handled. This method, however, has been followed for the last five years, so that the quantities and values given for 1928 are comparable with those reported for the preceding years. If this value as stated is correct it will be evident from the table that the tenor of the ground dredged in 1928 was more than 5 cents a cubic yard higher than that of the ground dredged in 1927, though considerably lower than the average for the preceding years.

The length of time that the different dredges were operated varied widely. The longest season reported was 162 days for the dredge of the Tanana Valley Gold Dredging Co., and one of the dredges of the Fairbanks Exploration Co., both of which are operating in the Fairbanks district of the Yukon-Tanana region. The length of the working season was not determined wholly by climate or other conditions beyond human control, however, but was determined in part by breakage or purely personal reasons. Therefore the dates of earliest and latest working of all the dredges may be more significant than the record for any single dredge. In 1928 the earliest date for commencing dredging was May 1, by the Tanana Valley Gold Dredging Co. in the Fairbanks district. The latest date for stopping dredge work was December 12 for one of the dredges of the Fairbanks Exploration Co., also in the Fairbanks district. In other words, the operations of these two dredges spanned a period of 226 days that might have been utilized for dredging if the climate alone had been the controlling element. That these records for 1928 do not represent unusual conditions is shown by the fact that in 1926 a dredge in the Yentna district began work on May 5, and a dredge in the Nome region did not shut down until December 4. The season of 1927 was unusually late in opening and early in closing, the extreme dates being June 1 and November 24. It is therefore evident that even under rather adverse conditions a dredging season of 175 days is not at all excessive for well-equipped, skillfully handled dredges of moderate size in most of the Alaska placer camps situated south of the Arctic Circle. However, the record of the 12 dredges for which details are available for 1928 shows that they averaged a working season of 118 days. For practically all of these dredges the difference between their actual and possible working season was due to some cause which prevented taking full advantage of the available season; for instance, the construction of certain of the dredges of the Fairbanks Exploration Co. was not completed until late in the season, and the dredges of the Hammon Consolidated Gold Fields, in the Nome district, discontinued work early in October, presumably because an adequate amount of thawed ground had not been prepared in advance for mining.

The following is a list of Alaska dredges that did some productive mining during the year:

Yukon Basin:	
Fairbanks district—	
Chatham Gold Dredging Co	Chatham Creek.
Fairbanks Exploration Co. (3)	Goldstream and Chatanika River.
Fairbanks Gold Dredging Co	Fairbanks Creek.
Tanana Valley Gold Dredging Co. (Ltd.)	Fish Creek.
Hot Springs district—American Creek Dredging Co	American Creek.
Iditarod district—	
J. E. Riley Investment Co	Otter Creek.
North American Dredge Co	Do.
Innoko district—	
Flume Dredge Co	Yankee Creek.
Innoko Dredge Co	Ganes Creek.
Tolovana district—Nome Creek Dredging Co	Nome Creek.
Kuskokwim region:	
Tuluksak-Aniak district—New York Alaska Gold Dredging Co	Bear Creek.
Seward Peninsula:	
Casadepaga district—Casadepaga Mining Co	Casadepaga River.
Council district—	
Northern Star Dredging Co	Ophir Creek.
Ophir Gold Dredging Co	Do.
Fairhaven district—Keewalik Mining Co	Candle Creek.
Koyuk district—Dime Creek Dredging Co	Dime Creek.

Seward Peninsula—Continued.

Nome district—

Bangor Dredging Co	Anvil Creek.
Dry Creek Dredging Co	Dry Creek.
Hammon Consolidated Gold Fields (3)	Old beach line.

Solomon district—

Goldsmith Dredging Co	Solomon River.
Shovel Creek Dredge Co	Shovel Creek.
Solomon Valley Dredge	Solomon River.

During 1928 5 dredges that were active in the preceding year were idle and 3 new dredges were constructed, so that the total number of active dredges in 1928 was 26. The 5 dredges that were mining in 1927 but were inactive in 1928 were 1 of the 2 dredges owned by the Flume Dredge Co. in the Innoko district, 1 of the dredges in the Fairhaven district, the dredges of the Crooked Creek Dredging Co. and of the Basin Creek Dredging Co. in the Council district, and the dredge of the Lomen Reindeer & Trading Corporation in the Solomon district. The Lomen dredge, which for many years had been mining the placers of the Solomon River, was dismantled and transferred to property that had been acquired on Osborn Creek, in the Nome district, and the name of the company was altered to the Osborn Mining Co. The three new dredges that were built during the year all belong to the Fairbanks Exploration Co. and were erected on the company's claims in the Fairbanks district. The materials for the two larger of these dredges were shipped in during the winter of 1927–28, the boats were built during the early months of the year in pits that had previously been prepared for them, and the first was ready to be mining on July 2. These dredges were built on lower Goldstream and on Cleary Creek near the town of Chatanika. Later in the spring and early summer the parts for another and smaller dredge were shipped in, and the dredge was built on Goldstream near the junction of Gilmore and Pedro Creeks. This dredge was completed early in September and began productive mining soon afterward. The dredge of the American Creek Dredging Co. on American Creek, in the Hot Springs district of the Yukon-Tanana region, which was built in 1927 but was operated only a short time in that year, was mining throughout the season of 1928. Like most new enterprises, this dredge lost considerable time while the operations were becoming thoroughly organized.

The success of most of the good dredges already built has induced many individuals and companies to reexamine formerly known extensive deposits that were too low in tenor to be worked by any of the methods that require less capital. As a result rumors are heard regarding dredging projects to be undertaken on placer ground from one end of interior Alaska to the other. Unquestionably all these projects deserve most careful consideration, and some of them will doubtless be successfully carried through, but there is such a tendency to regard the dredge as the magic method by which even worthless deposits may be mined at a profit that a word of caution may not be amiss to those who are considering investment in some of the projects. Fortunately, however, the amount of money needed to finance the building of a dredge is so great that the cost of a report by a competent engineer is relatively insignificant, and such a report should be obtained before any further step is taken. Even the most eminent engineer is not able to reach a sound decision from ordinary surface inspection, and therefore adequate tests by drilling or test pits must be made, so that his judgment may be firmly based on facts. All of this costs money, but unless it is done the enterprise is a pure gamble and not a mining enterprise that warrants confidence. There is no off-hand or short-cut method of ascertaining the value of a mining enterprise, and the cost of collecting the significant facts is as much a justifiable and unavoidable item of expense in the preliminary stage as the cost of power when the enterprise is in successful operation. Mining, and especially dredging, is a business and not a game of chance, and although it is subject to uncertainties, like every other business, these uncertainties can be approximated within definite limits, so that their effect on the success or failure of the enterprise may be relatively closely predicted. A full discussion of many of the problems of dredging and some of the methods by which they have been solved or handled are given in a recent publication of the Bureau of Mines. This report [6] includes a description of the mechanical features of all the Alaska dredges that had been built prior to 1925, as well as valuable information on the cost and methods of all kinds of placer mining.

Among the places where considerable prospecting is now in progress with a view to determining their suitability to dredging operations may be mentioned the tracts in the vicinity of the Arolic River in the Goodnews Bay district, of the Kuskokwim region; in the vicinity of the Bluestone River, in the Port Clarence district of Seward Peninsula; and in the vicinity of Shungnak, in northwestern Alaska. In addition to these projects that may be regarded as perhaps approaching a prospective stage there are of course many others that have not yet advanced so far, though some of them may be even more meritorious.

COPPER

Deposits containing some copper minerals are found throughout most of the length and breadth of Alaska. At present, however,

[6] Wimmler, N. L., Placer-mining methods and costs in Alaska: Bur. Mines Bull. 259, 236 pp., 1927. Price 55 cents from Superintendent of Documents, Government Printing Office, Washington, D. C.

practically all of the Alaska copper comes from two mines in the Copper River region that are operated practically as a single unit, though owned by different companies, and one mine on Latouche Island that is owned and operated by the same company that operates the two mines in the Copper River region. In addition to the copper recovered from these mines a few thousand pounds of copper was reported to have been recovered in 1928 at a smelter in the States from ores and concentrates shipped from southeastern Alaska. The total amount of copper recovered from Alaska ores in 1928 has been taken as 41,421,000 pounds, valued at $5,965,000. The bare statement of the quantity of copper produced is, however, more or less meaningless unless the basis on which it is computed is stated, because in all the processes that the ore undergoes, from the time it is broken out of the vein in the mines until all of the metallic copper that can be recovered from it is finally placed on sale, there are inevitable losses, so that at no two stages is the amount of copper exactly the same. Even though the losses incurred in these different stages are small compared with the amount recovered, the quantities involved are so large that even a small percentage of loss is equivalent to many thousands of pounds. For instance, with a production in the neighborhood of 50,000,000 pounds a loss of only 1 per cent is equivalent to 500,000 pounds. It is therefore obviously essential to recognize just what stage in the process of converting ore into metal is represented by the figures given. As an illustration of this condition the following facts, taken from the report of the Mother Lode Coalition Mines Co.,[7] are significant. This company in 1928 mined 61,074 tons of ore that assayed on the average 11.72 per cent copper, which would be equivalent to 14,315,745 pounds of copper. Shipments to the smelter from the mine, however, were reported to contain only 13,417,520 pounds of copper. Evidently nearly 900,000 pounds of copper was lost during the process of handling and milling, by which the bulk of the valuable copper minerals were separated from the worthless material with which they are associated. Although this amount at first sight seems to be enormous, it represents a loss of only about 6¼ per cent, which really indicates a very high mill recovery and exceptionally good practice.

The total copper-bearing ore mined in Alaska in 1928 is estimated to have been 579,500 tons and to have had a copper content of about 44,150,000 pounds. When this ore had been concentrated and was ready for shipment to the smelter it had been reduced to approximately 66,600 tons, having a copper content of 41,421,000 pounds, which represents a recovery of nearly 94 per cent of the copper that was contained in the original ore as mined. For the

[7] Mother Lode Coalition Mines Co. Tenth Ann. Rept., for 1928, 7 pp., 1929.

purposes of this report this has been adopted as the amount of copper yielded by Alaska mines during 1928.

In attempting to set a value for this copper many different methods may be employed and the results obtained will vary widely. Obviously it would be inaccurate to value all the copper in the ore as it comes from the mine at the current market price for the metal as it comes from the smelter, because not all of it is recovered and most of it is not in the form of metal and so is not worth the full price of metallic copper. Although the same conditions are also in a measure true of the ore and concentrates that are shipped to the smelter, the losses that they undergo in the smelting process are generally much less. As a consequence it has been the practice of the Geological Survey to compute the value of the Alaska output on the assumption that the copper in the ore and concentrates, as shipped to the smelter, is worth the average price at which metallic copper sold during the year. The average price of all copper sold in the United States in 1928, according to computations by the Bureau of Mines, was 14.4 cents a pound. The total value of the copper in the ore and concentrates shipped from Alaska mines during the year is therefore regarded as $5,965,000. It is recognized that this method of calculating the value does not take into account the fact that an efficient and fortunate selling agent would take advantage of fluctuations in the price of copper and thus dispose of as much of the copper as possible during periods of high prices and hold it during periods of low prices. That the Alaska copper mines were successful in obtaining better than average prices for their output is indicated by their reports. In fact, the average price received by the Mother Lode Coalition Mines Co. for its copper is stated in the annual report of that company to have been 14.887 cents a pound, and the other large company apparently received as much or even more. The figures relating to the value of the Alaska output of copper can not therefore be regarded as representing the amounts received by the different companies for their copper. They do, however, serve to indicate within close limits the magnitude of the industry and are comparable with the figures for value of the copper production for earlier years as stated in these reports.

In the following table are shown the amount and value of the copper produced in Alaska since the earliest recorded mining of copper took place. For the last five years there has been a gradual decrease in the output. Between the production of 1927 and that of 1928 there was a decrease of nearly 14,000,000 pounds in quantity and of $1,285,000 in value. This decrease in value would have been even greater had not the market price of copper in 1928 been about 1.3 cents higher than in 1927. This difference alone increased the total value of the 1928 copper production more than $500,000.

Copper and silver produced at Alaska copper mines, 1880, 1900–1928

Year	Ore mined (tons)	Copper		Silver	
		Pounds	Value	Fine ounces	Value
1880		3,933	$826		
1900–1915	1,232,396	220,773,969	35,031,225	2,351,726	$1,297,756
1916	617,264	119,654,839	29,484,291	1,207,121	794,286
1917	659,957	88,793,400	24,240,598	1,041,153	857,911
1918	722,047	69,224,951	17,098,563	719,391	719,391
1919	492,644	47,220,771	8,783,063	488,034	546,598
1920	766,095	70,435,363	12,960,106	682,033	743,416
1921	477,121	57,011,597	7,354,496	544,311	544,311
1922	581,384	77,967,819	10,525,655	623,518	623,518
1923	731,168	85,920,645	12,630,335	715,040	586,333
1924	761,779	74,074,207	9,703,721	572,078	383,292
1925	860,023	73,855,298	10,361,336	596,607	412,131
1926	670,000	67,778,000	9,489,000	605,190	377,600
1927	645,000	55,343,000	7,250,000	525,100	297,800
1928	579,500	41,421,000	5,965,000	350,430	205,000
	9,796,800	1,149,479,000	200,878,000	11,021,530	8,390,000

The general trend of the copper-mining industry in Alaska is graphically shown by the curve in Figure 3, which shows the output of copper in pounds for each year from 1900 to 1928. On the same diagram has also been plotted the average price of copper for each year. It is significant to note that up to very recent times there has been a very close relation between the price of copper and the Alaska output. In other words, when the price of copper was high there was a corresponding stimulation in output, and when prices were lower the output fell off. The foregoing statement applies only to trends and does not at all mean that a certain price for copper will bring out a certain tonnage. For instance, in 1907, when the price of copper was 20 cents a pound, only 6,308,000 pounds was produced, whereas in 1927, with a price of 13.1 cents a pound, the output was 55,343,000 pounds, or nearly nine times as much. Interpretation of the conditions, however, shows that in 1907 an increase in price over the preceding year was accompanied by an increase in output, and in 1927 a decrease in price was accompanied by a decrease in output.

No new developments of note were reported at the mines of the Kennecott Copper Corporation at Kennecott, in the Copper River region, during 1928. The ore from this property, as in the past, was largely high-grade copper sulphide and carbonate containing considerable silver but no gold. The highest-grade ore is sacked and shipped directly to the smelters, but the lower-grade ores are concentrated before shipment. According to the published statements of this company[8] 74,688 tons of ore was mined during the

[8] Kennecott Copper Corporation Fourteenth Ann. Rept., for 1928, p. 7, 1929.

year, which was estimated to have an average content of 12.50 per cent of copper and 2.440 ounces of silver to the ton. At the mine of the Mother Lode Coalition Mines Co., which is contiguous to the properties of the Kennecott Copper Corporation and is operated by that corporation, although the accounting and bookkeeping are conducted separately, the ore is essentially the same, being a high-grade copper sulphide and carbonate containing considerable silver. The

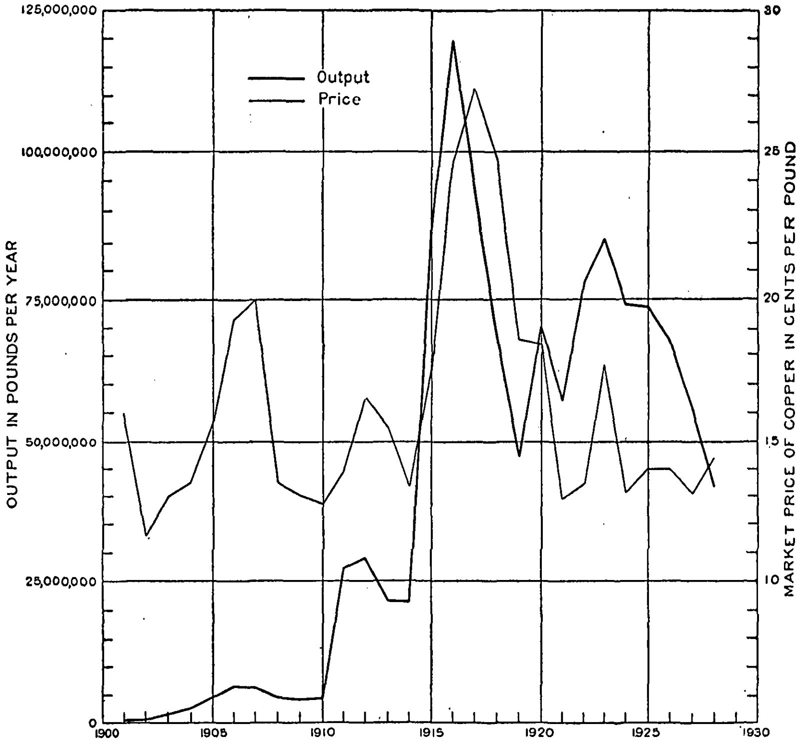


FIGURE 3.—Quantity of copper produced from Alaska mines, 1900–1928, and fluctuations in the price of copper during that period

report of this company [9] shows that during the year 61,074 tons of ore was mined, which had an estimated content of 11.72 per cent of copper and 1.63 ounces of silver to the ton.

The ore of the Beatson mine of the Kennecott Copper Corporation, on Latouche Island, is entirely different from that of the mines in the Copper River region, just described, being a low-grade copper-iron sulphide, mined by a system of caving. All the ore is concentrated at mills near the mine, and only the concentrates are shipped to the smelter in the States. According to the published report of this company [10] 442,765 tons of ore was produced in 1928, which had

[9] Mother Lode Coalition Mines Co. Tenth Ann. Rept., for 1928, p. 3, 1929.
[10] Kennecott Copper Corporation Fourteenth Ann. Rept., for 1928, p. 7, 1929.

an estimated content of 1.26 per cent of copper and 0.264 ounce of silver to the ton.

So far as reported, no new ore bodies of moment were discovered at any of these large mines, but the owners have by no means concluded that the possibilities of finding such bodies have been exhausted; instead, they appear to feel that the search should be continued even more vigorously. The continued success of this operating company has a most vital bearing on the general development of Alaska, because it furnishes so large a tonnage to the transportation agencies of the Territory.

The amount of copper produced by mines other than those already mentioned was practically negligible, amounting to only a little more than 2,000 pounds and coming from mines that can not properly be regarded as copper mines, the copper being a by-product. There was some prospecting for copper lodes at several places. Probably the most active work of this kind that was done was in the Chitina and Nizina Valleys. Some work was done on the Copper Creek mines, in the Kotsina district, north of the Chitina River, where copper claims have been held for several years on which some development work is done annually. No mining was in progress at the Green Butte mine, on McCarthy Creek, but the property is being looked after so that it can be reopened when its owners desire and when operating conditions are favorable. Late in the season prospecting in the vicinity of Glacier Creek, in the Chitistone Valley, disclosed copper ore of the same general type as that at the large operating copper mines. Arrangements were made to carry on further exploration of the deposit to determine its extent and other physical characters and thus prove whether or not it is of commercial value. This work will take considerable time, so that no early determination of the significance of this find can be made. It may be said, however, that the present indications are such as amply to justify the work necessary to get the determinative facts and to stimulate still further search for commercial deposits in this region. To the north, in the valley of the Nabesna River, prospecting was continued on the property of the Alaska Nabesna Corporation. A group of the financial backers of this enterprise visited the property in July, 1928, evidently with the object of inspecting the work already done and studying the conditions for its future development. No report of the results of these studies has been given out.

Some renewal of activity in prospecting for copper lodes in the Prince William Sound region was reported. Options on the old copper claims on Knight Island were said to have been taken by the Consolidated Mining & Smelting Co. of Canada, and plans were in preparation for a thorough examination of them by a group of engineers from this company. This work will necessitate an extensive drilling and sampling program, and some time will be required to get adequate facts from which the practicability of taking up active mining can be decided. A little prospecting for copper lodes was also done in the vicinity of Valdez, but no details were learned as to its outcome, though apparently no significant new finds were made.

SILVER

None of the ores that are mined in Alaska are valuable solely for the silver they contain, and by far the greater part of the silver that is produced occurs as a relatively minor constituent in ores whose principal value lies in some other metallic constituent. Thus, as shown by the table below, silver to the value of $205,000 was recovered in 1928 from ores that are valuable principally for the copper they contain. This source alone accounts for nearly 80 per cent of all the silver that was produced in Alaska in 1928. The amount of silver in the copper ore, however, is actually very small, as is shown by the fact that the average silver content of all the copper ore that was reported amounted to less than 1½ ounces to a ton of ore, and the ore from the mine that reported the highest average silver content contained only 2.44 ounces to the ton.

All the gold-lode mines yield some silver in addition to their gold. Thus the mine of the Alaska Juneau Gold Mining Co., though worked principally for gold, yielded 77,591 ounces of silver in 1928, according to the company's published report.[11] The silver from all the gold-lode mines amounted to 80,340 ounces and was worth $47,000. Some silver is also contained in all the gold that is recovered from Alaska placer mines. This silver is not recognizable, as it is intimately alloyed with the gold and is recovered only after the gold is treated chemically or refined. The total silver from this source was worth $14,000.

Data regarding the production of silver have been referred to in several places in the preceding pages and included in some of the tables that cover the production of other metals. For convenience the sources and the quantity and value of the production from each source in 1928 and 1927 are set forth in the following table.

Silver produced in Alaska in 1928 and 1927

Source	1928		1927	
	Ounces	Value	Ounces	Value
Gold lodes	80,340	$47,000	79,400	$45,000
Gold placers	23,930	14,000	23,300	13,200
Copper lodes	350,430	205,000	525,100	297,800
	454,700	266,000	627,800	356,000

[11] Alaska Juneau Gold Mining Co. Fourteenth Ann. Rept., for 1928.

It is evident from this table that the output of silver in 1928 was worth about $90,000 less than the output in 1927. It should be remembered that as the bulk of the silver is merely an accessory to the other metals, notably the copper, its output fluctuates widely, being dependent upon the production of the other metals. As the production of copper fell off nearly 14,000,000 pounds, naturally there was a corresponding decrease in the silver that was recovered from the copper ores. There was an increase in the production of silver from gold lodes and placers, but as those sources contain only a relatively slight amount of silver this increase afforded only a slight offset to the decrease from the copper ores. Although the total quantity of silver produced was considerably less in 1928 than in 1927, the increase in the average market price of silver, as computed by the Bureau of Mines, from 56.7 cents an ounce in 1927 to 58.5 cents in 1928 offset some of the decline in production.

The development in Alaska of ores which are principally valuable for their silver content is necessarily attended by many more difficulties and expenses than are likely to be met in developing gold mines. Among the most obvious reasons for this difference is the much lower value per unit of weight of the silver and the fact that more elaborate and expensive processes are usually required to recover it in a readily salable metallic state than to recover gold. As a result it is more or less unfeasible at this time to attempt to develop or even to search for silver lodes in remote parts of Alaska unless the ore has an especially high tenor. Therefore, although silver-lead lodes have been reported at many places in interior parts of Alaska none of them have been given very thorough examination or serious consideration by capitalists. It is true that some shipments of silver-lead ores have been made from interior Alaska, especially from the Kantishna district, north of the Alaska Range, but although the ore was of high grade the expense of transporting it to smelters in the States and having it smelted consumed practically all the profits. In southeastern Alaska, however, where the region is much more accessible to deep-water transportation and all operating costs are lower, there have been many attempts to find and develop silver-lead deposits. The greatest amount of work of this kind has been done in the Hyder district, at the head of Portland Canal, near the international boundary. In 1927 some shipments of silver-lead ore were made from this camp, but in 1928 no shipments were reported, though more than a score of prospectors were engaged in prospecting and development work, and on several properties promising leads were said to have been found. The Hyder district adjoins the mineralized region north of Stewart, in British Columbia, in which the famous Premier silver and gold mine is situated. This very rich deposit occurs under geologic conditions by no means unlike those that are found in parts of the adjoining Hyder district, and this similarity has sustained interest in the search for profitable silver and gold deposits on the American side of the boundary. During 1928 one of the mines in the Hyder district that had been brought to a producing stage in an earlier year was closed down, but the suspension was reported to be only temporary, and it should be operating again soon. A summary statement regarding general mining activity in this district is made in the section of this report describing the gold lodes (p. 15).

A little development and prospecting work on silver-lead ores is reported to have been done during the year on claims lying a short distance north of the settlement of Wrangell. North of Skagway the Inspiration Point Mining Co. is reported to have continued work on its property where indications of silver-lead lodes that are said to appear promising have been found. In the Susitna Valley of west-central Alaska, about 9 miles east of Chulitna station, on the Alaska Railroad, where a unique deposit containing ruby silver was found some two years ago, little development work was in progress, and the property lay practically idle throughout the season of 1928. A prospector near the head of the Cosna River, in the Yukon Valley, reported doing further work on a silver-lead lode which he stated was showing encouraging signs of developing into a real body of ore. The remoteness of the district will be a severe handicap to its early commercial development unless the lode proves to be of large size and high tenor. The remarkably efficient development of the Mayo deposits, in Yukon Territory east of Dawson, and the successful handling of the ore from that remote camp encourages the belief that methods are being made available whereby even deposits in the remote regions of Alaska, if they afford a considerable tonnage of rich ore, may be mined in spite of adverse physical conditions. With the improved transportation facilities that are already available in Alaska many regions that were formerly almost inaccessible are less difficult to reach, and these facilities are being constantly improved and will doubtless be still further extended as the opening up and development of the Territory as a whole inevitably takes place.

LEAD

The lead produced from Alaska ores in 1928 amounted to 2,038,655 pounds, an increase over the production in 1927 of about 22,000 pounds. This stands as the greatest quantity of lead that Alaska has ever produced in a single year. The value of the output at 5.8 cents a pound, the average market price of the lead sold in the States in 1928 according to the Bureau of Mines, was $118,000. This was a slight decrease in total value from that of 1927. The decrease in value accompanying increased production was due to the decline in market price, which in 1927 was 6.3 cents a pound.

Lead produced in Alaska, 1892–1928

Year	Tons	Value	Year	Tons	Value	Year	Tons	Value
1892	30	$2,400	1905	30	$2,620	1918	564	$80,088
1893	40	3,040	1906	30	3,420	1919	687	72,822
1894	35	2,310	1907	30	3,180	1920	875	140,000
1895	20	1,320	1908	40	3,360	1921	759	68,279
1896	30	1,800	1909	69	5,934	1922	377	41,477
1897	30	2,160	1910	75	6,600	1923	410	57,400
1898	30	2,240	1911	51	4,590	1924	631	100,899
1899	35	3,150	1912	45	4,050	1925	789	140,571
1900	40	3,440	1913	6	528	1926	778	124,400
1901	40	3,440	1914	28	1,344	1927	1,008	127,000
1902	30	2,460	1915	437	41,118	1928	1,019	118,000
1903	30	2,520	1916	820	113,160			
1904	30	2,580	1917	852	146,584		10,830	1,440,000

In Alaska no ores are mined solely for their lead content. Practically all of the lead is recovered as a by-product in the course of gold or silver mining, the concentrates containing lead being shipped to smelters in the States for treatment to recover the various metals they contain. All the lead that is reported in the foregoing table as produced in 1928 was recovered in the course of treatment of the gold ores of the Alaska Juneau mines, in southeastern Alaska. According to the published reports of this company for 1928 it produced 2,038,655 pounds of lead in addition to other metals during that year. This represents a recovery of only a little over half a pound of lead from each ton of ore that is mined and trammed to the mill, or 1⅛ pounds of lead from each ton of ore that is fine milled.

Although all the lead produced in 1928 came from one mine, this condition has not prevailed in the past, and usually some lead has come from the Hyder district of southeastern Alaska, the Kantishna district of the Yukon Valley, or other widely scattered districts. All the information regarding the recent developments on ores that contain lead as well as other metals has already been given in other parts of this report, especially those that describe the gold or the silver lodes. Lead is a heavy low-priced commodity which requires rather elaborate treatment to produce in readily salable metallic form and thus offers little incentive to development in remote regions. The outlook for any notable increase in the production of this metal therefore seems to depend on the stimulation of the mining of other metals and the consequent increase in their production as well. That this increase in mining lodes of mixed metallic content is likely to take place is regarded as a certainty, and that some of the silver-lead deposits which are now lying idle will be opened up again in the near future seems almost equally certain. An increase in the output of lead is therefore looked for with considerable assurance.

PLATINUM METALS

Platinum is one of a group of several metals which, because they are closely related in physical and chemical character, are often not differentiated by name or are not even identified specifically in the usual forms of assay or analysis but are spoken of as the platinum metals or, even more loosely, as platinum. Platinum, palladium, osmium, and iridium are some of the individual members of this group. Some of these metals have been found both in lodes and in placers in Alaska. The total quantity of platinum metals produced in Alaska in 1928 is estimated to have been approximately 120 fine ounces, which at the average market price for that metal, as computed by the Bureau of Mines, was worth about $9,000.

The only occurrence of a metal of this group in a lode that has produced any appreciable quantity was at the mine of the Alaska Palladium Co. on Kasaan Peninsula, Prince of Wales Island, about 30 miles west of Ketchikan. The principal platinum metal found at this mine was palladium. Unfortunately, decrease in the price paid for palladium and some internal difficulties resulted in the closing of this mine in the fall of 1926, and it has not been reopened since. As this mine while it was running produced several hundred thousand dollars' worth of platinum metals a year and in addition a good deal of gold and some copper, its cessation of production has not only made a very decided drop in the Alaskan output of platinum metals but has been felt in the total mineral production of the Territory.

The only platinum metals that were mined in Alaska in 1928 were recovered from placers in the Dime Creek district, of Seward Peninsula, and in the Goodnews Bay region, south of the mouth of the Kuskokwim River. The Seward Peninsula deposits have been known for a long time and have been more or less continuous producers, though their annual yield has amounted to only a few ounces. The occurrence of platinum in the Goodnews Bay region has also been known for a number of years, but interest in the deposits was especially keen during 1928, and for a time it appeared that a small stampede was in progress. Rumors of the richness of these claims, however, seem to have become more glowing the farther they traveled away from their source. In spite of such exaggeration, it is true that placer deposits containing platinum, worth continued careful prospecting, occur in this district, and that about six men were engaged during the summer in the search for places where concentration had been great enough to form deposits that could be worked at a profit. The most extensive work is reported to have been done in the vicinity of Salmon Creek, a small stream lying between Goodnews and Chagvan Bays, about 2 miles north of the native village of Kiniginagimut. This region has not been surveyed, and the position of the different streams in that region is not known to the writer. According to local reports, however, there were four camps that produced some platinum—one on Clara Creek, two on Squirrel Creek, and one on Platinum Creek, the last worked solely by natives. The facts that more than 100 ounces of platinum were produced from this region in 1928 and that what little is known about the geology of the region seems to be favorable make it evident that this region well warrants more complete investigations as a placer platinum camp. The facts so far known, however, are not such as to justify any stampede to the region or hope that easily won riches await picking up by the first comer. A curious feature of the platinum that has been recovered is that it is accompanied by surprisingly little gold. In the Seward Peninsula camps, where some platinum is found, the quantity of gold is many times that of the platinum, whereas in the Salmon Creek region, where a clean-up was reported which yielded more than 3 ounces of platinum, only a few small specks of gold were found. This condition is also unlike that which is reported at places north of Goodnews Bay, where small amounts of platinum have been found in earlier years associated with much greater quantities of gold.

Although no other places are known to have produced platinum metals that were sold in 1928, it is not at all unlikely that small amounts may have been produced elsewhere and held by their producers. Places where platinum has been recognized are widespread through other parts of Alaska, and some of them have produced platinum that has been sold. Among these places may be mentioned the Chistochina district of the Copper River region; Metal Creek, in the Kenai district; some of the beach placers of Kodiak Island, in southwestern Alaska; the Kahiltna River and near-by streams, in the Yentna district of the Susitna region; Boob Creek, in the Tolstoi area of the Innoko district; Granite Creek, in the Ruby district of the Yukon region; and some streams in the Marshall district, in the western part of the Yukon region. Some platinum is reported to have been found in the gold ores of the Nuka Bay region, in Kenai Peninsula. This report has not been definitely verified, and its accuracy seems doubtful, as the general geology of that district is unlike that in known platinum fields and does not appear favorable for the occurrence of the metal.

TIN

Alaska's tin production showed a fairly large increase in 1928, though the amount of metal recovered was far below that of the period from 1911 to 1919, when the industry was at its height. The increase, however, is regarded as indicating that the production of tin ore in Alaska is decidedly on the upward trend. The output in 1928 was 58.6 tons, which contained 41 tons of metallic tin. The average price of metallic tin for the year, as computed by the Bureau of Mines, was 50.46 cents a pound, so that the value of the Alaska production was $41,000. Practically all this tin ore was shipped out of Alaska for treatment, only a few hundred pounds remaining unsold in the hands of the producer. Almost all the ore is shipped to Singapore for reduction.

Tin produced in Alaska, 1902–1928

Year	Ore (tons)	Metal (tons)	Value	Year	Ore (tons)	Metal (tons)	Value
1902	25	15	$8,000	1917	171	100	$123,300
1903	42	25	14,000	1918	104.5	68	118,000
1904	23	14	8,000	1919	86	56	73,400
1905	10	6	4,000	1920	26	16	16,112
1906	57	34	38,640	1921	7	4	2,400
1907	37.5	22	16,752	1922	2.3	1.4	912
1908	42.5	25	15,180	1923	3	1.9	1,623
1909	19	11	7,638	1924	11	7	7,028
1910	16.5	10	8,335	1925	22.2	13.8	15,980
1911	92.5	61	52,798	1926	12.85	8	10,400
1912	194	130	119,600	1927	37.5	26.7	34,000
1913	98	50	44,103	1928	58.6	41	41,000
1914	157.5	104	66,560				
1915	167	102	78,846		1,754.6	1,092	1,048,000
1916	232	139	121,000				

Tin minerals have been found in the veins and mineralized country rock of the York and Port Clarence districts, Seward Peninsula, and at one time were extensively mined. The tin produced in 1928, however, did not come from lodes but from placer deposits, principally in the York district, of Seward Peninsula, and the Hot Springs district, of the Yukon Valley. In the York district the placer tin, or cassiterite, is mined principally for itself, though some placer gold is also found with it. In the Hot Springs district the tin ore is a by-product obtained from deposits that are mined primarily for their gold. In the York district the tin ore was mined by two small camps, the larger of which is on Goodwin Gulch. In the Hot Springs district the tin ore was mined at several small camps in the vicinity of Tofty.

The National Tin Mining Co. shipped into the York district during 1928 a considerable outfit of machinery and supplies to reopen the tin lodes on the old Crim-Randt-O'Brien properties and carry on productive mining. It is understood that present plans contemplate the employment of 8 or 10 miners throughout the year and the active development of the most promising lodes. The operations of this company will be watched with considerable interest, as this is the only place in North America where lode mining for tin ore is being undertaken.

Considerable interest in tin mining was revived in the Hot Springs district of the Yukon-Tanana region by the acquisition of options on most of the lowland areas in the vicinity of Tofty and Woodchopper Creeks by an English company which proposed to dredge the placer deposits there to recover the tin and gold that they contain. This transaction was not completed until late in the open season, so that the only steps taken in 1928 were to have engineers of the company examine the ground and make such preliminary tests as the time at their disposal permitted. Doubtless this will be followed up by more extensive tests before the company undertakes to formulate definite plans or start active construction work. The inception of this enterprise, like that of several other projects which have been undertaken in interior Alaska, was due to George F. Lemon.

During 1928 considerable activity was shown in searching for tin in the Ruby district of the Yukon region. This work was being carried on at a score or more claims on Big Creek, some distance east of the town of Ruby, and finds of tin ore both in the placers and in masses that apparently had not traveled far from the parent ledge encouraged search for both lode and placer deposits that might be mined at a profit. This ground has been examined by several mining engineers, and although their reports have not been made public the general conclusions seem to be favorable, as the ground has been taken under option and prospecting carried on consistently.

COAL

More coal was produced from Alaska fields in 1928 than in any other year since coal mining began in the Territory. Although this is an encouraging indication that the industry is becoming firmly established, it should be realized that with a production of only 126,000 tons the industry is still small and by no means supplies even the local market. Thus 71,000 tons of coal was imported from fields outside of Alaska in 1928 and no Alaska coal was exported. A comparison of the records of coal production and consumption in Alaska for the entire period for which records are available is afforded by the statistics set forth in the table on page 63.

Coal produced and consumed in Alaska, 1880–1928

Year	Produced in Alaska, chiefly subbituminous and lignite		Imported from States, chiefly bituminous coal from Washington [a] (short tons)	Imported from foreign countries, chiefly bituminous coal from British Columbia [a] (short tons)	Total coal consumed (short tons)
	Short tons	Value			
1880–1915	71, 633	$456, 993	679, 844	1, 079, 735	1, 814, 047
1916	12, 676	57, 412	44, 934	53, 672	111, 282
1917	54, 275	268, 438	58, 116	56, 589	168, 980
1918	75, 816	413, 870	51, 520	37, 986	165, 322
1919	60, 894	345, 617	57, 166	48, 708	166, 768
1920	61, 111	355, 668	38, 128	45, 264	144, 503
1921	76, 817	496, 394	24, 278	33, 776	134, 871
1922	79, 275	430, 639	28, 457	34, 251	141, 983
1923	119, 826	755, 469	34, 082	43, 205	197, 113
1994	99, 663	559, 980	40, 161	41, 980	181, 804
1925	82, 868	404, 617	37, 324	57, 230	177, 422
1926	87, 300	459, 000	35, 620	34, 254	157, 174
1927	104, 300	548, 000	35, 212	27, 225	166, 700
1928	126, 100	662, 000	39, 184	32, 521	197, 805
	1, 112, 554	6, 214, 000	1, 204, 026	1, 626, 396	3, 929, 805

[a] Compiled from Monthly Summary of Foreign Commerce of the United States, 1905–1928, Bureau of Foreign and Domestic Commerce. No figures on imports before 1899 are available.

In the table the total value of the coal produced in Alaska in 1928 is stated to have been $662,000. This value can only be regarded as a fair approximation, because the records are not available for precise determination of the actual selling price of the coal. Much of the coal is purchased by the Alaska Railroad on contract for large quantities, so that the price paid by the company is not a fair basis on which to compute the price paid for the lots sold to the smaller consumers, who in the aggregate buy a large part of the output and pay much higher prices. From all the available information, and by weighting the resulting estimate as closely as practicable, it appears that the average price of all the coal mined in Alaska in 1928 was approximately $5.25 a ton, which is the same as in 1927 and is about 50 cents a ton less than the average for the entire period shown in the table.

The Alaska coal came principally from three mines, two in the Matanuska field and one in the Nenana or Healy River field. The two mines in the Matanuska field were that of the Evan Jones Coal Co. at Jonesville and that of the Premier Mining Co. in the valley of Moose Creek. The Evan Jones mine was inactive throughout the winter and early months of the year, but from May until the end of the year it was engaged in filling its contract with the railroad and supplying other customers. Mining at the Premier was carried on throughout the early part of the year at approximately the same rate as in 1927, but beginning in August its production dwindled, and in the last five months of the year it produced only a few tons, mainly derived in the course of development work. The litigation regarding this property, which had been dragging on for several years, was still unsettled at the end of the season. In addition to these two principal producing mines a little work was in progress at the Pioneer mine, in the southern part of the Moose Creek Valley, and small quantities of coal were produced at the Ross Heckey property, on Coal Creek, in the eastern part of the Matanuska Valley near Chickaloon. The coal from the Heckey property is especially good for blacksmithing, and for several years the Alaska Railroad has operated a home-made coke oven, using this coal to make such coke as it requires for local use. The coke is strong and of good quality, and it seems entirely possible that a more extended use of this coal for that purpose, not only by the railroad but by others, will be made. The old Government-owned mine at Eska was maintained in a more or less stand-by condition throughout the year, so that if anything should happen which might endanger the supply of coal needed to run the railroad it could be quickly reopened and mining resumed.

In the Nenana coal field the only producing property was the Suntrana mine of the Healy River Coal Corporation, on the Healy River, about 4 miles east of the junction of that stream and the Nenana River. The mine is connected with the main line of the Alaska Railroad by a standard-gage spur track which crosses the Nenana River on a sturdily constructed steel bridge. The plant of this mine has been well laid out and is now equipped with the necessary modern machinery to handle 200 tons or more of coal a day. The corporation has a contract for supplying the coal used by the Fairbanks Exploration Co. in furnishing power to its dredges and in its large placer-mining operations in the vicinity of Fairbanks. The coal has a somewhat lower heating value than that from the Matanuska and near-by fields and as a consequence is not used in the railroad locomotives. This mine was in continuous operation throughout 1928 and yielded nearly half of all the coal mined in Alaska that year. Farther up the Healy River are the coal claims of Roth & Manley. In 1927 it was reported that negotiations had been practically closed for the railroad to extend the Suntrana spur up to this property, and that work would be started at once in opening up this coal, which was supposed to be of higher quality than that farther down the valley. The necessary financial arrangements, however, were not carried through, and this plan was either abandoned or lay dormant throughout the year. That there is coal of good quality in this part of the Healy River Valley has been abundantly proved. That it is of better quality than the other coals and can be mined more cheaply has not been demonstrated. Consequently the extra haul necessary to bring it to market would place an additional charge against it without any compensating offset, unless it can be mined more cheaply or has a higher heating value.

During 1928 a new development in the coal-mining industry of the Territory took place in southeastern Alaska. This was the development of the old Harkrader coal claims, on Kootznahoo Inlet, on the west coast of Admiralty Island. An inclined shaft continuing the old shaft on the property has been driven to a depth of several hundred feet, and several levels have been turned off to drift along the bed of coal. Several small shipments of coal have been taken to Juneau and used locally with satisfactory results. The coal is said to occur in two benches, the upper one about 2 feet thick and the lower one about 3 feet thick. The conditions for mining are in general regarded as favorable, but only further work can determine adequately the extent of the deposits and, what is of perhaps even more importance, the cost of mining and making the coal available for shipment. The solution of these problems as well as the transportation and marketing of the coal will require careful investigation if the enterprise is to be successful.

Elsewhere in Alaska there are numerous deposits of coal, and from some of them small supplies are taken to supply local needs. In northwestern Alaska, in the vicinity of Wainwright, are extensive coal beds that furnish a few hundred tons of coal to the people living in that region. According to newspaper reports about 300 tons of coal from these deposits was mined in 1928, mostly by natives, and carried by them in their skin boats to Wainwright, where it was disposed of to the traders and others. Some of this coal was said to have been loaded aboard the *Boxer*, the boat belonging to the Bureau of Education, and delivered to a number of the schools along the coast that are under the jurisdiction of that bureau. This coal has long been known, but as the coal mined comes from close to the surface and is weathered and mixed with much dirt it is not of as good a quality as the coal that is shipped in from other fields. In fact, it is said that the local people prefer to import coal from outside rather than use the local coal, even though the outside coal costs nearly three times as much. It is believed that the apparent difference in quality of this local coal is not inherent in the coal but is due to the methods of mining and the fact that the coal is taken too close to the outcrop.

In the Bering River field, where extensive deposits of coal, ranging in composition from bituminous to anthracite, have long been known, prospecting or other development work relating to the coal resources was at a standstill. Rumors of renewed activity in this field were heard from time to time, and requests for extensions of some of the Government permits for coal prospecting there were received. It is evident that this field has too much potential value to be allowed to remain idle long, but it is also evident that the present coal consumption of Alaska is not such as to stimulate large companies to undertake the opening up of extensive projects and that until there is a greater demand for their product or until they are prepared to invade a more distant market where competition will be more severe they will not enter this field. Furthermore, the development work already done in the field indicates that some complex geologic conditions will be encountered, so that desultory prospecting by small, poorly financed, or technically unskilled operators holds little promise of success, and full development must await a company that is able to go into the matter in a large way and can stand the necessary expense of exploring a new field.

PETROLEUM

The only petroleum produced in Alaska comes from the wells of the Chilkat Oil Co., in the Katalla field. This company obtains oil from a number of relatively shallow wells, few of which are more than 1,000 feet deep and none more than 2,000 feet. A small refinery is operated at Katalla by the company, and the products—gasoline and distillate—find a ready market near at hand, especially for use by boats of the fishing fleet near Cordova. A new condensing plant was built at the refinery during the year. The production from these wells was maintained at approximately the same rate as heretofore, and its value was also about the same. Owing to the wreck of the vessel used in carrying the company's products to Cordova it was necessary to reduce production during the first three months of the year, until a new boat was obtained. No other new developments are reported to have taken place in this field during the year.

The small domestic production of petroleum from the Katalla field is not at all adequate to supply even local needs, and the demand for large quantities of petroleum products throughout the Territory is met principally by imports from the States. The most notable feature that is brought out by the data of the subjoined table is the constant increase since the war in the amount of gasoline and related lighter products of distillation imported. This increase is called for by the growing use of power in fishing boats and other water craft, in the canneries, in many mining developments, and in the operation of means of transportation such as automobiles and gas cars or engines on practically all the railroads.

Petroleum products shipped to Alaska from other parts of the United States, 1905–1928, in gallons [a]

Year	Heavy oils, including crude oil, gas oil, residuum, etc.	Gasoline, including all lighter products of distillation	Illuminating oil	Lubricating oil
1905	2,715,974	713,496	627,391	83,319
1906	2,688,940	580,978	568,033	83,992
1907	9,104,300	636,881	510,145	100,145
1908	11,891,375	939,424	566,598	94,542
1909	14,119,102	746,930	531,727	85,687
1910	19,143,091	788,154	620,972	104,512
1911	20,878,843	1,238,865	423,750	100,141
1912	15,523,555	2,736,739	672,176	154,565
1913	15,682,412	1,735,658	661,656	150,918
1914	18,601,384	2,878,723	731,146	191,876
1915	16,910,012	2,413,962	513,075	271,981
1916	23,555,811	2,844,801	732,369	373,046
1917	23,971,114	3,256,870	750,238	465,693
1918	24,379,566	1,086,852	382,186	362,413
1919	18,784,013	1,007,073	3,515,746	977,703
1920	21,981,569	1,764,302	887,942	412,107
1921	9,209,102	1,403,683	2,021,033	232,784
1922	15,441,542	1,436,050	2,095,675	345,400
1923	12,285,808	4,882,015	473,826	454,090
1924	14,412,120	5,554,859	566,431	506,364
1925	16,270,746	6,993,560	562,844	580,321
1926	14,000,664	5,069,584	328,615	730,924
1927	17,628,744	8,141,574	516,306	620,450
1928	13,000,176	8,025,402	463,134	715,082
	372,179,963	66,876,375	19,723,014	8,198,055

[a] Compiled from Monthly Summary of Foreign Commerce of the United States, 1905 to 1928, Bureau of Foreign and Domestic Commerce.

Search for new oil fields in Alaska has not been vigorously carried on during the year. At only one place was any drilling done, and at one place where drilling had been done in 1927 formal notice was given in 1928 of the company's intention to abandon the well that had been started. Hundreds of permits for prospecting for oil that have been issued by the Government and cover tracts in all parts of Alaska are outstanding in the hands of individuals and companies, but most of them were taken up solely for speculative purposes and will lapse after a short time if no active work is done under them. At present the interest in Alaska oil prospecting has flagged, as the test wells already sunk have proved that the discovery of commercial pools there will require much work and the expenditure of large sums of money. There is no reason, however, to believe that the chances of finding oil in Alaska have been exhausted, and the lack of success that attended some of the wildcat wells that have already been drilled is not unlike the history of the early drilling in fields in the States that subsequently have proved to be immensely productive. There are many tracts in Alaska that are believed to show favorable structure and will warrant extensive testing when the pressure to find new supplies of oil becomes stronger. These tests, however, should not be undertaken by any but a strong organization that is able to carry through the exploration of the tract selected to a determinative conclusion and that is advised by a competent technical staff able to interpret and utilize to the fullest the facts that are disclosed in the course of the work.

The only other place where drilling for oil was in progress in 1928 was in the Matanuska Valley, a few miles west of Chickaloon, on the property of the Peterson Oil Association. Work at this place was started in 1926, and when operations were suspended in the winter of 1927 the well had been put down to a depth of 865 feet. In 1928 drilling started at this depth and was carried down to a depth of 1,300 feet by the end of the year. The work was done rather slowly, as care had to be taken to keep the hole alined. In part of the section rather massive, dense rock was penetrated, which probably was a sill of igneous rock similar to rocks exposed at the surface near Chickaloon. This rock is interbedded with the shales and sandstones that occur throughout the rest of the section. Apparently the dip of the formation, which in the upper part was rather steep, becomes less near the bottom of the hole and at the depth reached in 1928 is said to be almost flat. The operators were experiencing considerable difficulty in sinking the hole deeper with the Star rig that had been used in the shallower ground and had made arrangements for the purchase of a Standard rig, which was to be shipped in early enough to be used throughout the season of 1929. Apparently the showings are regarded by the owners as sufficiently promising to warrant their continuing drilling for at least another year, and inasmuch as they have carried the work so far that decision is probably justified, so that the question as to whether or not oil occurs there may be definitely settled. The geologic conditions in the vicinity of the well, so far as known, are not those usually found in the areas in the States where the larger commercial pools of oil occur, and a geologist can not but entertain grave doubts as to the occurrence of oil in that region. The finding of a commercial deposit of oil would be of so much benefit to the region as a whole, as well as to the individual operator, that it is earnestly hoped that the enterprise may be successful.

MISCELLANEOUS MINERAL PRODUCTS

The list of minerals of value that have been found in Alaska is long. In addition to those described in the preceding sections of this report the following have at one time or another been produced in quantities large enough to have more than local significance, and some of them have been and still are the basis of profitable mining industries: Metallic minerals, antimony, arsenic, bismuth, chromium, iron, manganese, mercury or quicksilver, molybdenum, nickel, tungsten, and zinc; nonmetallic minerals, asbestos, barite, building stone, clay, garnet, graphite, gypsum, jade, limestone, marble, and sulphur. Without doubt in 1928 small quantities of practically all these minerals were "produced" in the broadest sense of that word, but with the exception of stone, marble, antimony, and quicksilver none of them were reported to have been produced and sold in quantities that justified their being considered as having contributed materially to the mineral output of the Territory.

In the following table, as well as in certain of the other tables accompanying this report, all these minerals that were produced in quantities so small that to list them separately would disclose the production of individual operators have been grouped together under the collective term "miscellaneous mineral products." Among the mineral products that have been described elsewhere in this report but are included in this table are platinum and petroleum.

Value of output of miscellaneous mineral products of Alaska, including platinum, petroleum, gypsum, marble, and other products, 1901–1928

Year	Value	Year	Value	Year	Value
1901	$500	1911	$141,739	1921	$235,438
1902	255	1912	165,342	1922	266,296
1903	389	1913	286,277	1923	229,486
1904	2,710	1914	199,767	1924	348,728
1905	710	1915	205,061	1925	454,207
1906	19,965	1916	326,737	1926	444,500
1907	54,512	1917	203,971	1927	162,000
1908	81,305	1918	171,452	1928	164,000
1909	86,027	1919	214,040		
1910	96,408	1920	372,599		[a] 5,289,000

[a] $112,000 of placer platinum metals mined prior to 1926 and $238,000 of antimony mined prior to 1927 is not distributed by years but carried in total.

Practically the entire output of Alaska marble comes from quarries owned and operated by the Vermont Marble Co. In the past the company's output of marble has come mainly from quarries at Tokeen, on Marble Island, off the northwest coast of Prince of Wales Island. Depletion of these deposits and demand for more of its product led the company to search the adjacent region for other deposits of the type desired. After a long hunt satisfactory masses of marble were found in the vicinity of Calder and El Capitan, and they are being developed as rapidly as conditions permit. At present all the marble shipped by the Vermont Marble Co. is rough stone, which is dressed in the States for use in interior decoration. In the past several marble quarries were in operation in southeastern Alaska, but they are now standing idle. It seems strange that more limestone deposits favorably situated with respect to ocean transportation have not been profitably developed. A recent report by Buddington is accompanied by a map [12] which shows, among other

[12] Buddington, A. F., The geology and mineral deposits of southeastern Alaska: U. S. Geol. Survey Bull. 800, pl. 1, 1929.

things, the distribution and extent of some of the large belts of limestone that traverse much of southeastern Alaska. According to Burchard,[13] many different types of marble occur in these deposits, some even approaching statuary grade.

A new industry that bids fair to be of great importance in the development of southeastern Alaska commenced productive work in 1928. This is an enterprise to quarry high-grade limestone required as one of the constituents of cement. The work is being done by the Pacific Coast Cement Co., whose cement plant that uses the limestone is near Seattle. The quarries from which the limestone is taken are on View Cove, off Baldy Bay, on the east coast of Dall Island, one of the southwesternmost islands of southeastern Alaska. The quarry is opened on a floor about 150 feet above the sea. The rock is blasted down by dynamite, loaded into cars by a steam shovel, trammed to a crusher, which breaks up the larger pieces and feeds to a hammer mill that breaks it down into still finer pieces, the largest of which will pass through a 1-inch ring. The crushed rock is temporarily stored in an excavation below the crusher until such time as it is loaded aboard freighters and taken to Seattle. The loading is done by an extension of a belt conveyor which delivers the rock from storage through towers directly into the holds of the vessels. Transportation to Seattle is effected by two steel freighters having a cargo capacity of about 6,500 tons each, which are operated by the Pacific Coast Steamship Co. and which, when operations have become standardized and on schedule, plan to deliver a shipload of limestone at Seattle every nine days.

Antimony minerals are widely distributed through Alaska, and the common antimony mineral, stibnite, is recognized in most of the mineralized areas in interior Alaska. There has been little demand for this metal lately, and the market for it is said to be fairly closely controlled. In 1928, however, a Los Angeles firm reports having purchased a carload of antimony ore that came from the Fairbanks district. Specific information as to the mine from which this shipment was made is not at hand, but it is believed to have come from one of the gold-lode mines on the northern flanks of Pedro Dome and to have been accumulated in the course of other mining. A considerable number of veins of high-grade antimony ore have long been known to occur at various places in Cleveland Peninsula, in the Ketchikan district; several attempts have been made to open them up, and some ore has been shipped. Renewed activity in prospecting some of these veins was reported to have been under way, and promising results were obtained. There was also a revival of interest in

[13] Burchard, E. F., Marble resources of southeastern Alaska: U. S. Geol. Survey Bull. 682, pp. 29–39, 1920.

the antimony lodes that occur on Stampede Creek in the Kantishna district of the Yukon region. Plans were under discussion for the taking over of a number of claims in this district by an English company that had become interested in the project from reports made to it by George F. Lemon, and engineers were to be sent in to examine into the technical details. It was reported that if this project was carried through it would be undertaken on a large scale, as the company was not interested in taking hold of a small or moderate-sized venture in that rather remote region, realizing that economical development would call for considerable outlays for transportation and other facilities.

Prospecting and development work is said to have been continued on the known nickeliferous sulphides of the Chichagof district, in southeastern Alaska, but no ore is reported to have been produced for sale during the year.

No detailed information has been received by the Geological Survey regarding the developments during the year at the quicksilver deposits in the Kuskokwim Valley. It is currently reported that during 1928 a small retorting plant was built at the quicksilver property lying north of the Kuskokwim River, between Georgetown and the mouth of Holitna River, and that for a while the operator was turning out more than a flask of quicksilver a day. This plant, however, had been running only a short time when it caught on fire and was destroyed, so that production ceased. Most of the quicksilver from this property is sold to the placer mines in the Iditarod district or the near-by parts of the Kuskokwim Valley. In the Bluff district of Seward Peninsula there was considerable activity during the year in prospecting and development work on one of the old lodes near the town of Bluff that carries some quicksilver. Several claims are included in the tract on which most work is being done, and some veins were uncovered that encourage further search. The ore is said to be on the whole of low grade, but the tenor is believed by the owners to be high enough to pay for mining if there is any considerable quantity of it. Work will be continued here on a small scale for some time at least, or as long as the showings continue to be encouraging.

In the Kobuk district, northwestern Alaska, search for workable deposits of asbestos and jade is said to have been undertaken in the vicinity of Shungnak and the Ambler River. That these minerals occur in that remote district has long been known, but the expense and difficulty of developing them, even if they should be of higher quality than any samples so far seen, seems to shut out the possibility of their being mined at a profit or in appreciable quantities at present. In southeastern Alaska, on Bear Creek, near the north end of Admiralty Island, about 2½ miles from the shore, some work had been done on claims on which some asbestos had been found and a considerable amount of surface construction, both of houses and roads, was started. Some of the samples of asbestos from this place have fibers nearly a foot long, but they are rather weak and brittle. Possibly these samples were badly weathered, and material of better quality may be found when mining penetrates the deposit farther underground, away from the surface influence. A microscopic examination of a specimen of this asbestos was made by J. B. Mertie, jr., who identifies it as belonging to the chrysotile variety.

In the course of the studies made by the companies that are undertaking the development of the paper-pulp industry in southeastern Alaska some consideration has been given to the possibility of obtaining the required sulphur from local sources. As a result some scouting has been done to look over the pyrites deposits that have been reported in various parts of the region, but no decision as to the outcome of this search has been announced. No recent developments have been reported at any of the small sulphur deposits known to be associated with some of the volcanoes of the Aleutian Islands.

A few years ago there was a considerable production of gypsum from a mine on Iyoukeen Cove, on the east coast of Chichagof Island, southeastern Alaska, but this work was discontinued, and there has been no production from that place since. Prospecting is being continued, however, and a number of tunnels aggregating several hundred feet in length have been driven lately to explore the deposit.

ADMINISTRATIVE REPORT

By Philip S. Smith

INTRODUCTION

The task of obtaining information regarding the mineral resources of Alaska and assisting the industry in every practicable way has for many years devolved upon the Alaskan branch of the Geological Survey, and each year Congress appropriates certain funds to support the work. To give an account of the work that has been accomplished during the year just closed, so that the people may know how and where their money has been expended, is the prime object of this report. The details of the geologic results that are achieved are described more fully in reports covering the individual projects, which are published as soon after the completion of the work as possible. In the third of a century that this work has been in progress the Geological Survey has published several hundred reports on various phases of the mineral industry of Alaska, and these have been accompanied by several hundred maps of different parts of the Territory. Practically every known mineral-producing camp has been visited by the geologists, engineers, and topographers of the Geological Survey, and reports regarding these camps have been issued. There still remain, however, extensive tracts of Alaska that have not yet been surveyed, though they are believed to hold promise of containing mineral deposits that may be of value. In fact, although more than 40 per cent of the Territory has been surveyed, at least on exploratory standards, there is probably an area of more than 200,000 square miles that is regarded as of potential mineral value which should be studied as soon as funds and personnel can be assigned to the work. This is a conservative estimate and would exclude about 150,000 square miles of country, such as the Yukon Delta and Yukon Flats, where, though there may be deposits of value, the chances are regarded as not sufficiently favorable to warrant much work until studies in other more promising areas have been completed. Furthermore, it should be evident that the exploratory and reconnaissance standards that have been adopted for practically all the work so far accomplished are adequate to give only general information, so that detailed investigations, such as are essential to the solution of most mining problems, are required for higher standards of work. The task of investigating the mineral resources of Alaska is a large one, on which only a start has yet been made.

In attempting to set forth in this report the recent activities of the Geological Survey in its Alaska work difficulty is at once encountered, in that the work is a continuing project which has no clearly marked steps or interruption to serve as well-marked breaks from which to report progress. Most of the work bears little relation to the calendar year. Many of the projects start in May and may last a few months or several years, but some have been started in February and others in July. The fiscal year which so clearly forms a basis from which to define much of the other Government work has little significance in reporting on the work in Alaska. This is true because most of the appropriations for Alaska work are made immediately available on the passage of the act through which the money is appropriated. Thus the act may pass at any time and the funds it authorizes may at once be allotted and expenditure commenced. For example, the appropriation for the Alaska work in the act for the Interior Department covering the fiscal year 1928–29 became effective on March 7, 1928, and was available for expenditure at any time after that date until June 30, 1929. At the same time the similar appropriation contained in the act for 1927–28 was available until June 30, 1928, and the act for 1929–30, which was passed March 4, 1929, was available after that date until June 30, 1930. Under these conditions it is evident that the determination as to which of these appropriations should be charged with a certain project is more likely to be decided by administrative convenience than by any real difference in the character or object of the work. To attempt to differentiate two jobs simply because they were paid for from different appropriations would obviously fail to give a correct understanding of the work to a person who was more interested in that aspect than in mere accounting procedure. For this reason the projects have been described principally on the basis of what may be called field seasons, though it should be realized that not all the time devoted to a project is spent in the field. Thus the field season of 1928 for many projects began early in the spring of 1928, when the field men began to assemble their supplies and equipment. It continued through the period of actual field operations and into the fall and winter and the spring of 1929, while the office and laboratory work of preparing the report of the results was in progress. The last stages of this work may have gone on more or less coincidentally with the beginning of preparations for the field season of 1929 and may have ceased only when the geologist or engineer left headquarters to undertake the new project. Certain of the projects, of course, naturally fall better into other periods. For example, the statistical studies of mineral production relate to the calendar year, though the most intensive part of the work falls in the early part of the year succeeding that to which the statistics relate. Thus, though collection of data and sending out of questionnaires for the 1928 canvass went on throughout 1928, the bulk of the replies was not received until the end of the year, and the final compilations could not be made until well into the spring of 1929. The project of collecting these data relating to the calendar year 1928 therefore has been considered as belonging to the season of 1928.

Although there is no direct relation of the field season to the fiscal year, the amount of money spent during any field season closely approximates the amount of money appropriated for the fiscal year. Thus, broadly speaking, the expenditures for starting parties in the field season of 1928 in advance of July 1 that were paid from one appropriation are about balanced by the expenditures for parties that started in the season of 1929 in advance of July 1 and were paid from the next appropriation. In other words, the sum of the expenditures during a field season, though paid from different appropriations, is essentially identical with the total amount of the appropriation available for a single year, unless there has been a marked change in the amount of money appropriated for the two fiscal years. No marked change has been made in the appropriations for the Alaska work in the last few years.

The funds used by the Geological Survey in its Alaska work are provided in two items in the general act making appropriations for the Interior Department. One of these is " for continuation of the investigation of the mineral resources of Alaska." In the act for 1928–29 the amount appropriated was $64,500, which was later increased $3,000 through the provisions of the deficiency act to take care of salary advances made under the Welch Act. In the similar act for 1929–30 the amount appropriated was $67,500. Each of these appropriations was made available immediately on the passage of the act in which it was contained.

The other item is an allotment made from the appropriation " for the enforcement of the provisions of the acts of October 20, 1914, October 2, 1917, February 25, 1920, and March 4, 1921, and other acts relating to the mining and recovery of minerals on Indian and public lands and naval petroleum reserves." Appropriations carried for this item are available only during the specified fiscal year. In the fiscal year 1927–28 an allotment of $14,500 was made for work of this kind in Alaska, and for the fiscal year 1928–29 the allotment was reduced to $10,000.

The two types of work indicated by the different phraseology of the appropriation items will be described in some detail in the following pages. For convenience the work done under the first item will be referred to briefly as the work on mineral resources and the work under the second item as the leasing work.

WORK ON MINERAL RESOURCES

PRINCIPAL RESULTS OF THE YEAR

The principal products of the Alaska work of the Geological Survey are reports and maps based on original surveys or investigations. During the year eight such reports have been issued, as follows:

The Skwentna Region, by S. R. Capps. (Bulletin 797–B.)

Preliminary Report on the Sheenjek River District, by J. B. Mertie, jr. (Bulletin 797–C.)

Surveys in Northwestern Alaska in 1926, by Philip S. Smith. (Bulletin 797–D.)

Aerial Photographic Surveys in Southeastern Alaska, by R. H. Sargent and F. H. Moffit. (Bulletin 797–E.)

Geology and Mineral Resources of the Aniakchak District, by R. S. Knappen. (Bulletin 797–F.)

Mineral Industry of Alaska in 1927, by Philip S. Smith. (Bulletin 810–A.)

Administrative Report, 1927–28, by Philip S. Smith. (Bulletin 810–A.)

Geology of Hyder and Vicinity, Southeastern Alaska, with a Reconnaissance of Chickamin River, by A. F. Buddington. (Bulletin 807.)

Six reports have been completed by their authors and approved for editing or printing, as follows:

The Chakachamna-Stony Region, by S. R. Capps. (Bulletin 813–B.)

Mining in the Fortymile District, by J. B. Mertie, jr. (Bulletin 813–C.)

A Geologic Reconnaissance of the Dennison Fork District, by J. B. Mertie, jr.

Administrative Report, 1928–29, by Philip S. Smith. (Bulletin 813–A.)

Mineral Industry of Alaska in 1928, by Philip S. Smith. (Bulletin 813–A.)

Notes on the Upper Nizina River, by F. H. Moffit. (Bulletin 813–D.)

The following reports are in process of printing:

The Upper Cretaceous Floras of Alaska, by Arthur Hollick, with a Description of the Upper Cretaceous Plant-Bearing Beds, by G. C. Martin. (Professional Paper 159.)

Geology and Mineral Deposits of Southeastern Alaska, by A. F. Buddington and Theodore Chapin. (Bulletin 800.)

Geology and Mineral Resources of Northwestern Alaska, by Philip S. Smith and J. B. Mertie, jr. (Bulletin 815.)

The Mount Spurr Region, by S. R. Capps. (Bulletin 810–C.)

The Chandalar-Sheenjek Region, by J. B. Mertie, jr. (Bulletin 810–B.)

Geology of the Eagle-Circle District, by J. B. Mertie, jr. (Bulletin 816.)

The reports listed below are still in course of preparation but have not approached near enough to completion to warrant any definite statement as to when they are likely to be printed and available:

The Tertiary Floras of Alaska, by Arthur Hollick.

The Igneous Geology of Alaska, by J. B. Mertie, jr.

The Alaska Railroad Route, by S. R. Capps.

The Geology and Mineral Resources of the Chitina Valley and Some Adjacent Areas, by F. H. Moffit.

Geology of the Fairbanks-Rampart Region, by J. B. Mertie, jr.

Geographic Dictionary of Alaska, 3d edition, by James McCormick.

Several other manuscripts have long been in course of preparation, but as they will require further field work before they can be completed, they are no longer considered as in progress.

Practically all the completed reports are accompanied by maps, the bases of which have been made principally from surveys conducted by the topographers of the Alaskan branch. The following maps have been published during the year:

Drainage map of part of the Ketchikan-Hyder region, southeastern Alaska, compiled mainly from aerial photographs made by the Navy Department at the request of the Geological Survey. Compilation made under direction of R. H. Sargent; scale, 1:250,000. Published in Bulletin 797–E.

Topographic map of the Hyder district (new ed.); topography by R. M. Wilson; scale, 1:62,500. Published in Bulletin 807.

Topographic map of the Pavlof region, Alaska Peninsula; scale, 1:250,000; by C. P. McKinley, of the National Geographic Society, Pavlof Volcano Expedition. Published by the Geological Survey as a preliminary lithographic edition.

The maps listed below were completed during the year, under the direction of R. H. Sargent, and submitted for publication:

Topographic map of Valdez and vicinity, by J. W. Bagley and C. E. Giffin; scale, 1:62,500. To be published as a sale map. The base of this map is largely the Port Valdez map, now out of print, but it covers a somewhat larger area, has been revised and brought up to date, and includes the results of hitherto unpublished surveys.

Topographic map of Revillagigedo Island, southeastern Alaska, by R. H. Sargent; scale, 1:125,000. The topography of this map is based on surveys made in 1928 by the usual ground methods but is incorporated with drainage features of the Hyder-Ketchikan map, which was compiled from aerial photographs. To be issued as a preliminary photolithographic edition.

Progress was also made in the preparation of a topographic map of the Mount Spurr region, scale, 1:250,000, compiled from surveys in the Skwentna, Mount Spurr, Chakachamna-Stony, and Lake Clark districts in recent years.

In addition to these detailed maps the base map of Alaska on a scale of 1:5,000,000 was revised and brought up to date for publication as an index map to show the progress of topographic mapping in the territory. This contains a list of selected publications of the Geological Survey that describe the mineral deposits of Alaska and the features of its major geographic divisions. Considerable work has also been done toward the revision of the map of Alaska on a scale of 1:2,500,000, with a view to the publication of a new edition as a sale map.

Several other maps are in preparation, but so little progress has been made in putting them into shape for publication that they are not listed here.

Besides the official reports, several articles were prepared by the scientific and technical members of the Alaskan branch for publication in outside journals, and ten or more public lectures were given regarding the general work of the branch or some of its special features. Most of these were prepared unofficially but represent by-products of the regular work and serve to reach special audiences not readily reached by the official publications. Among these articles may be mentioned the following:

Gold Reserves of Alaska, by Philip S. Smith, for presentation at the International Geological Congress in South Africa, 1929.

Geology and Geography of Alaska, by Philip S. Smith, for publication in "Geology of North America," included in "Geologie der Erde."

The pre-Cambrian of Interior Alaska, by J. B. Mertie, jr. Delivered before the Geological Society of Washington.

Notes on Geographic Features of Alaska, by R. H. Sargent, delivered at the meeting of the Association of American Geographers in New York.

Field Work of the Geological Survey in 1928, by F. H. Moffit, for publication in Alaska newspapers.

PROJECTS IN PROGRESS DURING THE SEASON OF 1928

Some of the results that the Geological Survey has accomplished in its Alaska work may be expressed in terms of the area covered. The following tabular statement indicates the areas covered by the surveys of different types as well as the percentage of the total area of Alaska that has been covered by all types of surveys. The areas reported in this table are based on the field season and not on the fiscal year. It is for this reason that in this tabulation no account is taken of the work that was started during the field season of 1929 but remained uncompleted at the end of the fiscal year 1928–29. This procedure has been adopted in part because at the end of the fiscal year most of the parties at work during the field season of 1929 were out of communication and so could not report the extent of the work they had accomplished, but in part it has been adopted because the field season is a more practicable unit of measurement.

Areas surveyed by Geological Survey in Alaska, 1898–1928, in square miles

Field season	Geologic surveys			Topographic surveys		
	Exploratory (scale 1:500,000, or smaller)	Reconnaissance (scale 1:250,000)	Detailed (scale 1:62,500 or larger)	Exploratory (scale 1:500,000, or smaller)	Reconnaissance (scale 1:250,000)	Detailed (scale 1:62,500 or larger)
1898–1927	75, 150	169, 305	4, 277	55, 630	204, 565	4, 066
1928		5, 450			[a] 3, 965	
	75, 150	[b] 174, 305	4, 277	55, 630	208, 530	4, 066
Percentage surveyed of total area of Alaska	43.3			45.8		

[a] Includes 2,000 square miles mapped by National Geographic Society Pavlof Expedition on Geological Survey standards.
[b] 450 square miles surveyed prior to 1928 deducted because of resurvey during 1928.

In the table given above only the net areas surveyed are listed in the appropriate column under geologic surveys or topographic surveys, though of course most of the areas that have been surveyed geologically have also been surveyed topographically. It is by no means unusual that areas surveyed hastily are resurveyed with more precision, and if the areas thus revised were not excluded from the totals the same areas would be counted twice. It is for this reason that an area of 450 square miles which was reexamined geologically in 1928 has been deducted from the total in the column of reconnaissance geologic surveys. The necessity for resurveying some areas in more detail is generally not due to faulty execution of the earlier surveys but to the need of covering a large tract rapidly at first. Then as development takes place in certain parts of that large tract more accurate and detailed work may be required to furnish the desirable information. To cover the entire tract with that same degree of care would unduly delay the work and cost far more than would be warranted. Therefore the resurvey of certain tracts here and there as required is really the most economical and logical procedure. Even in those tracts where more detailed work is known to be needed, it is usually best to make first a relatively rapid, inexpensive survey so as to supply immediate needs and then to follow this up with the necessarily slower, more expensive detailed surveys. This policy is well illustrated by the procedure adopted in surveying the Seward Peninsula placer camps. Within two or three months after the return of the Federal geologist from this camp during the height of the first stampede to Nome a rough exploratory map and report on the environs of Nome were published by the Geological Survey. During the next field season reconnaissance surveys were made of the entire region within 100 miles of Nome, and these in turn were later succeeded by detailed mapping and reports on smaller tracts in the vicinity of the richest camps.

The scale most commonly adopted for Alaska surveys, either geologic or topographic, has been called the reconnaissance scale and is 1:250,000, or about 4 miles (250,000 inches) on the ground represented by 1 inch of paper on the map, with a contour interval of 200 feet. This scale has been chosen because all the larger features of the country can be represented by it, so that it is adequate for most general purposes and at the same time can be made expeditiously and cheaply. It is obvious, however, that so small a scale can not effectively show detailed features of topography or geology, and yet many of these are of prime importance in their relations to the mineral resources of the region. Therefore, although more than two-fifths of the Territory has been mapped on reconnaissance or exploratory standards, there is a constant demand for more detailed work, and this demand will become more and more insistent as the Territory develops. But even for the reconnaissance type of mapping there still remains about 200,000 square miles of country holding promise of containing mineral deposits of value that has not been surveyed. The present rate at which the work is being carried on is entirely inadequate to meet even the most general needs. At this rate it will be many decades before even the reconnaissance mapping of the prospective mineral areas can be completed, and the requisite detailed mapping of the most promising tracts must be postponed far into the future or must supplant the equally pressing reconnaissance work unless more funds are available with which to speed up the work.

The parts of Alaska in which the surveys in 1928 tabulated above were conducted by the Geological Survey were the Ketchikan and Juneau districts of southeastern Alaska, the Chitina-Nizina district of the Copper River region, the vicinity of Mount Spurr in the Alaska Range, and a tract lying north of the Tanana River and west of the international boundary.

The work in the Ketchikan district consisted of reconnaissance topographic mapping conducted by R. H. Sargent. The principal object of this work was to furnish a complete topographic map of this district, which is economically important. Ores of various metals have long been known to occur in this region, and some of them have been worked more or less successfully. The easy accessibility of most parts of the region to ocean transportation holds promise of making many of the costs of development low, and the general geologic conditions are such as to encourage search for deposits of commercial extent. Although the principal object of this topographic mapping was to furnish a base which would serve for the mineral investigations, it has met a very immediate need of those concerned with the development of the timber, pulp, and water-power resources of this region. This project is of special technical interest because the topographer made use of the first of the drainage maps compiled from the aerial photographs taken for the Geological Survey by an expedition sent by the Navy Department to the region in 1926. The use of these aerial pictures proved highly advantageous in facilitating the work of the topographer in this region of high relief and almost impenetrable timber cover. As the photographs taken by the naval expedition cover nearly 10,000 square miles of southeastern Alaska, this project is the forerunner of similar surveys that will be carried on in this region as rapidly as funds and personnel permit. A word here regarding the utilization of these airplane views in making complete topographic surveys of this region may not be out of place, as many people do not realize the multiplicity of steps that must intervene between the compilation of the drainage map from the airplane pictures and the production of the finished topographic map. The drainage map shows no relief, so the topographer must make many stations in the field throughout the area covered by it, and by means of triangulation with his instruments determine the actual height of a great number of points. He must then sketch the contour lines which pass through points of similar elevation, so that the form of every part of the mapped area can be indicated graphically. In the course of this field work it often becomes apparent that distortion of the pictures through lack of horizontality of the airplane from which they were taken has introduced errors in compilation that must be corrected before the base map is in satisfactory adjustment. This may require revising the original compilation so as to fit the points as determined by the ground surveys. Then the corrected field map must be carefully penciled in detail and later inked so that it will be suitable for preservation and for yielding sharp photographic copy. It is then ready to undergo the various processes of reproduction, which for most Geological Survey maps involve being engraved on copper or reproduced on stone or metal for photolithographic reproduction. As the topographic map of part of the Ketchikan district was the first of its kind to be made of a tract of Alaska topography, it has presented many technical problems that required special consideration. As a result it has raised many questions as to the best method of procedure and has been carefully studied at all stages to determine its relative expense as compared with other methods of doing the work. Obviously, if it had not been for the hearty cooperation of the Navy Department and the excellent results achieved by its personnel to whom was intrusted the original making of the pictures, this method would have been entirely impracticable.

The surveys in the Juneau region of southeastern Alaska were performed by R. K. Lynt, a topographer of the Geological Survey, who was temporarily assigned to duty with a party of the Forest Service. The cost of this work was borne entirely by the Forest Service through a transfer of funds to the Geological Survey, and the resulting map was turned over to the Forest Service. It has not been included in the table of areas surveyed nor in the table of expenditures. This work was especially desired by the Forest Service in connection with its activities in developing the paper-pulp industry in southeastern Alaska, and although the Geological Survey would doubtless have mapped that area eventually in the course of its regular mineral investigations, the immediate needs of the Forest Service were so urgent that that organization bore the entire cost. The work covered a small tract on the west coast of Admiralty Island and was done with the accuracy required for publication on a scale of 1:62,500—the detailed scale adopted by the Geological Survey. The tract is exceedingly difficult to survey, and the map covered an area of only a few score square miles.

The work in the Nizina district of the Copper River region consisted principally of the revision of earlier geologic surveys and the critical study of some of the places where different interpretations that have been advanced could be tested. This work was done by F. H. Moffit, who, with a small pack train and camp assistant, traversed much of the known copper-bearing region north of the Chitina River and greatly refined the broad determinations of the geology resulting from the earlier more hurried expeditions. The much more precise knowledge of the stratigraphy and geologic history thus obtained is essential in directing the search for valuable deposits in this important mineralized region. In addition to these areal studies, Mr. Moffit spent some time at the large copper mines near Kennecott and at the placer gold camps on Dan and Chititu Creeks and visited all the places in the district where prospecting has recently been in progress, so far as time permitted, to obtain information regarding current conditions.

In the vicinity of Mount Spurr, in the Alaska Range west of Anchorage, a combined geologic and topographic party in charge of S. R. Capps, geologist, with Gerald FitzGerald as topographer, carried on extensive surveys by means of a pack-train expedition. The geologist, topographer, and recorder were carried by airplane to the point where the new surveys were to be started. This afforded a good example of the effectiveness of airplane transportation, for the trip from Anchorage to the initial point consumed only 80 minutes, whereas the pack train that was sent overland from the west shore of Cook Inlet took more than 20 days to make the trip. In a region like that of the Alaska Range, where the season is limited to less than 100 days, this great saving in time is evidently of almost paramount importance. But even if this greatly increased length of working season is not considered justification enough of itself, the saving in food and salaries almost, if not quite, makes this means of transportation cheaper than tramping on foot across the country. The geologic and geographic results of this work are of great interest and significance. The party traversed with pack train a pass across the Alaska Range leading on the west side to streams flowing into the Stony River, one of the large southern tributaries of the Kuskokwim River, and mapped a tract of 1,000 square miles that has hitherto remained a blank on all authoritative maps of the Territory. This route, however, did not prove to be a practicable one for common use in traversing the range. Some indications of mineralization were seen, but there were almost no signs of prospectors or even hunters in most of the area.

In the vicinity of the international boundary north of the Tanana River and extending more than 100 miles to the west is a triangular tract that lies south of the gold placer camps of the Fortymile district. A reconnaissance topographic map of this tract had been made some years ago, but until the season of 1928 it had not been possible to map the area geologically. In that year J. B. Mertie, jr., with a small pack train and two camp assistants, left Eagle to carry on reconnaissance geologic surveys. A serious injury to one of the camp assistants before reaching the field necessitated the return of the party to Eagle to get medical attention. The loss of the assistant still further hampered the party, which even before the accident had been undermanned, but in spite of this Mr. Mertie pushed ahead with only one camp hand, and was successful in mapping the major geologic features of an area of nearly 4,000 square miles. The geologic features observed seem to indicate that at a number of places the conditions are favorable for the occurrence of gold mineralization and that where concentration has been effective placer deposits may be sought with considerable assurance of success.

The only other field work that was done during the season of 1928 by a member of the staff having headquarters in Washington was the customary broad survey of recent developments in the mining industry as a whole, with special visits to some of the more active mining camps or those that have not been recently visited by members of the Geological Survey. This work was done by the chief Alaskan geologist. In the season of 1928 it was possible for him to visit several of the lode camps in the Ketchikan district, in addition to spending several days with Mr. Sargent's party that was engaged in topographic mapping; to visit Juneau and to spend a few days with Mr. Stewart at the Juneau office and confer with members of the Forest Service regarding future work; to visit the large copper mines in the Kennecott district and to spend a couple of weeks with Mr. Moffit's party in the areal geologic work both east and west of Kennecott; to go over the Richardson Trail to Fairbanks, stopping for a short time at the Tenderfoot placer camp; to visit all the larger operations in the Fairbanks district, including Nome Creek; to visit most of the mining operations in the vicinity of Hot Springs, including those on Woodchopper, Tofty, and American Creeks; to go to Tanana and thence up the Yukon, stopping on the way at Rampart and joining Mr. Mertie's party for a 10-day trip to study the geology of the country adjacent to the boundary, especially in the vicinity of the Tatonduk River; thence to go to Circle and across the newly opened automobile road to Fairbanks, and thence by the Alaska Railroad to Seward, from which he returned to the States. A general familiarity with the mining industry, such as may be gained by a rapid survey of this type, is regarded as essential in keeping track of recent developments and in laying out plans for future work so that they will fit the needs of the mining industry.

The Geological Survey maintains in Alaska two district offices, one at Juneau and one at Anchorage. The main duties of the personnel attached to these offices relate to mineral leasing, but a part of their service relates to general investigations of mineral resources. Up to July 1, 1928, both kinds of work were conducted under a single appropriation, but on that date the two were separated, and although no change in the actual handling of the work was involved, the accounting was changed. Under this arrangement approximately two-fifths of the time of B. D. Stewart, who is in direct charge of the local offices, was allotted to general investigations of mineral resources, including, besides office duties, visits to different parts of the Territory as conditions warrant. Mr. Stewart's long familiarity with mining matters throughout the Territory and his availability for consultation at Juneau have made his advice much sought by many of the Federal and Territorial agencies in Alaska, including the Alaska Railroad, the Forest Service, the governor, and members of the Territorial legislature, as well as by many of the individual operators and prospectors. The Alaska offices also act as local distributing points for publications of the Geological Survey and assist in furnishing the main office at Washington with information on many phases of the mineral industry in the Territory. The suitable coordination of the mineral investigation work done from the Alaskan offices with that done from the Washington office is still in process of being worked out, but the aim is to make such an adjustment that the combination will be able to give better and greater service to the mining industry with less expense.

A field project that really does not properly belong to the work of this branch, as it was financed by a non-Federal organization and was performed by members of the Geological Survey, who belong to other branches, was the National Geographic Society's Pavlof Expedition to the Alaska Peninsula, which was in charge of T. A. Jaggar, jr., volcanologist, with C. P. McKinley as topographer. Through the courtesy of the National Geographic Society the excellent topographic field charts which resulted from this survey were made available without expense to the Geological Survey, which has issued the resulting map in a preliminary edition that is in every respect comparable to the standards used for its own maps. This map has been listed among the maps issued by the Geological Survey during the year, and the area covered by it has been included in the table on page 79. This adds one more to the already long list of notable contributions which the National Geographic Society has made to Alaskan exploration.

In addition to these distinctly field projects the Alaskan branch each year compiles and issues statements regarding the production of all the different mineral commodities that are mined in the Territory. This work is mainly carried on from the Washington office, but the wide acquaintance of the field men and their surveys in different parts of the Territory each year make them a source of much definite authoritative information. These annual production reports are conducted on the basis of the calendar year, but the work of assembling the data and canvassing the different producers goes on practically without interruption. For example, the task of accumulating the facts regarding the production of minerals for 1927 commenced the 1st of January of that year and was not completed until June, 1928, when the report was finally transmitted for publication. Necessarily during the period from January to June, 1928, data relating to the mineral production of two separate calendar years were being collected coincidentally. The statistical data are compiled principally by Miss L. H. Stone, and the material is coordinated and the resulting report prepared by the chief Alaskan geologist.

Each of the field projects involves considerable office work in examining and testing the specimens collected, preparing the illustrations and maps, and writing the reports. In addition to work of this sort on the field projects enumerated above, there was considerable office work required on field projects of earlier years. Some of the work represents only the normal routine of seeing a report through the press, such as proof reading the text and illustrations, but some represents the completion of work that for some reason or other was not finished during the year in which the field surveys were made. Some progress was also made during the year toward the completion of certain of the reports listed on page 77 as still in the authors' hands. Of these the most active work was done on the Geographic Dictionary of Alaska, 3d edition, by James McCormick, and the report on the geology and mineral resources of the Chitina Valley and some adjacent areas, by F. H. Moffit.

In all the office work on the technical reports the members of the Alaskan branch have received much assistance and valuable advice from their associates in other branches of the Geological Survey. T. W. Stanton, G. H. Girty, J. B. Reeside, jr., Edwin Kirk, David White, and E. W. Berry, paleontologists, have examined and reported on the fossils collected in the course of the field surveys. The map editors have been especially helpful in critically scrutinizing the Alaska maps that were in course of preparation to see that they conform so far as practicable to the best Geological Survey standards.

PROJECTS FOR THE SEASON OF 1929

The six projects that have been approved for the season of 1929 had been under way for only a short time at the end of the fiscal year 1928–29, and on most of them only a start had been made. Furthermore, almost all the parties were out of touch with ordinary means of communication, so that no specific details were available regarding the work actually accomplished. Under these conditions it has seemed desirable at this time to outline only the principal objects of these projects, which include topographic studies in connection with the airplane photographing expedition of the Navy Department in the northern part of southeastern Alaska; geologic reconnaissance surveys in the Alaska Range in the vicinity of Mentasta Pass and Chistochina, at the head of the Copper River Basin; a combined geologic and topographic reconnaissance survey of an unexplored tract of the Alaska Range northwest of Lake Clark, in southwestern Alaska; a geologic reconnaissance of the White and Crazy Mountains, in the north-central part of the tract between the Yukon and Tanana Rivers, central Alaska; investigations of mineral properties in the vicinity of the Alaska Railroad; and a general inspectional trip to obtain information regarding recent mining activities throughout the Territory and, so far as time permits, to visit some of the field parties.

The projected work in southeastern Alaska is essentially a part of the undertaking by the Navy Department to photograph from airplanes a large tract including Baranof and Chichagof Islands and contiguous territory. This work is really a continuation of similar work done in 1926, when about 10,000 square miles of the southern part of southeastern Alaska was photographed and the resulting films were turned over to the Geological Survey for working up into drainage maps. The value of the pictures was at once apparent, and subsequently the Forest Service, feeling the urgent need of similar pictures for the northern part of this region, entered into an agreement whereby the work should be resumed by the Navy during the season of 1929. Under this agreement most of the extra expense of the photographic work is borne by the Forest Service, the Geological Survey contributing only $2,000 and the services of R. H. Sargent, topographer, who serves as technical adviser, to see that the resulting films are suitable for cartographic use. It is expected that as a result of this work many thousand new films will be obtained and that with these, as well as those already in hand from the earlier expedition, it will be practicable to compile drainage maps of almost all the hitherto unmapped portions of southeastern Alaska. The task of taking off the cartographic data from these views is laborious, and the funds for this work at the disposal of the Geological Survey are so small that unless they are materially increased these valuable data can not be worked up into maps in the near future. It is hoped, however, that maps of some of the tracts most urgently needed can be worked up at once. The former success of the Navy in this work and the whole-hearted enthusiasm with which its personnel have started in on the new project give every assurance of its successful completion. The resulting maps will be of service not only to the Geological Survey in its mineral investigations but to everyone having an interest in the development of any of the natural resources of this region. The topography of southeastern Alaska gives a very severe test of the application of methods of photographic surveying, because the relief is so strong that distortion of scale is especially great. Furthermore, the atmospheric conditions are bad, with a great amount of clouds and rain and the intricate interspersal of land and water areas. Aerial photographic methods, however, have many advantages over ground methods in this region, because of the difficulty of traversing on foot the high ridges, precipitous ledges, and almost impenetrable jungle of forested and brush-clad slopes.

The geologic reconnaissance in the Alaska Range, at the head of the Copper River, is being conducted by F. H. Moffit, accompanied by a small pack train and two camp assistants. The country adjacent to Mentasta Pass has long been known to be a mineralized area, which has afforded evidence of the presence of gold and lead and some indications of the presence of copper. Development work is in progress in this district on prospects of lode gold and lead. Productive gold placers have long been worked in the Slate Creek district, which lies along the western margin of the area to be surveyed. The region as a whole lies across the axis of the Alaska Range, and the surveys are expected to yield information as to the relation of the metamorphic rocks on the north side of the range to the Paleozoic and Mesozoic sediments on the south. A part of the area was mapped both topographically and geologically by very hasty reconnaissance methods in 1902, but the results of the geologic investigations were never published. It is especially desirable now to revise and extend that mapping in the light of the present knowledge of the stratigraphy and the renewed interest that is being taken in the mineral deposits in this general region.

The combined geologic and topographic surveys to be made in the Alaska Range region north and west of Lake Clark are in charge of S. R. Capps, geologist, with Gerald FitzGerald, topographer. These surveys started from the previously surveyed region adjacent to Lake Clark and will extend northward as far as time and other conditions permit, possibly tying in with the surveys made during the field season of 1928 in the valley of the Stony River, a tributary of the Kuskokwim. The party, consisting of its technical members and camp assistants, with a pack train and the necessary supplies for the season, was landed at Iliamna Bay early in June and proceeded at once overland to the point where the new work was to be started. The surveys should fill in some of the gap that now exists between the work that has been done in the northern and central part of the Alaska Range and that done in the south. The region holds promise of containing deposits of valuable minerals, but it is practically unexplored, and this possibility can be stated in advance of survey only as a surmise. In fact, the very absence of authoritative information regarding it makes its exploration by the Geological Survey especially desirable at this time.

The work in the Yukon-Tanana region will be principally a geologic reconnaissance and revision of the older mapping of parts of the country adjacent to the White Mountains and the extension of the surveys northward to the Yukon Flats and eastward to the Crazy Mountains. The work is in charge of J. B. Mertie, jr., accompanied by a pack train and two camp assistants, who went into the country by way of Fairbanks. In the course of the work the party will have the opportunity of visiting some of the old placer camps, especially those near Circle, and will collect information regarding the progress of mining and prospecting in those places. This work is part of the general revision that Mr. Mertie has been carrying on for a number of years in the Fairbanks and Circle districts. The results of this critical study, when completed, should be of much significance in determining the general geologic history of the region and in throwing light on the conditions under which the mineralization was effected and consequently giving clues to the places where further prospecting is most likely to be successful.

Early in 1929 Col. O. F. Ohlson, in charge of the Alaska Railroad, broached the question of organizing a geologic staff as part of the railroad personnel, to assist the railroad in its search for tonnage and in solving problems that arose in its work that required this special type of information. The Geological Survey agreed to make available to the railroad the services of an engineer or geologist for about four months a year and to meet so far as possible any requests for areal work that might be submitted by the railroad officials. This arrangement was started in the season of 1929, and at the end of the fiscal year the results were not yet sufficient to afford adequate measure of its success. It is proposed that in the main the needs of the railroad for an engineer or geologist shall be taken care of by members of the staff attached to the local offices at Anchorage and Juneau. If, however, this arrangement does not work out as planned, additional assistance will be given by the chief Alaskan geologist or such other members of the field force as are in the general neighborhood of the railroad. The successful operation of the railroad as a means of developing Alaska is of most vital concern to the entire mining industry, and the Geological Survey in its relation to that industry feels keenly concerned with making this cooperation effective, though it may take a little time to work out the most practicable way by which this assistance can be contributed.

The general work on mineral resources performed by B. D. Stewart from the Alaska offices, in addition to that called for by the arrangement with the Alaska Railroad, will be closely comparable with that done by him in the season of 1928. It will consist in such general field studies as time and other conditions permit, the maintenance of office records, the answering of inquiries, and the holding of such conferences as may be required. These duties are so varied and diverse that no estimate of the proportion of time required for the different items can be made in advance.

The only other field work that the Geological Survey proposes to do in Alaska in 1929 is the customary broad survey of recent developments in the mining industry as a whole, with special visits to some of the more active camps and to some of those that have not been visited recently by members of the Geological Survey. In the course of this work it is proposed to visit such of the field parties as can be reached without too much delay, and to visit each of the local offices so as to be in close personal touch with the problems they are meeting. This work will be done by the chief Alaskan geologist, who will reach Alaska the later part of July and spend the rest of the season on the project.

Although not to be regarded as field projects, the general office duties attendant on the annual statistical canvass, the answering of hundreds of inquiries from all sources, the advancing of the preparation of such old reports as are awaiting further attention, the revision of pending reports, and the necessary proof reading of those in course of publication will call for no small share of the time of the members of the Alaskan branch, both technical and clerical, so that they might well be counted in as part of the projects facing the branch during the season of 1929.

EXPENDITURES

The funds used for the work of the Geological Survey on Alaska's mineral resources during the field season of 1928 were made available through the Interior Department appropriation acts for 1927–28 and 1928–29. The amount appropriated by the act of 1927–28 was $60,000; for 1928–29 it was $64,500, to which was later added through the deficiency act $3,000 to take care of salary adjustments brought about through the Welch Act. During the field season of 1929 the funds used were made available through the Interior Department appropriation act for 1928–29 and the supplementary deficiency act, already noted, and the act for 1929–30, which appropriated $67,500. From the foregoing it is evident that for a large part of the time two appropriations were running concurrently. All the expenditures from these different items have, of course, been properly accounted for under the usual system of bookkeeping, but the analysis from that standpoint, as has already been pointed out, gives only an imperfect picture of the real conduct of the work. An attempt here has been made to summarize the expenditures and group them under a number of major heads, so as to show the principal objects for which the funds appropriated during the fiscal year 1928–29 were expended.

Expenditures from funds appropriated for investigation of mineral resources of Alaska for the fiscal year 1928–29

Projects for the season of 1928	$13,566
Projects for the season of 1929	11,350
Administrative salaries, July 1, 1928, to June 30, 1929	3,150
All other technical and professional salaries, July 1, 1928, to June 30, 1929	28,167
All other clerical and drafting salaries, July 1, 1928, to July 30, 1929	7,667
Office maintenance and expenses	3,251
Balance	349
	67,500

In the first two items in the foregoing statement no charges are included for the salaries of any of the permanent employees of the branch, as all these are carried in the three following items. Proper proportional charges for these services, as well as for the expenditures listed as office maintenance and expenses, might well have been made in these first two items, for practically every expenditure made by the branch relates more or less directly to these projects. Thus the administrative officers are concerned primarily with the successful accomplishment of these projects, the scientific and technical personnel is maintained solely to carry out these projects, the clerical and drafting force is required to help in preparing the reports and maps and in attending to the innumerable details connected with the task of properly conducting the projects, and all the office supplies and other equipment purchased are really incidental to the task of carrying through the projects.

The expenditures for the projects of 1928 amounted to $13,566, which includes $7,938 for geologic and general investigations and $5,628 for topographic work. These figures are based on the assumption that in combined geologic and topographic parties the expenses are divided equally between the two types of work. A similar analysis of the expenditures for the season of 1929 shows that expenditures from funds for the fiscal year 1928–29 amounted to $11,350, of which $6,675 was for geologic work and $4,675 for topographic work. Of the $24,916 allotted to field projects for both seasons from the appropriation, $14,613, or about 58 per cent, was allotted to geologic or related general work and $10,303, or 42 per cent, to topographic work.

The item for administrative salaries in the foregoing table includes only those salaries that are directly related to general administration and does not include charges for administration such as each party chief is called on to perform with regard to the party in his charge, though that work requires considerable time and much administrative skill to discharge properly. During the fiscal year 1928–29 the chief Alaskan geologist was in the field until early in October and was on leave from April 3 throughout the rest of that year. During his absence the general administration of the branch was carried on by S. R. Capps until he left in May to undertake field work in the Alaska Range region. During part of May and all of June Miss L. M. Graves served for the chief of the branch. Part of Mr. Stewart's salary has been included in this item, as the local administration of the Alaska offices is in his charge. The low cost of administration is due principally to the fact that the administrative officers are engaged also in technical projects, which therefore bear their proportional charge of their salaries. This makes for low cost of administration but lessens the amount of time available for real directive handling of many of the affairs of the branch and would not be at all practicable except with a branch whose personnel has long been familiar with the work to be done and is well qualified to solve for itself many of the problems that arise.

The item for clerical and drafting salaries for the Washington office covers part of the salary of the chief clerk, a junior clerk, and a draftsman, and the services for a little more than three months of a stenographer. In addition the item includes part of the salary of a clerk in the Anchorage office. Approximately three-fourths of the time of the junior clerk in the Washington office is directed to the canvass and compilation of data regarding the production of minerals in the Territory and the necessary office work related thereto, which is practically a technical project. The draftsman is engaged in all kinds of map preparation, especially in the finer kinds of work required where photolithographic methods are to be used for reproducing the original copy. The present clerical and drafting personnel is entirely too small to handle the volume of business that passes through the office. As a result many things conducive to the proper conduct of the work are unduly rushed or laid aside, thus crippling the work. This condition is the result of curtailments in appropriations, which have been met by curtailments in the clerical force, so as to make as much money as possible available for the field projects. This procedure is having an injurious effect on the work as a whole and can not much longer be continued.

The item for office maintenance and expenses includes all the miscellaneous expenses incident to the general conduct of the work that are not directly part of a definite project. It includes purchase and repair of all the technical instruments used and the photographic and related work required in the course of the compilation and preparation of the maps. Other expenditures that fall under this item are telegrams, stationery, technical books, services rendered by other units of the Geological Survey, such as making thin sections of rocks and minerals needed in microscopic examinations, editorial inspection of maps and other cartographic data submitted for publication, and shipment of material not for use in designated projects. By far the heaviest charges entering into this item during the fiscal year 1928–29 were those for new instruments. These amounted to $1,742 and covered principally a transit and its equipment, a telescopic alidade to replace instruments that have been long in service and are now worn out, a photographic printer especially designed for airplane films, and a special stereoscopic apparatus necessary for handling the airplane views used for map compilation. The amount spent for new instruments is unusually large and represents in fact a replacement that will not be necessary again for some years, unless the scope of the work is expanded. The next largest item of expense under this heading covers photographic and related work, which amounted to about $800. Nearly 40 per cent of this total was for the cost of preparing a preliminary edition of the Pavlof map, which was made available to the Geological Survey by the National Geographic Society, and 15 per cent was for work on the drainage map prepared from airplane pictures of part of southeastern Alaska. The cost of all other supplies and equipment for the branch was considerably less than 1 per cent of the total appropriation. This proportion is rather less than can be consistently maintained.

In the following tables the cost of the work, including field expenses and the salaries paid from different appropriations, by geographic regions or by classes of work, has been set down. In these tables the cost of the salaries charged against each project is only approximately accurate, for the whole time of a geologist or topographer assigned to a project is charged against that project, whereas much of his time at the office is required for miscellaneous duties. The columns of salaries, except as specifically noted, do not include administrative salaries or clerical salaries, and the columns of expenses do not include items charged to office maintenance or expense. For these reasons, as well as because two different appropriation years are tabulated together, the total given in the last column does not equal, even approximately, the total given in the table on page 90 for a single fiscal year.

Approximate cost and distribution of work by geographic divisions for the season of 1928

Region or work	Appropriation for 1927-28		Appropriation for 1928-29		Total
	Expenses	Salaries	Expenses	Salaries	
Southeastern Alaska [a]	$1,900	$765	$3,278	$3,333	$9,276
Copper River region	660	765	2,408	4,167	8,000
Alaska Range	2,600	1,445	4,700	7,200	15,945
Yukon-Tanana region	2,400	700	2,089	4,000	9,189
General investigations			986	3,533	4,519
Statistical studies				[b] 2,200	2,200
Alaska offices			105	[c] 2,563	2,668
	7,560	3,675	13,566	26,996	51,797

[a] Does not include $1,925 transferred to Geological Survey from Forest Service for detailed topographic mapping.
[b] Includes $1,515 for clerical salaries.
[c] Includes $1,000 for administrative salary and $480 for clerical salary.

Approximate cost and distribution of work by geographic divisions for the season of 1929

Region or work	Appropriation for 1928-29		Appropriation for 1929-30		Total
	Expenses	Salaries	Expenses	Salaries	
Southeastern Alaska	[a] $2,350	$833	$600	$4,167	$7,950
Copper River region	1,800	833	3,000	4,167	9,800
Alaska Range	4,650	1,533	3,585	7,670	17,438
Yukon-Tanana region	2,550	800	3,150	4,000	10,500
General investigations			1,000	2,400	3,400
Statistical studies				[b] 2,272	2,272
Alaska offices			1,837	[c] 2,563	4,400
	11,350	3,999	13,172	27,239	55,760

[a] Includes $2,000 transferred to Navy Department for aerial photography.
[b] Includes $1,215 for clerical services.
[c] Includes $1,000 for administrative salary and $480 for clerical salary.

LEASING WORK

Part of the activities of the Alaskan branch are related to the proper conduct of mining work on the public mineral lands that have been leased to private individuals or corporations under certain laws. Funds for this work throughout the United States are provided in a general item contained in the Interior Department appropriation act, and the amount that is allotted for the different districts, including Alaska, is determined by the relative needs of each. For the fiscal year 1928-29 the allotment for Alaska leasing work was $10,000. This was nominally somewhat less than heretofore but in reality was exactly the equivalent of the $14,500 allotted during the preceding year, because, as explained on an earlier page, certain work that was paid for out of the allotment for leasing work in 1927-28 was in 1928-29 carried in the appropriation for the work on mineral resources.

In order that the policies and practices that have been developed by the leasing unit of the conservation branch of the Geological Survey for handling the much larger volume of similar work in the States should be maintained in Alaska and at the same time the specialized knowledge of Alaskan affairs possessed by the Alaskan branch should be utilized, the general conduct of the leasing work in Alaska is in a measure shared between the two branches, the office work in Washington being done principally by the conservation branch and the field work by the Alaskan branch. The field work is done by the same engineers as the mineral resources work that is assigned to the Alaska local offices, under the immediate charge of B. D. Stewart, supervising engineer, who has headquarters at Juneau, and J. J. Corey, coal-mining engineer, at Anchorage. The use of the same personnel and facilities for both the leasing work and the work on mineral resources makes it extremely difficult and at times uncertain to distinguish accurately between the two. Except from an accountant's point of view, however, the distinction is really of little importance. The point of real importance is that by this close cooperation or consolidation of interests duplication of activities is avoided, costs are lowered, and the technical facilities are focused on the main problem, which is the development of the Territory's mineral resources. At present about three-fifths of Mr. Stewart's time, all of Mr. Corey's time, and two-thirds of the time of the clerk is considered to be devoted to the leasing work. The charges for the maintenance of the local office are shared between the leasing and mineral-resources work on ratios of about 2 to 1. In the fiscal year 1928–29 the allotment for field expenses was approximately $1,400, an amount that is inordinately low and that proved adequate only because the Alaska Railroad has extended to the limit its services in facilitating the movement of the engineers.

The primary purpose of the leasing work is to supervise the operations under the coal and oil leases or permits that have been granted by the Government and to advise and consult with the proper authorities, both Federal officers and private applicants, regarding lands that may be under consideration for lease or permit. Practically all the coal mining and much of the oil prospecting in Alaska is done on public lands by private individuals or companies under leases or permits issued by the Secretary of the Interior. The interest of the Government in these lands requires not only that these grants shall be a source of revenue to the Nation but that proper methods of extracting the minerals shall be employed, thus preventing waste or damage to the property, and that the lives, health, and welfare of those engaged in the work shall be properly safeguarded. Practically all the producing coal mines that have been opened in the Territory are in the region adjacent to the Alaska Railroad. The Government has therefore an especial interest in their successful operation. For this reason the Federal engineers have given intensive study to the problems confronting these mines and have been especially active in supervising their operations, not only to see that the terms of the leases are observed but also to be of as much assistance as possible to the small operators who are opening them, by giving them competent technical advice and aiding them in making their ventures successful. Among the points to which special attention has been given are the installation and maintenance of safe and efficient tramming and hoisting equipment, the adequate ventilation of the mines, the reduction of explosion and blasting hazards, and the providing of adequate pillars in advance of all mining operations. This service is appreciated by the operators, and the relations between them and the engineers are extremely cordial and friendly, with no hint of the antagonism that sometimes exists between inspector and inspected.

At the present time drilling for oil is being done under Government permit at only one point in Alaska, and consequently little of the time of the engineers is spent in the supervision of oil developments. There are, however, many tracts of public lands in Alaska that appear to hold promise of containing oil, and hundreds of prospecting permits for oil have been issued by the Government throughout the length and breadth of the Territory. If the staff were larger it would be good practice for the engineers to check up on these permits occasionally by field visits. Under present conditions it is necessary to rely mostly on local unofficial reports, especially as these indicate no active oil prospecting in progress. In this connection it should be pointed out that the number of engineers needed to look after the Government's mineral lands in Alaska is not comparable with the number required in certain of the States. Neither is the need to be measured by the revenues received by the Government, nor by the number of leases or permits outstanding. In Alaska the open season is so short, the distances so great, and the means of transportation so slow and infrequent that either a proportionately much larger force must be maintained or supervision in the more remote parts must be reduced merely to a gesture.

THE CHAKACHAMNA-STONY REGION

By Stephen R. Capps

INTRODUCTION

LOCATION AND AREA

The region considered in this report lies along the axis of the Alaska Range due west of the upper end of Cook Inlet and includes areas that drain eastward to Cook Inlet through the Chakachatna River and westward by way of the Stony River to the Kuskokwim River and Bering Sea. The crest of the range at Merrill Pass is 56 miles west of Cook Inlet at Trading Bay. In this region the axis of the range has a north-south trend. The geography and geology of the region in the vicinity of Mount Spurr and extending from Cook Inlet to the headwaters of the Chakachatna River have been described in a previous report.[1] The present report deals with the region lying immediately west of the Mount Spurr region and extending across the Alaska Range to and including the headwaters of the Stony River, between parallels 61° and 61° 40′ and meridians 153° and 154° 20′. This region comprises about 1,000 square miles, all of which was previously unsurveyed and had been little visited by white men.

EXPLORATION AND PREVIOUS SURVEYS

The history of exploration in this part of Alaska dates back to the middle of the eighteenth century, for by 1762 the Russian fur traders had reached Kodiak Island, and no doubt within the next few years they penetrated Cook Inlet. The first accurate information of record, however, was obtained by the British navigators Capt. James Cook, who in 1778 charted Cook Inlet as far northward as Point Possession, and Capt. George Vancouver, who in 1794 mapped Turnagain and Knik Arms. For the next 100 years little was done in the way of systematic survey or exploration in this region. During the period of the Russian occupation up to 1867 the sphere of influence of the Russian trading posts was extended,

[1] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 141–172, 1929.

and some crude knowledge of the courses of the major rivers was obtained, but no accurate mapping was done.

Modern history of this region began about 1894, when gold was first discovered at several places in the upper Cook Inlet area, mainly on the streams draining into Turnagain Arm. These discoveries brought an influx of prospectors into this part of Alaska, but the real stimulus to systematic exploration in Alaska came in 1898, when the discovery of rich gold placer deposits in the Klondike stirred the imagination of adventurers throughout the civilized world and brought about a tardy realization of the potential value of this northern territory.

Among a number of expeditions launched in 1898 and 1899 by the United States Army and the United States Geological Survey and in later years by the Geological Survey, only those will be mentioned here that contributed to the exploration of the region north and west of Cook Inlet.

The first exploration to penetrate the Alaska Range west of the Susitna River and to bring out an accurate survey of the route traversed was the expedition of the Geological Survey in charge of J. E. Spurr [2] and W. S. Post, who in 1898 ascended the Susitna, Yentna, and Skwentna Rivers in canoes, crossed the range through a high pass at the head of Portage Creek, and thence descended the Kuskokwim to Bering Sea, returning to the Pacific shore by way of Bristol Bay and across the Alaska Peninsula to Katmai village. In this remarkable journey they completely encircled the south end of the Alaska Range and obtained important geologic and geographic information about a great area that was previously unknown.

The next expedition of importance was that of Brooks,[3] in 1902, which with pack horses left Tyonek in the early spring, crossed the range at Rainy Pass, traversed the north flank of the range to the Nenana River, and proceeded thence northward to the Yukon. Among the fruits of this exploration was first knowledge of the geography and geology of a large area of the Alaska Range. Between 1902 and 1921 a number of geologic and geographic explorations were made by the Geological Survey around the west, south, and east sides of the Alaska Range, all of which added greatly to knowledge of the range, but there still remained a great area lying between Cook Inlet on the east, Lakes Clark and Iliamna on the south, the Mulchatna-Stony-Kuskokwim lowland on the west and the Skwentna on the north about which accurate geographic and geologic

[2] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 43–264, 1900.

[3] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, 234 pp., 1911.

information was entirely lacking and into which few white men had penetrated. The Geological Survey had for years had under consideration plans to carry surveys into this region, but demands for work elsewhere and lack of funds had delayed these projects.

In 1926, however, a series of expeditions, planned to explore this unknown area, was begun, and a combined geologic and topographic party in charge of S. R. Capps,[4] geologist, and K. W. Trimble, topographic engineer, ascended the Skwentna River to its head and mapped the headwaters of that basin, as well as some country tributary to the South Fork of the Kuskokwim River. In 1927 a second expedition, in charge of Mr. Capps,[5] with R. H. Sargent, topographic engineer, approached the region from the west shore of Cook Inlet, east of Mount Spurr, and explored and mapped most of the basin of the Chakachatna River, as well as a large area of the coastal region between Cook Inlet and the mountains.

PRESENT INVESTIGATIONS

The Chakachamna-Stony region adjoins to the southwest the area covered during the two preceding seasons. It includes part of the western headwaters of the Chakachatna River, most of the basin of the Necons River, and the upper, mountainous portion of the valley of the Stony River, all previously unsurveyed and largely unexplored. The lack of knowledge of this area was due mainly to its difficulty of access.

The eastern front of the mountains is separated from Cook Inlet by a belt of swampy lowland and of rolling brushy ridges, crossed by torrential glacial streams. In summer the lowland offered a serious obstacle to travel, and in winter the rugged mountains with their heavy snows and high winds presented little attraction to the prospector or trapper. Approach to this region from the southwest and west was also difficult, involving a long journey either from Bristol Bay or from the Kuskokwim River over a country devoid of trails, or up rivers that narrow canyons and rapids make difficult to navigate even by poling boat or canoe. Under the conditions that prevailed until within the last few years a prospecting or trapping expedition to the west front of the Alaska Range in this region was considered to be a 2-year undertaking, the first summer being used to transport the necessary supplies by poling boat to the head of navigable waters, from which supplies were taken by dog sled to the chosen field after the freeze-up in the fall. The winter was spent in trapping, building cabins, and opening trails, and the following summer could be devoted to prospecting. Few men have so far cared

[4] Capps, S. R., The Skwentna region: U. S. Geol. Survey Bull. 797, pp. 66–98, 1929.
[5] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 141–172, 1929.

to undertake such an expedition into this region. Mr. R. M. White had spent some time trapping on the headwaters of the Stony River, and he furnished a rough sketch map of the drainage with which he was familiar. During the last two or three years, however, the Geological Survey has surveyed considerable portions of this hitherto unexplored area, and in the winter of 1927–28 several men took advantage of the establishment of a commercial airplane service from Anchorage to fly into the headwaters of the Chakachatna and Stony Rivers to trap and prospect, and without doubt others will follow.

In the expedition of which this report is an account it was planned to utilize airplane transportation, in addition to pack train, in order to expedite the freighting of supplies and personnel to the field of operations and so lengthen the season of productive work. Arrangements were made in advance for the transportation of the three technical members of the party and about a ton of supplies and provisions by airplane from Anchorage to the head of Kenibuna Lake, in the Chakachatna Basin. This was accomplished on May 10 and 11, 1928. Meanwhile, the pack train and remaining supplies, with the two packers and the cook, were transported by launch and an open barge to Trading Bay, just east of Mount Spurr, and there put ashore to join the airplane party by way of the trail established the preceding summer. As a result of the bad condition of the trail, much snow on the ridges above timber line, rainy weather, and absence of adequate grass for horse feed due to the late spring, the pack-train party was three weeks on the way from Anchorage to the base camp, to which the other members had gone by air in a little more than an hour. Upon the arrival of the pack train at the head of Kenibuna Lake, on June 30, the expedition proceeded westward toward the crest of the range. The personnel included, in addition to the writer, who was geologist of the expedition, Gerald FitzGerald, topographic engineer; William A. Spurr, recorder; C. C. Tousley, packer; R. A. Francis, assistant packer; and Jim Brown, cook. To all these men the writer wishes to express his earnest appreciation of their faithful service during a season of trying weather conditions and difficult trail.

After leaving Kenibuna Lake the expedition proceeded westward to the head of Another River, toward Merrill Pass, a pass across the crest of the range which was discovered from the air by Russell H. Merrill, pilot of the Anchorage Air Transport Co., and which it was hoped would be feasible for pack horses. This pass is low, having an altitude of 3,180 feet, and is approached from both east and west by easy grades. The pass itself, however, is obstructed by coarse granite talus slides that extend down from the cliffs on both sides and that in three places meet along the valley axis. In their natural state these accumulations of coarse blocks offered little difficulty to the passage of a man on foot but were entirely impassable for pack horses. Several days' work by all members of the expedition were required to fill in the interstices with fine material and to grade out trail on steep slopes before the horses could be taken through. A part of the trail so constructed will be fairly permanent, but on certain unstable slopes slides are sure to occur, and more trail work will be necessary before horses can again be safely taken across the pass.

Once across the crest of the range the party proceeded westward down a tributary valley to the Necons River and down that river to Two Lakes. From the head of Two Lakes a well-traveled game trail was followed westward across a high ridge to the valley of the Stony River, and that stream was ascended to its head, where an easy pass was found leading northward into the basin of some northward-flowing stream, possibly the Hartman River. Unfortunately, the lateness of the season prevented the exploration and mapping of this northward-flowing drainage system. From the head of the Stony River the party turned back and returned to Cook Inlet at Trading Bay by the trail followed in the spring. In spite of much trail work and an unusually rainy season, an area of about 1,000 square miles was mapped topographically and geologically, and much information was gained as to the interrelations of the drainage systems that carry the waters from this mountain mass to the sea by way of the Skwentna, Chakachatna, and Kuskokwim Rivers and Lake Clark. On the accompanying geologic map the geologic units portrayed are shown in a generalized way only. The difficulties of travel, unusually rainy weather during the field season, and the desire to cover as large an area as possible in the short time available prevented the tracing out of many of the geologic boundaries and made impossible any attempt to subdivide certain groups of deposits into smaller units. In this region fossils are extremely scarce, only a single invertebrate fossil having been found during the entire summer, so that the age determinations of most of the formations mapped are rather indefinite and have been made largely by correlation with similar formations in adjoining areas.

The thin sections of rocks collected during this expedition have been studied by J. B. Mertie, jr.

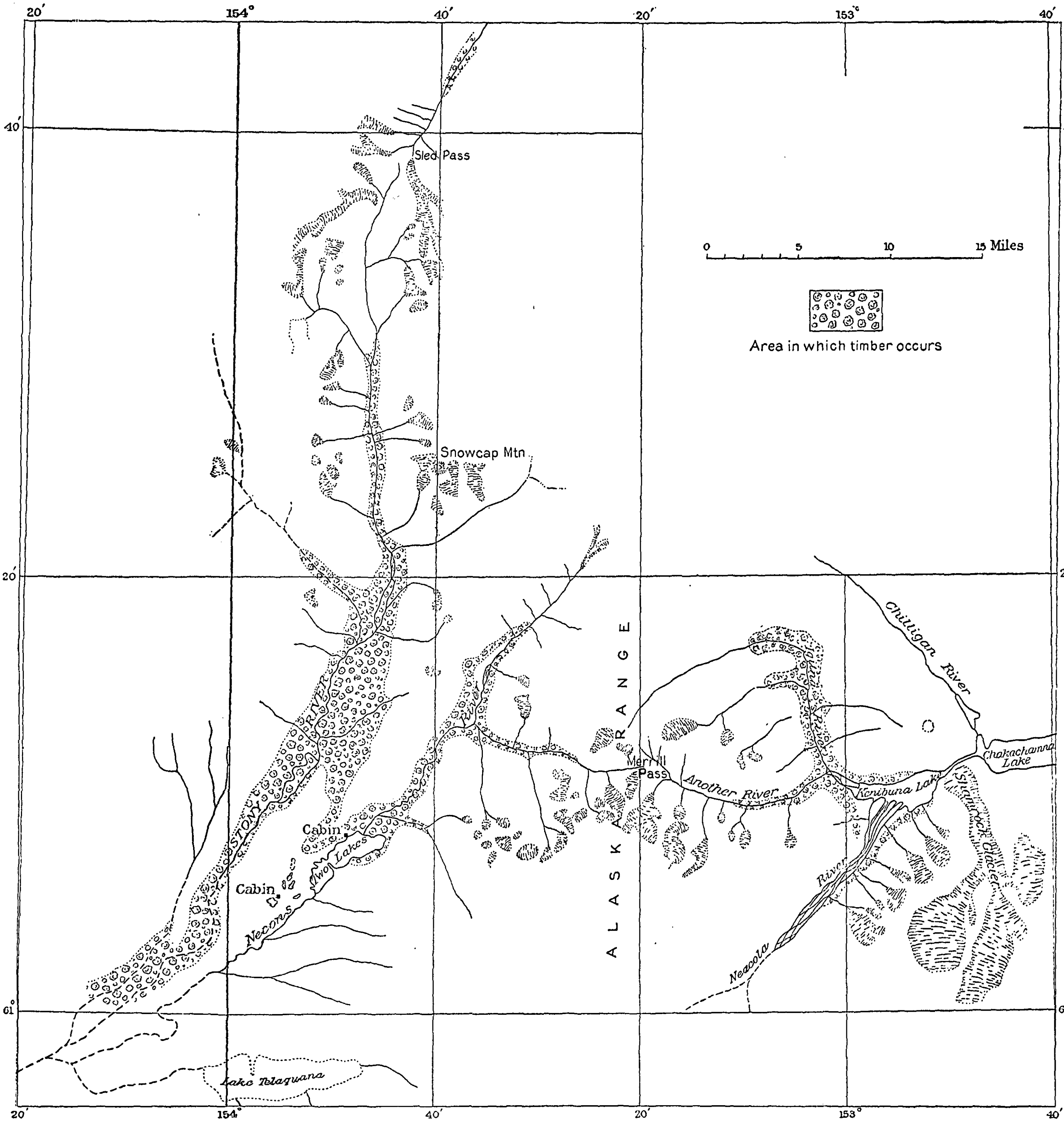
GEOGRAPHY

Drainage.—The drainage systems of the area discussed in this report include part of the extreme westward headwaters of the Chakachatna Basin and part of the headwaters of the Stony River. The greater part of the Chakachatna Basin was explored and mapped in 1927 and is described in a report on the Mount Spurr region.[6] In that report it is stated that Chakachamna Lake and its westward extension beyond Shamrock Glacier is 23 miles long, but at that time it was not known whether there is a single lake, constricted near its middle by Shamrock Glacier, or two separate lakes, separated by a short stream flowing along the margin of Shamrock Glacier. In the expedition of 1928, however, the technical members traveled by airplane up Chakachamna Lake and found that Shamrock Glacier actually separates two distinct lakes. The upper of these is called Kenibuna Lake and lies at an altitude about 100 feet higher than Chakachamna Lake, to which it drains through a turbulent river 2 miles long that flows along the north margin of Shamrock Glacier. Except in its northeastern portion Kenibuna Lake is very shallow, and it is rapidly being filled by sand from the glacial streams that join it from the southwest and northwest and by drainage from Shamrock Glacier itself. Its average area is 5 or 6 miles, but the lake is subject to a fluctuation of level of 6 feet or more, and low water exposes several square miles of sand beaches and bars that are covered in periods of high water. The Neacola River, the large glacial tributary that enters Kenibuna Lake from the southwest, was not ascended, though good views up it for 12 miles or more showed the extensive sand and gravel bars characteristic of glacial rivers.

The valley of Another River, which joins Kenibuna Lake from the west, was followed to Merrill Pass. Another River can be crossed on foot at a few places in ordinary stages of summer flow, but in many places its swift current and the coarse boulders over which it flows makes it dangerous to ford, even with horses, in ordinary stages of water, and during periods of high water it is a roaring torrent, impossible to ford. Fortunately either side of the valley can be followed by pack train, the north side offering the less difficulty, so that crossing this river is unnecessary in order to reach the pass.

The drainage on the west slope of the Alaska Range in the region here described is tributary to the Stony River. In its lower course this river flows west-northwestward to join the Kuskokwim about 50 miles above Georgetown. Its headward portion, within the high mountains, however, flows in a southerly direction, not swinging to the westward until it has emerged from the mountains onto the Kuskokwim lowland. In the area surveyed the Stony receives two large tributaries, West Fork, which enters from the northwest and only the lower portion of whose basin was mapped, and the Necons River, which for most of its length flows in a course roughly parallel with the Stony. At the face of the mountains the Necons River empties into a large double lake, known as Two Lakes, below which its course gradually converges with that of the Stony. These streams

[6] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 141–172, 1929.



SKETCH MAP OF THE CHAKACHAMNA-STONY REGION, ALASKA

Showing areas in which timber occurs

join in the lowland many miles below Two Lakes. The largest tributary of the Necons enters it from the east and receives the drainage from the main crest of the range for some distance north and south of Merrill Pass.

Another large lake, known to the natives as Telaquana Lake, lies some miles southwest of Two Lakes and drains into the Necons River. It was seen only from a distance, and neither its exact outline nor its area is accurately known.

At the head of the main Stony River there is an easy pass, entirely feasible for pack horses, that leads northward into the head of some northward-flowing stream, probably one of the headwater tributaries of either the South Fork of the Kuskokwim River or the Hartman River. Further exploration will be necessary to determine this question.

Relief.—The Chakachamna-Stony region, as the term is here used, is almost exclusively an area of rugged mountains and deep valleys, though it is bordered on the southwest by an area of much milder topography, the upland edge of the great Kuskokwim-Mulchatna lowland. Part of this lowland was seen at a distance, but the route followed by the Geological Survey party lay entirely within the mountains.

In that part of the Alaska Range here described the range is of extraordinary width from its eastern to its western front. The distance measured in a straight east-west direction from the Cook Inlet face of the range to the mountain front of Two Lakes is 50 miles, and that width is increased 20 miles northwest of Two Lakes by the western bulge of the mountain front beyond the Stony River. Throughout this wide belt the range consists of an unbroken area of rugged mountains and steep-walled valleys, and views from the air at an altitude of 7,000 to 8,000 feet give the impression of an endless sea of sharp crags and ridges. The highest mountains of the region lie along the ridge of which Mount Spurr is the southern point, and many peaks on that ridge rise to altitudes of 11,000 feet or more. Farther west the summits are lower, though no less rugged in character. From Kenibuna Lake to the west front of the range most of the higher peaks reach altitudes of 7,000 to 7,500 feet, with a few mountains attaining 8,000 to 9,000 feet. All these mountains show the effects of severe glaciation in the past, and in many valley heads active glaciers still survive. To reach the crests of most of the interstream ridges requires alpine climbing of considerable difficulty, and hundreds of peaks are almost or entirely unscalable. The granitic rocks that occupy much of the region take on extremely rugged forms under the influence of glacial erosion and yield scenery of impressive grandeur.

The main valleys throughout this region are deeply carved and lie at altitudes of 1,100 to 2,500 feet. Kenibuna Lake is 1,250 feet above sea level, Merrill Pass 3,180 feet, and the Necons River at the mouth of its main eastern tributary about 1,400 feet. Two Lakes lie at 1,270 feet, only a little higher than Kenibuna Lake. The valley of the Stony River west of Two Lakes is at 1,350 feet, and the grade of that river for the next 20 miles upstream averages only about 12 feet to the mile. In the lower portion of the part of the Stony River shown on the accompanying map that stream is only moderately swift and meanders through a rather flat-floored valley in a single channel bordered by timbered banks. Farther upstream the river is swifter, flows in many branching channels over gravel bars, and has the characteristics of heavily loaded glacial rivers. Travel along any of the larger valleys by pack train offers no unusual difficulties, though at many places some trail cutting is necessary. The presence of well-traveled moose trails greatly facilitates travel in many brushy areas, and by following them one may avoid much chopping and be assured of fairly good footing.

Climate.—No reliable records of temperature and rainfall are available for the part of the Alaska Range here under discussion. The nearest point at which accurate weather observations are taken is Anchorage, and as Anchorage has entirely different surroundings with respect to mountains and ocean and different prevailing winds, its weather is quite unlike that of the Alaska Range. Any generalizations made here are therefore based on the experience of the Geological Survey parties of 1927 and 1928 during the periods between June 1 and September 15. Both of those summers are reported to have been unusually cloudy and rainy in the Cook Inlet region in general, and they may therefore not represent the average conditions in the Chakachatna and Stony Basins. In 1927, between June 11 and September 13, there were 70 days on which there was some rain. In 1928, in the corresponding season, there were 60 days that were rainy in the part of Chakachatna and Stony Basins in which the party happened to be, and on many other days there was low-lying fog. The summer temperatures are generally mild, though some rainy days were rather chilly and some clear days were oppressively hot. Nothing definite can be said about the climate during the winter further than that it is probably much like that of the other mountain provinces that border Cook Inlet. Such evidence as could be obtained from the attitude of the brush indicates that the snowfall is moderate. High winds are likely to prevail in the mountain valleys and passes.

Vegetation.—Within the portion of the Alaska Range here described timber grows only in narrow strips along the lower valley slopes to altitudes of not more than 2,500 feet, and even at lower levels there are many areas in which no trees grow. Plate 1 shows the areas in which timber occurs in the region, although in parts of the areas so shown the trees are scattered, and there are irregular marshy tracts without trees. Practically none of the trees are large enough or clear enough to have any value as merchantable timber, but they serve well for the local uses of the trapper and prospector. Spruce is the most abundant tree, and some specimens 2 feet or more in diameter at the butt were seen. Some birch occurs on well-drained slopes. Cottonwood grows in places on the stream flats, and a few groves of quaking aspen were seen.

Within the timbered areas there is nearly everywhere some brushy undergrowth that includes alders, willows, and various shrubs, so that some trail cutting is necessary for the passage of pack animals, and in many places on the mountain slopes above timber line alders grow in such dense stands that they are almost impassable, even for a man on foot. Willows large enough for tent poles and for the camp fire are generally to be found in the valleys for considerable distances above the last timber.

Grass is fairly well distributed throughout the region, though it is necessary to have the question of forage in mind when choosing a camp site, as there are considerable areas in which grass is scanty. The commonest grass is a variety known as redtop, which locally grows in lush, luxurious stands. There is also some bunch grass and in places some vetch known as "pea vine." The leaves of certain types of willows are also eagerly sought by horses. As most of the types of forage plants are nutritious only during the growing season, the time during which pack animals can subsist properly on what they can obtain by grazing extends only from about the early part of June to the middle of September.

Game.—This portion of the Alaska Range is fairly well stocked with large game animals, though in fewer numbers and smaller variety than in some other parts. Both black and grizzly bears are common, more than 60 bears being seen by the party during the summer of 1928, and they are equally numerous in the adjoining areas surveyed during the two preceding years. As these bears have had little experience with man, they show little fear, and the black bears especially are bold and are likely to raid any provisions left unguarded. Wolverines are also common, and precautions must be observed to keep them out of caches.

In the western part of the Chakachatna Basin, in the valley of the Necons River, and in most of the Stony Basin sheep and caribou are scarce, though a little sign was observed. Moose, however, are plentiful, and well-traveled moose trails may be found along all the valleys. As the head of the Stony was approached caribou began to appear, and still farther upstream a few sheep were seen. The pass between the head of the Stony and the northward-flowing stream that drains the north side of the pass is the summer range of a considerable number of caribou, and sheep sign was more abundant there than elsewhere in this region.

The fur-bearing animals that are to be found in this area include beaver, in the Stony Basin, and some lynx, mink, fox, and wolverine. Except for beaver, upon the trapping of which there are restrictions from time to time, the region is said to offer no exceptional inducements to the trapper.

Among the small game animals rabbits were seen only in moderate numbers, though in favorable years they are no doubt abundant here, as elsewhere in Alaska. Ptarmigan, like the rabbits, vary greatly in abundance from year to year. In 1928 only a few were seen. A few spruce hens were observed in the timbered areas.

As all the larger streams receive glacial waters and are muddy in the summer, they are unfavorable for fishing. Here and there are clear-water creeks and lakes that contain trout, grayling, and pickerel, and these fish are a welcome addition to the camp larder. Salmon run up the Necons as far as Two Lakes and also up the main Stony and are caught and dried by the natives on both of these streams.

Routes of travel.—The Chakachamna-Stony region is difficultly accessible, and until the last few years it could be reached only after a long and arduous journey. The Chakachatna Basin was virtually unknown and unexplored until it was mapped by the Geological Survey during a series of expeditions, the third of which is described in this report. No trails had been opened by which to approach it overland, and the Chakachatna River is too swift for boating in the summer and probably does not freeze solidly enough to provide a sled route in the winter. As a result, the upper basin of this river had been visited by not more than two or three white men, and the Cook Inlet natives, who formerly hunted in this basin, have avoided it for the last 30 years. In 1927 the Geological Survey party cut out and graded a passable trail from the beach of Cook Inlet at Trading Bay to the foot of Chakachamna Lake, and thence by way of the Nagishlamina and Chilligan Rivers to the headwaters of the Igitna River. In 1928 the pack train came in by this same route, and the trail was extended down the Igitna to Kenibuna Lake, up Another River to Merrill Pass, down the westward-draining valleys to Two Lakes, and thence northward to the extreme head of the Stony River. The pack train returned to Cook Inlet over the same route. This trail is well blazed from Cook Inlet to Chakachamna Lake and can be followed, but its course lies through much soft ground, and in places fallen timber adds to its difficulties. Horses can still be taken over it, but anyone attempting this trail with horses should realize that it is a slow, difficult trail, with many stretches of soft ground that horses find barely passable. From the foot of Chakachamna Lake westward the trail offers no serious difficulties until it reaches Merrill Pass, where a party with horses should be prepared to do considerable pick and shovel grading in order to cross the pass. A considerable part of the grading done by the Geological Survey party was on unstable ground, and parts of the trail will surely slump off or be filled by slides from time to time. On the Kuskokwim side no unusual difficulties are to be encountered other than those incident to travel in any new country.

This region has been approached from the west by two distinct routes, one leading from the Kuskokwim River up the valley of the Stony, and the other from Lake Clark to Telaquana Lake and thence to Two Lakes. The route by way of the Stony River is said to be difficult in summer, as there are several canyons on the Stony through which boats can not be taken, and some of the portages around the canyons are reported to be several miles long. That route can be followed by dog sled in winter, but the trip is long from any base of supplies on the Kuskokwim.

It is reported that an old Indian trail leads from Lake Clark along the west face of the Alaska Range to Telaquana Lake and Two Lakes. It seems likely that this route would be feasible for pack horses, though none have yet been taken over it, and no description of this trail has been obtainable. In view of the length and probable character of the trail, there seems to be little choice between the route from Trading Bay to Two Lakes and that from Iliamna Bay to Two Lakes by way of Lake Clark.

With the establishment of a commercial aviation service at Anchorage the problem of transporting passengers and freight to points in this region has been wonderfully simplified, and a number of trappers have used this service in taking outfits into the Chakachatna and Stony Basins. In 1928 the charge for this service was about $1 per plane-mile, the capacity of the plane was a pay load of about 700 pounds, and landings were made with pontoons on some of the numerous lakes. This service was used by the Geological Survey party in taking part of the personnel and part of the supplies from Anchorage to the upper end of Kenibuna Lake, but the pack horses necessary for the prosecution of the work had to be taken in overland from Trading Bay.

GEOLOGY

GENERAL OUTLINE

The areal distribution of the rocks of the Chakachamna-Stony region is shown in Plate 2 in so far as the formations have been differentiated. Before the expedition on which this report is based the region was unexplored and unmapped. Only reconnaissance mapping was attempted on the expedition of 1928. The time available for field work was only about 60 days, during much of which the efforts of all members of the party were required in building or cutting trails. Bad weather also handicapped the prosecution of the geologic and topographic surveys. A still further obstacle to the careful mapping of the geologic boundaries arose from the fact that the topographic mapping was carried on concurrently with the geologic mapping, and the completed topographic base map was not available until several months after the field work had been finished. All these difficulties are present in some degree in any surveys carried out in a new country remote from transportation facilities, and because of these difficulties and of the reconnaissance character of the work, the geologic boundaries shown on the accompanying map are only approximate.

The geologic units shown on the map include five rock groups, of which two are intrusive igneous rocks and three are bedded and mainly of sedimentary origin. There are in addition two units that represent unconsolidated materials. All these units have been described in reports on adjoining areas, and only brief descriptions of their character, occurrence, structure, and age will be given here, with references to more complete descriptions published elsewhere.

Probably the oldest rocks in this area are a group that includes fragmental volcanic material now consolidated into tuff, lava flows, and associated clastic sediments, all considerably metamorphosed. This group has yielded no fossils in this region but is believed to be Mesozoic and probably of Lower Jurassic age. It is associated with and overlain by metamorphosed sediments that were originally sand and mud, but are now altered to argillite, slate, graywacke, and quartzite. These rocks are probably of Jurassic or Cretaceous age. A third group, younger than those already mentioned, consists largely of black argillite and slate, with minor amounts of graywacke. The rocks of this group have locally been severely metamorphosed to form black fissile schist penetrated in all directions by long andalusite crystals. From this group a single fossil was collected that indicates an Upper Cretaceous age.

A large proportion of the Alaska Range in this region is composed of granitic rocks. To the north, west, and southwest of Kenibuna Lake the granitic materials show a pronounced gneissic character, and these granitic or dioritic gneisses may be older than the surrounding unaltered granite, though definite proof of this was not obtained. The alternate view is that the granitic gneisses are of the same age as the associated unaltered granite, but that they were changed to gneisses through fairly local metamorphism. There is evidence that granitic intrusion has taken place in this part of the Alaska Range during more than one period. Nevertheless, the great bulk of the granitic rocks are believed to have been intruded in late Mesozoic time, for they cut rocks believed to be of Upper Cretaceous age and have nowhere been seen to cut rocks of known Tertiary age.

Tertiary sediments are present on the east flank of the Alaska Range in this latitude and are known to occur on the north and northwest flank north of this region. No Tertiary beds were observed in the present investigation.

Unconsolidated materials of Pleistocene and Recent age are widely distributed in this region, particularly in the valley of the Stony River. These materials include glacial morainal deposits, alluvial fans, talus accumulations, and the gravel, sand, and silt of the present streams. The entire region shows evidence of the presence of great glaciers during the last glacial period, and the topography within the mountains is typical of a heavily glaciated mountain region. Many active glaciers still exist in the higher mountain valleys and supply débris to the rivers during the summer.

The geologic sequence for this region, so far as it has been determined, is as follows:

Quaternary: Gravel, sand, and silt of present streams; lake deposits of sand and silt; talus accumulations; peat and impure organic deposits, or muck; soil and rock-disintegration products in place; deposits of existing glaciers; volcanic ash; terrace and bench gravel, in part of glaciofluvial origin; morainal deposits of Wisconsin age.

Tertiary: No Tertiary deposits have been recognized in this area, though it is likely that Eocene beds may occur on the west flank of the Alaska Range.

Mesozoic: Granitic intrusions; granite and diorite gneiss (possibly in part older than Mesozoic); black slate, shale, and graywacke, locally altered to schist, believed to be in part at least of Upper Cretaceous age; metamorphosed sediments, including slate, argillite, graywacke, and quartzite, of probable Jurassic or Cretaceous age; andesite, dacite, rhyolite, and basalt tuffs and flows, probably Lower Jurassic.

Pre-Mesozoic: Possibly the granite and diorite gneiss near Kenibuna Lake is pre-Mesozoic.

GRANITE AND DIORITE GNEISS

On the north, west, and southwest sides of Kenibuna Lake the prevailing rocks consist of granular intrusive materials that have undergone varying amounts of metamorphism. They range from fairly coarse quartz diorite, with incipient foliation, through banded gneiss, to finely foliated and fissile biotite schist. All gradational phases may be found from the little-altered material through rocks in which biotite becomes more abundant and a parallelism of the crystals begins to appear to banded gneiss in which little-foliated, sinuous bands of light-colored diorite alternate with darker, somewhat fissile bands. This rock in turn grades into highly fissile mica schist, in which biotite is very abundant, all the minerals are recrystallized, and a suite of minerals not present in the original unaltered rock appear. Within the area of gneissic rocks there are numerous later intrusive bodies, also so metamorphosed that their original composition is not readily determinable. Among these is an altered dacite or quartz latite which originally contained plagioclase, quartz, possibly orthoclase, and accessory minerals, as well as ferromagnesian minerals that are now altered to epidote. Much secondary quartz is also present.

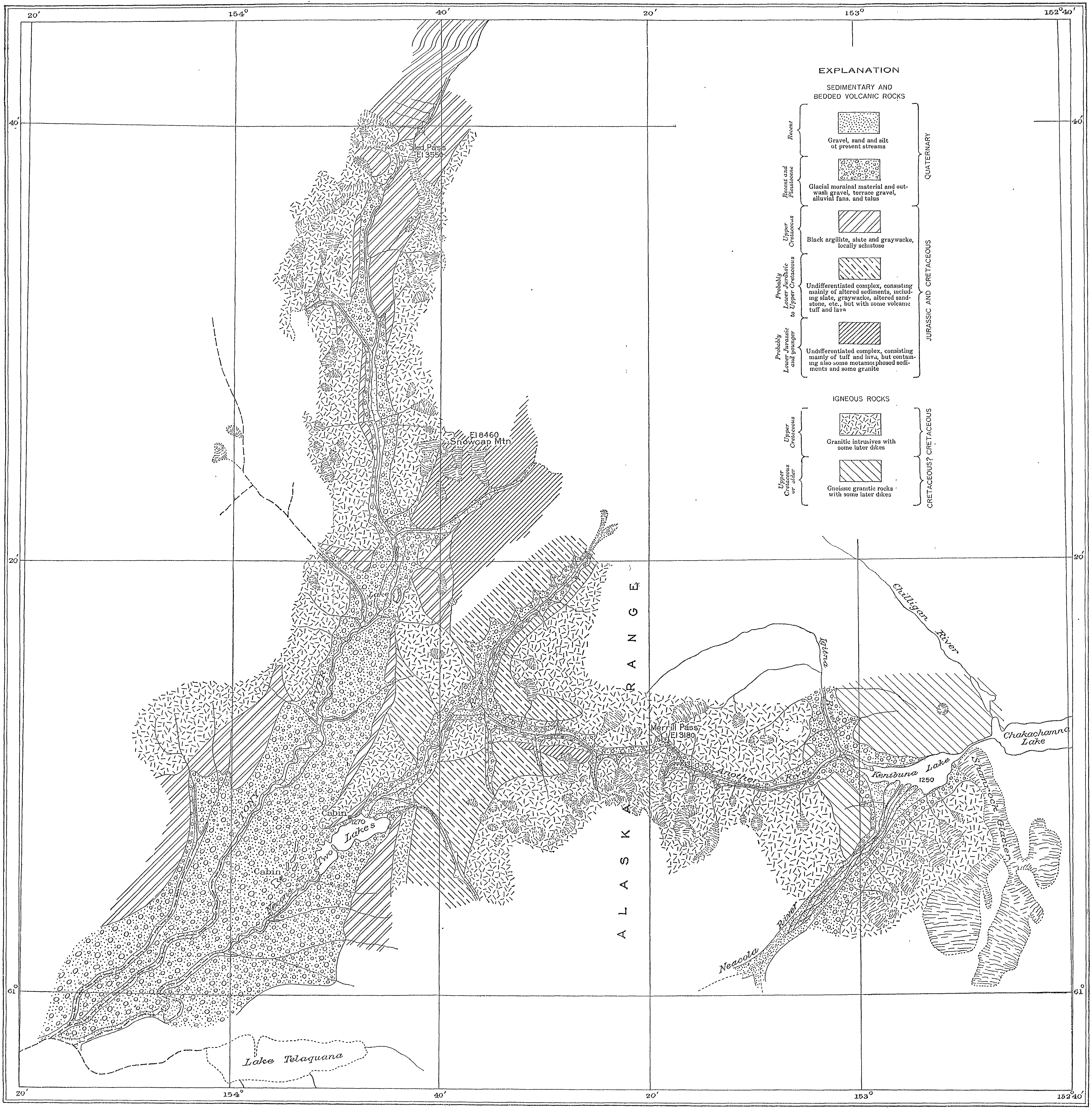
The age of these gneissic rocks is not definitely known. Time was not available to trace out the boundaries accurately, even if those boundaries are sharply defined. If the gneiss can be shown to be a distinct unit, not related to the surrounding granite, its degree of metamorphism would indicate that it is older than the unaltered granite. Fragments of granitic rocks within the tuff formation, to be described later, show that there were granitic rocks in this region before the intrusion of the prevailing granite. It is entirely possible that the gneissic rocks are much older than the sediments and tuffs in this area and than the prevailing granite, but the possibility should be kept in mind that the gneiss may be the result of local metamorphism of the prevailing granitic rocks and of the same age.

In the valley of the Nagishlamina River, about 20 miles east-northeast of Kenibuna Lake, there are schistose rocks[7] that include hornblende schist, as well as altered banded rocks that are probably metamorphosed sediments, which are considered to be older than the granite and the sedimentary and tuffaceous rocks of that region. Possibly the gneiss near Kenibuna Lake may be related to the schistose rocks of the Nagishlamina Basin, though this is only a suggestion. The age of the gneissic rocks near Kenibuna Lake is still uncertain. They may be older than Mesozoic, or they may be late Upper Cretaceous, like most of the associated granitic rocks.

MESOZOIC ROCKS

With the possible exception of the gneissic rocks in the vicinity of Kenibuna Lake, already described, all the hard rocks of the Chakachamna-Stony region are believed to be of Mesozoic age. These rocks include four units that have been differentiated on the accompanying geologic map. In ascending order they are (1) a group composed mainly of volcanic tuffs and lava flows, with some included and associated sedimentary rocks; (2) a group of undifferentiated rocks, including some of the tuff and lava of group 1 but consisting mainly of metamorphosed sediments—argillite, chert, slate, gray-

[7] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 155–156, 1929.



Scale 1/250,000

0 5 10 15 Miles

GEOLOGIC MAP OF THE CHAKACHAMNA-STONY REGION, ALASKA

Geology by S. R. Capps. Base prepared by Alaskan branch from surveys by Gerald FitzGerald

1930

wacke, and quartzite, with a little limestone; (3) a group composed mainly of black argillite and graywacke, which have locally been metamorphosed to schist; and (4) the granitic intrusive rocks that form the most conspicuous element in this part of the Alaska Range. All these rocks are cut by dikes and sills, but so far as is known these intrusive rocks, which are of considerable variety but of minor quantity, are of Mesozoic age also. None of the rock groups listed above carries fossils in sufficient abundance to serve as a reliable guide in stratigraphic work. In three successive field seasons in this general region careful search has resulted in the finding of only two determinable fossils, one a plant and the other an invertebrate. Both of these were found in the upper shale-argillite-graywacke group, and both suggest an Upper Cretaceous age for that group. The determination of the age of the underlying rocks is therefore somewhat uncertain, depending on correlation with other formations of known age some distance away.

TUFFS, LAVAS, AND ASSOCIATED SEDIMENTS

Character and distribution.—Probably the oldest bedded rocks in the area here considered are included in a group composed of andesite, dacite, and rhyolite porphyry and basalt flows, tuffs and agglomerates of the same materials, and minor amounts of metamorphosed sediments that were originally shale, sandstone, and limestone. In this region these rocks are present on the east fork of the Necons River, 5 or 6 miles west of Merrill Pass, and are abundant on the main east fork of the Stony River, where they predominate over the other rocks. Similar rocks have been observed in adjacent regions, including the valleys of the Skwentna River [8] and of the Igitna River [9] in the Chakachatna Basin. The rocks here included in this group will doubtless some time be subdivided, but at present information on which such a subdivision could be made is lacking.

The most characteristic phase of this predominantly volcanic group of rocks consists of a great variety of tuffs and agglomerates interbedded with porphyritic lava flows. The tuffs range in color from dark gray or almost black through lighter gray, pink, and various hues of green, purple, and brown. The included fragments are angular to subangular or rounded and range in size from microscopic particles to pieces 8 inches or more in diameter. They are composed for the most part of andesite, dacite, rhyolite, and basalt, but there are in some places abundant pieces of shale and argillite, and a few pebbles and fragments of granitic rock were seen. These tuffs are

[8] Capps, S. R., The Skwentna region: U. S. Geol. Survey Bull. 797, pp. 82–86, 1929.
[9] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 156–160, 1929.

interbedded with lava flows that include andesite, rhyolite, dacite, and basalt, and with some altered sedimentary materials such as argillite, graywacke, black chert, and a little limestone. Some of the lava beds are finely banded and show flow structure.

Structure and thickness.—Structurally the tuffs and lavas show various attitudes, but in general they form a group of competent rocks that are less deformed than the associated sediments. In many places they are only mildly folded, and their structure is relatively simple. Elsewhere they are closely folded and crumpled and are intricately faulted, particularly near some of the contacts with the intrusive granite, which cuts the lavas and tuffs and which has sent many dikes and apophyses into them. The areas of the tuff and lava group are separated from one another by patches of sedimentary rocks and by granitic intrusive rocks, so that precise correlation between parts of the group at different places is difficult, but the group as a whole has such characteristic lithology that a general correlation of the several patches of these rocks is open to little question.

The maximum thickness of the lava-tuff group in this region is not known. Its intricate structure, the obscurity of the bedding in places, and the lack of complete sections all add to the difficulty of determining the thickness. All that can now be said is that probably the group as a whole is at least 2,000 feet thick, and it may be much thicker.

Age and correlation.—No precise evidence of the age of this tuff-lava group has been procured in this region. No fossils have been found in it, and as the associated metamorphosed sediments are also unfossiliferous its assignment to any time period must be based on its correlation with similar rocks in neighboring regions where more positive evidence of age is available. The only older rocks that have been recognized in this part of the Alaska Range are the schists of the Nagishlamina Valley, northwest of Mount Spurr,[10] and possibly the gneisses near Kenibuna Lake, described on pages 109–110. The age of neither of these formations is definitely known, although the schist is thought to be of pre-Mesozoic age and possibly the gneisses are also. The age of the group of metamorphosed sedimentary rocks that is associated with and in part overlies the lava-tuff group is also not definitely known. The still younger group, composed of black argillite and graywacke and their schistose equivalents, is believed to be Upper Cretaceous. From direct fossil evidence, therefore, it is known only that the lava-tuff group is considerably older than Upper Cretaceous.

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[10] Capps, S. R., The Mount Spurr region: U. S. Geol. Survey Bull. 810, pp. 155–156, 1929.

By correlation on the basis of lithology and of general stratigraphic position, however, a more definite age assignment is obtained. The discussion of the age of these rocks has been fully presented in the reports on the Skwentna and Mount Spurr regions already cited and will be briefly reviewed here.

There can be little doubt that the lava-tuff group of rocks observed in the basin of the Stony River is to be correlated with similar rocks in the Chakachatna Basin, to the east, and with similar lavas and tuffs in the basin of the Skwentna River, where they also lie beneath argillite and slate that have yielded Upper Cretaceous plant remains. This whole assemblage of volcanic rocks appears to be most closely related to a similar group of rocks that occurs in the valley of the Matanuska River, to the east, where it was described as the Talkeetna formation by Martin[11] and assigned by him to the Lower Jurassic on the basis of fossils found in it. Whether or not all the lavas and tuffs of this group in this part of the Alaska Range are correlative with the Talkeetna formation, and, if so, how much of the associated sediments are also of Lower Jurassic age are not yet known, and those questions must remain unanswered until more fossil evidence is obtained from these very scantily fossiliferous rocks.

UNDIFFERENTIATED METAMORPHIC SEDIMENTS

Character and distribution.—Within the basin of the Stony River, especially in the basin of the Necons River, its largest tributary from the northeast, there is a group of undifferentiated rocks that includes some lavas and tuffs, which may, upon more detailed study, be grouped with the lava-tuff group already described, and a series of metamorphosed sediments, at least a part of which may eventually be grouped with the Upper Cretaceous argillite-graywacke-schist group. These metamorphosed sediments are best developed on the Necons River north of Two Lakes and extend up that stream as far as the mapping was carried. They include a great variety of rock types, among which are coarse graywacke, some of which contains more or less rounded fragments of shale or argillite; finely banded and ribboned siliceous graywacke; dense rusty quartzite; and some black chert. All these rocks are cut by large and small siliceous dikes and by the prevailing granitic rocks of the region. Both graywacke and dike rocks contain disseminated pyrite, which, along with the secondary silica, is the result of igneous metamorphism. Over considerable areas the oxidation of the pyrite has given these rocks a rusty color.

[11] Martin, G. C., The Mesozoic stratigraphy of Alaska: U. S. Geol. Survey Bull. 776, p. 219, 1926.

Structure and thickness.—Little can be said of the general structure or the thickness of this group of metamorphosed sediments. Their structure is known to be complex in detail, with much minor folding and faulting and locally with intimate intrusion. In the main this group is believed to overlie the lava-tuff group already described, though the presence of tuffs along with these sediments suggests that it may be the upper continuation of the tuff-lava group and so may represent the waning of volcanic deposition with a consequently greater proportion of normal sedimentary material in the section. The maximum thickness of the rocks is likewise not known, though they are doubtless several thousand feet thick in places.

Age and correlation.—If the conclusion is correct that this group of metamorphosed sediments is younger than the lava-tuff group and older than the argillite-slate-graywacke group, described below, and if the age determinations of those groups are correct, then the age of this group of rocks must be somewhere between the Lower Jurassic and the Upper Cretaceous. So far no fossils have been found in these rocks, and their age must remain uncertain within the limits above set forth until diagnostic fossils are discovered or until their correlation is made more definite than it is at present.

ARGILLITE-SLATE-GRAYWACKE GROUP

Character and distribution.—In the valley of the Necons River, in the vicinity of Two Lakes, and along that part of the valley of the Stony River that is included in this investigation there is a group of black argillite and slate and dark-gray graywacke that appear to be distinct from the metamorphosed sediments and tuffs described above, and they are indicated by a separate pattern on Plate 2. They are characterized by their prevailing black color, in contrast to the rusty and brownish shades of the other sedimentary group, and their comparative freedom from igneous intrusive rocks.

In the vicinity of Two Lakes these rocks comprise black slabby argillite and gray siliceous graywacke. The proportion of argillite to graywacke varies from place to place. In one section a hundred feet or so of argillite, with little coarser material, gives place gradually to an intimately banded alternation of argillite with graywacke in layers an inch or less thick, and this in turn, by the increase in thickness of the graywacke bands and a decrease in thickness of the argillite bands, to a massive graywacke, with beds several feet thick separated by only thin partings of argillite. Locally the argillite shows slaty cleavage, and the graywacke is silicified and becomes an impure quartzite.

This same group of rocks appears to occupy a considerable area in the mountains bordering the valley of the Stony River west and southwest of Two Lakes, although that area was seen only from a distance. On the Stony River above Two Lakes the argillite-graywacke group crops out first on one side of the valley and then on the other but occupies only a narrow north-south belt, bordered by granitic intrusive rocks and by the older sedimentary and volcanic rocks. Apparently these sedimentary rocks have formed a line of weakness through an area of more resistant rocks and have determined the course of the Stony River.

As the main forks of the Stony River are approached from the south, the argillite-graywacke rocks show increasingly the effects of igneous metamorphism from the intrusion of the granitic rocks. Secondary mica and silica become more abundant, and a schistose cleavage appears. Still farther north these sediments become very schistose, the coarser phases becoming impure quartzite schist and the argillite being altered into a black fissile carbonaceous schist characterized by a remarkable development of needle-like andalusite crystals that lie parallel to the planes of schistosity but point in all directions within those planes. Secondary pyrite appears as scattered cubes throughout both coarse and fine phases of these rocks. Still farther north, near the pass at the head of the Stony River, these rocks again become less schistose, and normal argillite and graywacke prevail.

Structure and thickness.—The structure of the argillite-graywacke group of rocks appears to depend, in considerable degree, upon the size of the areas in which they occur. South and east of Two Lakes, where this group occupies an area of many square miles, the beds have a fairly uniform monoclinal dip of 15°–20° NE. Similarly, on the west side of the Stony River, west and southwest of Two Lakes, the bedding as seen from a distance seems to be only mildly deformed. By contrast, in those belts along the Stony Valley where the argillite-graywacke rocks occur in narrow areas bordered by granitic intrusives, the beds have steep dips, in many places approaching the vertical. Near the head of the Stony River, where these rocks again occur in large areas, their structure is simpler and the dips are less steep.

No accurate measurements of the thickness of the argillite-graywacke group have been made, for nowhere has the complete section been studied. All the areas of this group that were seen are bordered on at least one side by granitic intrusive rocks, and as these are the youngest hard rocks of the region, the uppermost beds have suffered erosion wherever they are exposed. On the mountains east of Two Lakes at least 3,000 feet of beds of this group are exposed, and a similar thickness is present east of the extreme head of the Stony River. The group is therefore at least 3,000 feet thick and may be considerably thicker.

Age and correlation.—The argillite-graywacke group is believed to be in part, at least, of Upper Cretaceous age. A single shell collected from these rocks in 1928 was identified by T. W. Stanton as an *Inoceramus*, which he believed to be Cretaceous and probably Upper Cretaceous. A single fossil leaf collected in 1926 on the upper Skwentna River, from what is believed to be the same group of rocks, was identified by Arthur Hollick as a dicotyledonous angiosperm of Cretaceous or Tertiary age. Inasmuch as the only rocks in this part of Alaska that are definitely known to be Tertiary are the coal-bearing sediments correlated with the Kenai formation, of Eocene age, and as these Eocene rocks are undoubtedly younger than the argillite-graywacke group here under discussion, the evidence seems definite that the argillite-graywacke group is in part, at least, Upper Cretaceous. The fossils noted above, however, were found at neither the top nor the bottom of this thick group of rocks. In the writer's opinion it is likely that all these rocks above the horizons at which the fossils were found are of Upper Cretaceous age, but there is no assurance that some portions of this group below the fossil horizons are not older. For the present, however, it seems best to classify this entire group in the Upper Cretaceous.

TERTIARY ROCKS

No Tertiary rocks have been found in the Chakachamna-Stony region, though Tertiary rocks are extensively developed in the lowlands east of the Alaska Range, from Cook Inlet to Broad Pass, as well as on the north and northwest flank of the range from the Delta River at least as far westward as Muldrow Glacier. These Tertiary rocks form a characteristic and easily recognizable series of shale, sandstone, and conglomerate, usually containing some lignitic coal. Their chief economic value lies in the coal, which in many places occurs in thick beds and which, though generally of too low grade to warrant commercial development at the present time, nevertheless constitutes an important fuel reserve. No detailed description of these rocks will be given here, but attention is called to the possibility that the coal-bearing formation may be present on the west slope of the Alaska Range in the lowlands or in the foothills flanking the main mountains.

INTRUSIVE ROCKS

A brief description of the gneissic rocks in the vicinity of Kenibuna Lake is given on pages 109–110. It is uncertain whether they are older than the Mesozoic tuffs, lavas, and sedimentary rocks or whether they represent only a local, metamorphic phase of the prevailing granitic rocks.

The most conspicuous single group of rocks in this region comprises the granitic intrusives, which occupy a large area, as shown on Plate 2, and to which is largely due the rugged character of this part of the Alaska Range. Throughout the width of the range in this latitude, from its eastern face near Mount Spurr to the edge of the Kuskokwim lowlands on the west, this great mountain mass is composed predominantly of granitic intrusive rocks. Furthermore, granitic rocks are known to constitute a large part of the range from Iliamna Lake northward to and beyond Mount McKinley.

The granitic rocks have commonly a gray color, though some are pink. Microscopic examination shows that these rocks are mainly to be classified as granite, though diorite is also present. They range in texture from fine-grained sugary rocks to coarse granite with orthoclase phenocrysts 2 inches or more long. As is usual where granite occurs in large areas, there is a wide range in color, from almost pure white through various hues of pink and gray to nearly black, the color depending upon the proportions of the different minerals present and upon the segregation of certain minerals within the granitic mass. All these rocks, however, have the granitic habit, and although a careful microscopic study would result in their classification into a large number of rock types, until such a systematic study is made they may well be included under the general term granitic rocks.

Dikes and sills in considerable variety cut the granitic rocks, and also the tuffs and sediments of the region. They include rhyolite and diorite porphyry and more basic types such as augitite, pyroxenite, diabase, basalt, and basalt porphyry. Although post-granite dikes, obviously younger than the rocks into which they are intruded, are common, their bulk as compared with the rocks into which they are injected is small, and they are not shown on the geologic map.

From information obtained in this part of the Alaska Range during the last three years the age of the main bulk of the granitic intrusives has been determined within fairly narrow limits. In 1926, in the valley of the upper Skwentna River, a fossil leaf was collected from shale cut by granite that is directly connected with and a part of the great intrusive mass here under discussion. That leaf was determined to be of Upper Cretaceous or Tertiary age. On the Stony River a single fossil shell from the argillite-graywacke group was identified as of Cretaceous age, probably Upper Cretaceous. The argillite and graywacke are also cut by the granitic intrusives, which must be younger than the sediments and therefore at least as young as Upper Cretaceous. On the other hand, there are in many places along the flanks of the Alaska Range beds of Eocene age, lying close to the granite but, so far as is known, nowhere cut by the granite. It seems fairly certain, therefore, that the intrusion of the main bulk of the granite of this portion of the Alaska Range occurred after these Upper Cretaceous sediments were laid down but before the beginning of Tertiary sedimentation in this region. These granitic rocks must therefore be of late Upper Cretaceous or early Tertiary age.

This age assignment refers to the great bulk of the granitic rocks that are so extensively developed between the Chakachatna and Stony Basins and Mount McKinley. It is recognized, however, that there are older granite pebbles in the tuff of probable Lower Jurassic age, and that there were earlier intrusions of granite in this part of Alaska, though the areas in which these older granites occur are not known. Possibly they are represented by the gneissic granite near Kenibuna Lake.

QUATERNARY DEPOSITS AND HISTORY

PREGLACIAL CONDITIONS

The Quaternary period of geologic time includes all the geologic events that have taken place during the great ice age (the Pleistocene epoch) and the time since the ice age (the Recent epoch). In the high mountains of Alaska the distinction between Pleistocene and Recent events is difficult to make, for here the final withdrawal of the great glaciers, which in many parts of the world marked the end of the Pleistocene and the beginning of Recent time, has been delayed, and great glaciers, the direct descendants of the Pleistocene glaciers, still exist. Pleistocene conditions have therefore merged gradually into present conditions, and glacial deposits are even now being laid down.

In a reconnaissance survey, such as that upon which this report is based, a large part of the effort and time of the party is consumed in travel to and from the field of work and in overcoming the difficulties of travel in a trailless country. As the purpose of the expedition was to survey as large an area as possible in a short working season, many details of geologic and physiographic interest had to be passed over hastily, to await more careful study in the future. Nevertheless, enough is known of the Pleistocene and Recent history of the region to justify a general statement outlining the more important events of this time.

At the end of Tertiary time the Alaska Range had the same position and general shape that it has to-day, and its summit peaks were probably even higher than they are now. Great valleys had been carved in it in about the same positions as the present valleys. In the details of topography and in the general appearance of the region, however, this part of the Alaska Range was very different then from what we see now. The mountain valleys, developed by running water, without the aid of valley glaciers, were more nearly V-shaped in cross section; their gradients were very different, and many of the tributary streams followed courses quite different from those we now find. Such lakes as Chakachamna, Kenibuna, Telaquana, and Two Lakes did not then exist, and the extensive mantle of morainal material and glacial outwash now present along the Stony and Necons Valleys and extending westward into the Kuskokwim lowlands had not yet been laid down.

GLACIAL EPOCH

Pleistocene time in Alaska, as in many other parts of the world, was characterized by a remarkable development of glaciers and is often spoken of as the great ice age. It is possible that the higher mountains of the Alaska Range harbored valley glaciers in preglacial times, as they do now, but these glaciers were small compared with the tremendous ice fields that overwhelmed this part of Alaska in Pleistocene time. At the beginning of the glacial epoch a change of climate took place by which the mean annual temperature was lowered, the winters became longer and more severe, and the summers became shorter, so that such small valley glaciers as may have been present in the higher mountains grew and lengthened, and in other valleys previously unglaciated snow banks remained unmelted through the summer, thickened year by year, and eventually became glaciers that lengthened and moved down the valleys. With continuing growth the glaciers from the many tributary valleys joined in the trunk valleys to form large ice streams with many branching heads, and these in turn pushed farther and farther down their basins. In the Cook Inlet-Susitna region so vast a mass of glacial ice advanced from the surrounding mountains that the entire Susitna Basin was buried beneath several thousand feet of moving ice, and this great glacier pushed down Cook Inlet at least as far as the forelands and possibly much farther. On the west and north front of the Alaska Range the precipitation was probably much lighter than on the Cook Inlet-Susitna slope, and the glaciers, although reaching a thickness of thousands of feet within the mountains, spread out into great spatulate lobes at the mountain flank, and most of them did not push out to any great distance into the Kuskokwim lowland.

In the north-central part of the United States, where the glacial deposits have been studied in great detail, it has been shown that during the glacial period there were several distinct stages during which the glaciers grew and expanded, and these stages were separated by interglacial stages during which the ice edge retreated far to the north and the glaciers may have disappeared altogether. In Alaska the sequence of glacial advances and retreats is not so well worked out, for the last great glaciers obliterated much of the evidence of their predecessors. Nevertheless, at a number of places in Alaska definite proof has been found that there were great ice advances long before the last great forward thrust of the glaciers, and it is probable that here also there were several stages of vigorous ice advance, separated by periods of deglaciation, and quite likely these glacial stages corresponded in time with those elsewhere on the continent.

In the Chakachamna-Stony region the erosive power of the thick streams of moving ice during the glacial epoch is well shown by the shapes of the valleys as we now see them. These valleys are straight or follow sweeping curves; their floors are relatively broad, and the walls rise steeply to the bordering peaks; and the mountain spurs between tributary streams have been cut away so that one's view is unobstructed for miles up or down these valleys. The smoothed and truncated valley walls show plainly that the glaciers scoured the sides of their walls to a height of as much as 3,000 feet above the bottom, and a view of the region at the height of the glacial epoch would have revealed only lines of ragged peaks and ridges projecting above a sea of ice. At that time the glacier surface was continuous through many low divides from one drainage basin to another, and whenever the snowfall in one basin was unusually heavy for a period of years, ice from that basin crowded across the borders of the basin through any low passes that existed and by its grinding action on those passes lowered them still more. In this way such low, broad passes as Merrill Pass and the pass at the head of the Stony River were formed.

GLACIAL DEPOSITS AND BENCH GRAVEL

While the glaciers were growing and during their period of greatest expansion they picked up and carried with them all the soil and loose materials over which they moved and used these rock fragments as tools with which to grind down their beds still further. Thus a vast amount of detritus was carried out of the mountains to the lowlands and there deposited as moraines or supplied to the rushing streams to be sorted by them and laid down as stream deposits or carried to the sea. As the ice retreated, however, it left behind extensive deposits of morainal materials, and the streams, reworking the ice-brought materials, built up wide and thick gravel beds. These deposits of moraine and of outwash gravel, the latter now generally intrenched by the streams to form benches or terraces, are shown on the geologic map (pl. 2) wherever they are sufficiently thick to conceal the underlying rock formations over considerable areas. They generally form narrow strips along the lower slopes of the valley walls, but they cover large areas in places where the valleys widen out near the flanks of the range.

At the time of the maximum glaciation the ancient glacier that flowed down the Stony Valley extended some 50 miles beyond the mountain front into the lowland.[12] The topography of the lowlands, as seen from the ridge between Two Lakes and the Stony River, indicates that this glacier spread out in a spatulate, piedmont lobe. Extensive terraces, cut from glacial outwash gravel, are widely developed in the Stony Basin below the main forks and east and south of Two Lakes. Two Lakes and the many small lakes near by lie in depressions in morainal material, and the low ridge that constricts Two Lakes is a moraine ridge. Probably Telaquana Lake also is dammed behind a glacial moraine. Kenibuna Lake owes its origin to the damming of its valley by Shamrock Glacier, a vigorous ice stream that pushes northward across the great east-west valley drained by the Chakachatna River. A farther advance of that glacier would deepen and enlarge Kenibuna Lake, by raising the barrier around which its outlet must pass. Chakachamna Lake, into which Kenibuna Lake drains, just east of the terminus of Shamrock Glacier, is similarly impounded by Barrier Glacier.

PRESENT STREAM DEPOSITS

The deposits of the present streams, as shown on Plate 2, include only those materials on the stream flats that are even now submerged at periods of unusually high water. In general these deposits lie in narrow strips, extending only a short distance back from the streams on either side. In the upper courses of some of the larger glacier-fed rivers, however, the heavily loaded streams have developed wide gravel flats over which the streams flow in many branching channels. The gravel in each of these valleys is coarsest near the glaciers in which the river heads and becomes progressively finer downstream; as the coarse gravel is dropped the gravel flats narrow and the stream flows in a single channel between well-defined banks. Thus the Stony River below the mouth of its main west fork flows in a single well-defined channel, whereas above that point it is a braided stream. Likewise the Necons River has extensive bare gravel bars above Two Lakes but is confined to a single channel below them. The Neacola River flows in many channels over a wide stream flat as far as Kenibuna Lake, into which it empties. The

[12] Smith, P. S., The Lake Clark-central Kuskokwim region, Alaska: U. S. Geol. Survey Bull. 655, pp. 85–96, 1917.

lower valley of that stream is a wide sandy plain, built in part as a river plain and in part as a delta into Kenibuna Lake. Considerable areas of this sand plain are overflowed by Kenibuna Lake during periods of high water but are exposed when the lake is low.

MINERAL RESOURCES

No mineral resources, either metallic or nonmetallic, have been developed in the Chakachamna-Stony region, and almost no prospecting has been done there, so that little is known of its possibilities. No coal deposits were seen during this investigation, and none have been reported from the area considered.

In an area as remote from transportation as this the only mineral deposits that would offer a likelihood of profit to the prospector are those of the precious metals, and gold placers have the greatest appeal, for by the use of simple equipment that can be made on the ground the placer miner can exploit his discoveries, accurately gage their value, and carry the product of his mining out with him. Therefore the first inquiry that the prospector makes concerning a new country is as to the possibility that it may contain placer gold. That part of the Chakachatna and Stony Basins here described does not hold out much promise as a field for placer-gold prospecting. Such panning as was done by members of the Geological Survey party yielded no gold at all on Another River and in the basin of the Necons River, and none on the Stony except at a point about 10 miles below the head of that stream, where a few fine colors were obtained. The severe scouring to which this country was subjected by the glaciers during the ice age resulted in the removal of all rock waste and stream gravel, and the ice no doubt ground away much of the bedrock also, so that any concentrations of placer gold that may have existed in preglacial time are likely to have been removed and scattered. The geologic conditions, however, are not unfavorable for the existence of gold-bearing veins, for the extensive granitic masses have mineralized the bordering sediments. Pyrite is abundantly present as scattered specks in the argillite and graywacke in many places, and numerous rusty patches on the mountain slopes result from the oxidation of the pyrite. It is quite possible that veins bearing gold, silver, copper, lead, and zinc may be found in this region, for these minerals are commonly present in veins associated with granitic rocks.

In this general region placer gold in encouraging amounts has been found at several places where the rock formations are similar to those here described. Some years ago there was a small stampede to a part of the Stony Basin some distance southwest of Two Lakes, but the results of prospecting there were disappointing, and no considerable amount of gold was recovered. In the basin of the Styx River, a tributary of the South Fork of the Kuskokwim River, at a point only 25 miles northeast of the pass at the head of the Stony River, coarse gold was found about 15 years ago, and a small amount was recovered, but no ground rich enough to justify mining under the existing conditions was located. In view of these occurrences of placer gold in this general region, it seems possible that some of the smaller and less heavily glaciated valleys on the west flank of the Alaska Range, both north and south of the Stony River, and in the adjacent foothills might offer promise of containing workable gold placers, and prospecting in such favorably situated places would be justified.

MINING IN THE FORTYMILE DISTRICT

By J. B. Mertie, Jr.

INTRODUCTION

The Fortymile district is the oldest mining district in interior Alaska. Gold was discovered in 1886 on the bars of the Fortymile River by Howard Franklin and shortly thereafter on numerous streams tributary to the Fortymile. Franklin Creek, named after Howard Franklin, was struck in the fall of 1886, and the Fortymile district has produced steadily from that date to the present time.

This district had not been visited by members of the Geological Survey for a number of year until 1928, when a field party in charge of the writer passed through it on the way to the country that lies to the south. The primary object of this expedition was to visit and map the area lying between the Fortymile mining district and the Tanana River, and the results of this work will be published in a separate report. At the end of the field season the writer visited the mining plants in the Fortymile district, and this paper, resulting from these examinations, is intended mainly to sketch the present progress of mining development in the district.

Mining in the Fortymile district centers about six more or less separated areas—namely, Dome Creek, Steel Creek, Wade Creek, Franklin Creek, Chicken Creek, and the headwaters of Walker Fork of the Fortymile River. Post offices are maintained at Steel Creek, Jack Wade, Franklin, and Chicken, and the mail is carried three times a month. The Walker Fork area lies near the international boundary, east of the main mail route, and receives its mail by private carrier from Steel Creek.

The Fortymile district is approached from Eagle, to the north; from Fortymile, to the northeast; or from Dawson, to the east. The Eagle route is the main line of approach, Eagle being the distributing point for summer and winter mail and one of the sources of supplies for the district. In winter, however, much freight is brought up the Fortymile River from Fortymile, Yukon Territory; and Dawson is depended upon for medical supplies and services and is also a partial source of supplies for the Walker Fork area. An airplane landing field has been built at Chicken, and in emergencies passengers are carried thence to Fairbanks or elsewhere in the Territory. One of the handicaps to communication in the district is the complete absence of telegraphic facilities, the nearest wireless stations being at Eagle and Dawson.

Supplies for the Fortymile district are carried by pack horses in summer and by horse sleds in winter from Eagle to Chicken, a distance of 90 miles. The summer freighting rates from Eagle to Steel Creek, Jack Wade, and Chicken are, respectively, 15, 20, and 25 cents a pound. The corresponding winter rates are 5, 6, and 7 cents. From Fortymile, Yukon Territory, winter freight is delivered at Jack Wade and Chicken, respectively, at 4½ and 5 cents a pound. The commercial winter freight rate from Fortymile to the Walker Fork area is 3½ cents a pound, but the Walker Fork Gold Corporation hopes to cut this rate in half by the use of caterpillar tractors. An interesting possibility for Chicken Creek and vicinity is the use of airplanes for commercial freighting from Fairbanks. The air-line distance is about 200 miles, and even at present commercial rates for airplane freight it should be possible to deliver supplies at Chicken at a rate as low as the present summer rate for land freight, if not lower. The use of airplanes for mail delivery in the Fortymile district, by providing regular business, should stabilize and materially cheapen air freight rates.

GEOGRAPHY AND GEOLOGY

The geography and geology of the Fortymile quadrangle, which includes the Fortymile mining district, has been described by Prindle [1] in earlier publications; and as no additional geologic work was done in this area in 1928 only a very brief statement regarding the geography and geology seems warranted.

The Fortymile mining district may be said to constitute the southern half of the Fortymile quadrangle and is drained entirely by the Fortymile River and its tributaries. (See fig. 4.) The Fortymile River has two main forks, the North Fork and the South Fork. O'Brien Creek, of which Dome Creek is a tributary, drains to the main Fortymile River. There are no mining operations on the North Fork of the Fortymile. The South Fork, as will be seen from Figure 5, is made up of three branches, which named in order upstream are Walker Fork, Dennison Fork, and Mosquito Fork. Wade Creek, one of the producing creeks, heads against Steel Creek and drains southwestward into Walker Fork. Other mining operations are being carried on at the head of Walker Fork. Franklin Gulch drains eastward into the South Fork, and Chicken Creek flows southward into Mosquito Fork. No mining operations are now in progress on Dennison Fork.

[1] Prindle, L. M., The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska: U. S. Geol. Survey Bull. 251, 1905; The Fortymile quadrangle, Alaska: U. S. Geol. Survey Bull. 375, 1909.

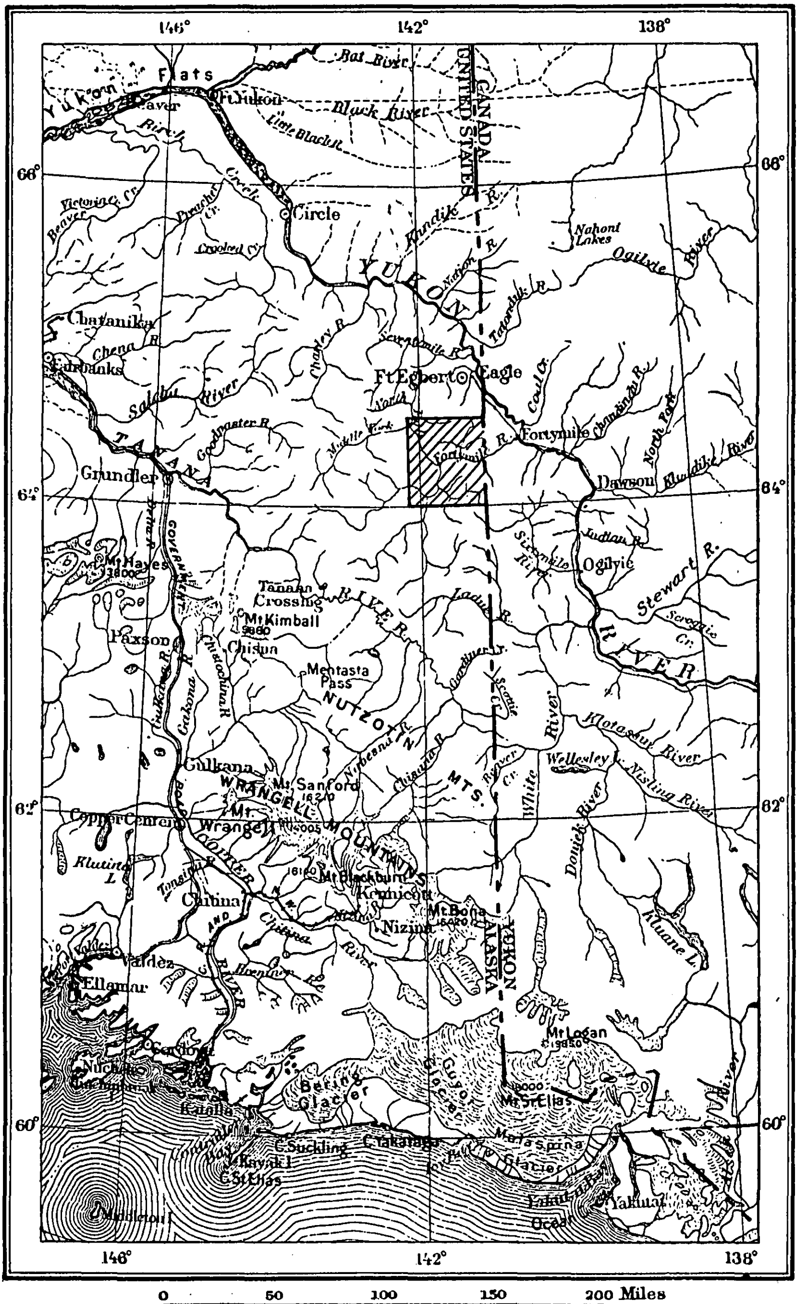

FIGURE 4.—Index map showing location of Fortymile mining district

The main Fortymile River in this area flows at an altitude of about 1,000 feet above sea level, and the ridge tops rise to 3,000 feet or more, making an average regional relief of a little more than 2,000 feet. At numerous places isolated prominences, known locally as domes, rise

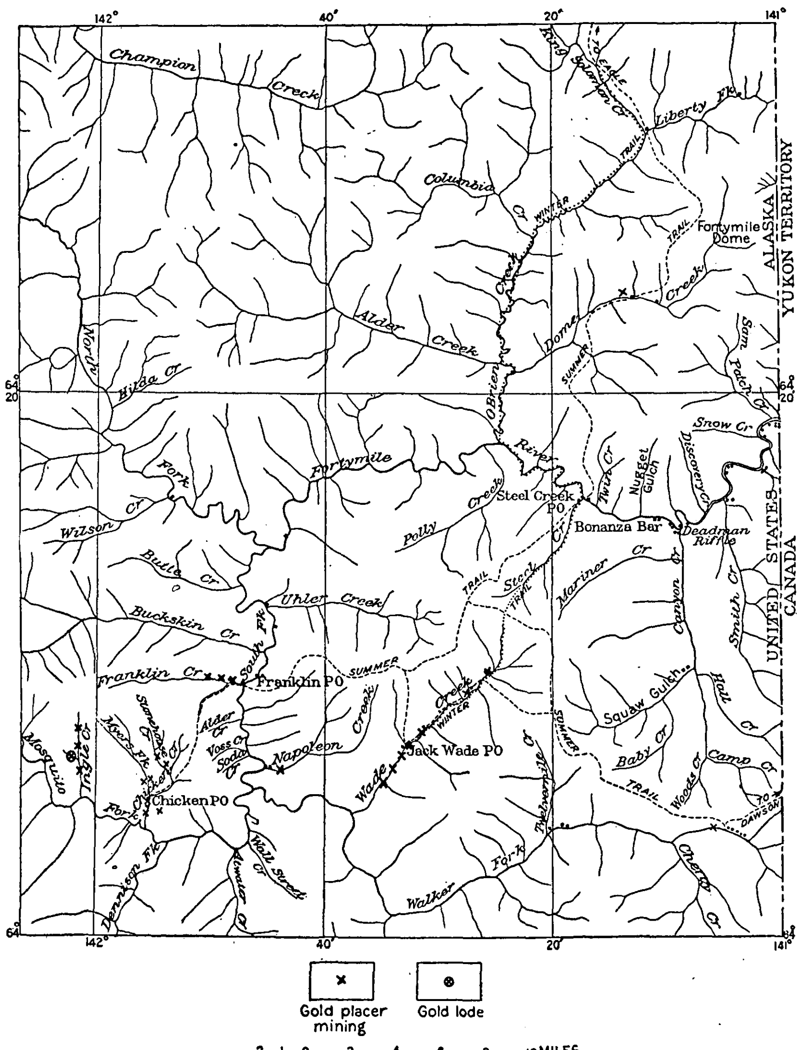

FIGURE 5.—Sketch map of Fortymile mining district showing location of gold placer mining operations

several hundred to a thousand feet above the average ridge level. The upland areas constitute in reality a maturely dissected land surface, of late Tertiary origin. By a lowering of the regional base-level, probably in late Pleistocene time, the Fortymile River was rejuvenated, and since that time it has incised itself into a deep, narrow valley, characterized by a well-developed system of benches, which occur at various levels from a few feet to 600 feet above the main valley. Some of these benches, particularly the lower ones, have yielded commercial gold placers.

Most of the bedrock in the Fortymile mining district is comprised in a group of metamorphosed sedimentary rocks, of pre-Cambrian age, known as the Birch Creek schist. These metamorphic rocks consist mainly of quartzite schist, quartz-mica schist, and mica schist. Associated with these are metamorphosed igneous rocks, of which the most abundant is a granitic gneiss, known as the Pelly gneiss, which may also be a part of the pre-Cambrian sequence. Other associated metamorphosed igneous rocks include amphibolite, hornblende schist, and greenstones of various types.

Infolded with the pre-Cambrian rocks are smaller areas of metamorphosed Paleozoic rocks, which are probably in large part of Silurian age. One area of such rocks forms the bedrock of the upper part of the South Fork of the Fortymile. These rocks consist of green and black phyllites, siliceous slate, chert, and quartzite, and associated igneous rocks, mainly greenstone and serpentine.

Economically the most important rocks of the area are granite and quartz diorite, which intrude the metamorphic rocks at a number of localities. Twenty such areas of granitic rocks have been mapped by Prindle,[2] of which the largest one occurs in the lower parts of Mosquito and Dennison Forks of the Fortymile and in the vicinity of Chicken Creek. These rocks are believed to have been the source of the gold in this region.

The youngest hard-rock formation in the area is composed of soft sandstone, conglomerate, and shale of Upper Cretaceous or Tertiary age, which crop out on Chicken and Napoleon Creeks. These rocks are of importance mainly because they carry beds of coal, which serves locally for blacksmithing and similar work.

The present streams and the bordering benches are characterized by fluviatile deposits of gravel and sand. The older bench gravel is sharply delimited, but the latest bench gravel merges imperceptibly into the gravel of the present streams. All these deposits of gravel and sand are derived from the erosion of the neighboring country rock and are not particularly different from similar deposits elsewhere. Many of these fluviatile gravel deposits in the Fortymile district, however, have proved to be auriferous, and such deposits constitute the Fortymile gold placers, which have been mined for more than 40 years.

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[2] Prindle, L. M., The Fortymile quadrangle, Alaska: U. S. Geol. Survey Bull. 375, pl. 5, 1909.

GOLD PLACERS

DOME CREEK

Placer-mining operations are being conducted on Dome Creek by the Alaska Consolidated Gold Corporation. A small tributary of Dome Creek, which enters from the north about 6 miles in an air line from the mouth of the creek, is known as Little Miller Creek. Mining of the creek gravel of this stream was begun in 1893. Afterwards pay gravel was struck on the north bench of Dome Creek, from Little Miller Creek downstream; and the present operations are a continuation of the mining of this bench gravel. One cut has been taken from the bench gravel on the east side of Little Miller Creek, at its mouth. Another cut from the gravel on the west bench of Little Miller Creek yielded $27,000 at an average value of 35 cents to the square foot of bedrock.

The present mining operations are being carried on about 1½ miles downstream from the mouth of Little Miller Creek, on the north bench of Dome Creek. A large open cut was begun at this locality in 1922 and is still being extended downstream. The gravel at the site of present operations ranges in thickness from a few feet at the south rim of the bench to 80 feet at the north end of the cut; it was 65 feet thick where the nozzle was in operation in June, 1928. As a rule there is little or no overburden, but at one place where a gulch has been cut down through the old gravel deposits a considerable deposit of muck was noted, which is said to contain remains of mammoth, bison, and other ancient vertebrates. It is evident that the gravel and muck deposits on this bench are of Pleistocene age. The bedrock consists of several varieties of schist and some thin seams of coarsely crystalline limestone. The schist is cut by numerous small seams of quartz, which carry pyrite and arsenopyrite.

Mining is being done by hydraulic methods. A ditch 8 miles long supplies water at a head of 150 feet at the workings, from a 2-foot intake reduced to 11 inches at the nozzle, which is of a 4-inch type. The capacity of the ditch is 1,000 miner's inches, but at the time of the writer's visit only a quarter of that amount was available. The bedrock in the cut is 140 feet above the present creek level, thus affording ample room for tailings, although a sluiceway usually has to be opened through the overburden to the bedrock level of the hill slope below the workings. The present ditch is being extended 6,000 feet downstream, 2,000 feet of which requires fluming, in order to work the bench gravel farther down the valley. The gravel at present being mined is said to average about 35 cents to the square foot of bedrock.

The placer gold is rather porous, especially in the larger pieces, and contains considerable quartz. It is of high grade, however, averaging $18.50 to $18.75 an ounce after melting.

FORTYMILE RIVER

The Fortymile River throughout much of its course in this district flows on bedrock, owing to the fact that the river has been rejuvenated and is still in process of adjustment to a lower base-level. The old meanders of the stream are now intrenched, and hence the river follows a meandering course through a steep-walled valley. As a result of lateral erosion the bedrock has been planated at places, especially at the bends of the river, and upon such surfaces a thin veneer of gravel has been deposited by the river. The bedrock along most of the river is schist, which has been mineralized to a greater or less extent. Alluvial deposits from tributary gold-bearing streams are being moved downward into the main river. Hence, many of the gravel bars along the Fortymile are in fact gold placers and have been worked intermittently since the district was discovered. All such mining has been done by shoveling the gravel into sluice boxes or other washing devices and by hand cleaning of the bedrock. Water is obtained by short ditches from near-by creeks or even from the river itself. Some of these bar operations yielded large profits in the early days, but the richer deposits were long ago worked out. Nevertheless, a number of men still work the bars of the Fortymile River every season, and during the season of 1928 six or seven men were reported to be engaged in such work.

WALKER FORK

Placer mining is being done in Walker Fork by the Walker Fork Gold Corporation. The camp is near the southeastern part of the Fortymile quadrangle, about 2 miles west of the international boundary, and is reached from Steel Creek by a good ridge trail 25 miles in length. Another trail from Walker Fork leads 12 miles eastward to Glacier Creek, on the Canadian side, from which a wagon road leads into Dawson.

Walker Fork, about 1½ miles above the camp, divides into three smaller streams, which constitute its headwaters. The north fork is called Davis Creek, the middle fork Poker Creek, and the south fork is Walker Fork. Cherry Creek, another tributary from the south, enters Walker Fork about 4 miles below the junction of the three forks above noted. Walker Fork flows about west and from the forks to Cherry Creek has a grade of about 100 feet to the mile and an altitude above sea level of about 2,200 feet. This part of the valley of Walker Fork is open, with a wide alluvial bottom, and gentle spurs lead to the ridges on both sides. Farther downstream the valley becomes constricted.

At the site of present mining operations the stream gravel is about 10 feet thick near the valley slopes, but only 5 to 6 feet thick in the center of the valley, with only about 1 to 2 feet of muck overburden. The general run of the stream gravel is small, but some boulders as large as 4 feet in diameter are uncovered, particularly where quartz ledges cut the bedrock. Most of the gravel consists of quartzite schist. The gold occurs both in the gravel and in bedrock, and even though 2 feet of bedrock is removed not all the gold is recovered. The bedrock consists of several varieties of blocky quartzite schist, the cleavage of which strikes about northeast and dips about 20° NW., or downstream, so that the gold sinks deeply into the cleavage cracks. The bedrock is cut by many thin seams and stringers of quartz, and at places thick veins of quartz have been uncovered.

Three cuts in the gold-bearing gravel were excavated and cleaned up in 1928. The lower cut was 300 feet long and 247 feet wide. Upstream the pay streak widened to 600 feet, so that two parallel cuts were taken, one on the south side 300 feet long and 160 feet wide, and one on the north side 300 by 300 feet. The extreme limit of pay gravel was not exploited in the south cut, owing to increasing depth of the overburden. The ground runs from 18 to 36 cents to the square foot of bedrock.

Placer mining is here accomplished by a combination of hydraulic and steam-shovel methods. Elevated sluice boxes are placed at one side of the cut, and a Bucyrus steam shovel with a 50-foot boom lifts the gravel and bedrock into the sluice boxes. The hydraulic nozzle is used to move the gravel from the far edge of the cut inward to a point where it can be reached and handled by the steam shovel. The steam shovel has a bucket with a maximum capacity of 1¼ cubic yards and can move 1 cubic yard of gravel a minute into the sluice boxes. Nine sluice boxes are used, of which the first four have cross riffles overlain by grizzlies and the last five have Hungarian riffles. Most of the gold is recovered in the first four boxes.

Water for the hydraulic operations and sluicing is obtained from two ditches on the north side of the valley. The upper ditch is 2 miles long and supplies water at a head of 175 feet to the nozzle used for hydraulic operations. A lower ditch, 1 mile long, is used for sluice water and incidentally picks up the seepage from the upper ditch. For hydraulic purposes the water is taken from the ditch in a 28-inch pipe, which is reduced to 12 inches at the giant. Wood is used as fuel for the steam shovel. The company owns 14 miles of claims on Walker Fork and employs 20 men in these placer-mining operations.

The gold ranges in size from small flat pieces down to very fine gold, though pieces as large as an ounce have been found. It is said to be worth $18.50 an ounce before and $18.67 an ounce after melting. The concentrates recovered with the gold consist mainly of magnetite, limonite, ilmenite, psilomelane, pyrite, and garnet.

WADE CREEK

Wade Creek heads against Steel Creek Dome and flows due southwest for 11 miles to join Walker Fork. The valley is exceptionally straight and at its lower end lies 1,400 feet above sea level and from 1,500 to 1,800 feet below the ridge tops on each side. According to Prindle,[3] the stream gradient in the lower 8 miles of the creek is about 75 feet to the mile. The valley is asymmetric, the walls being considerably steeper on the southeast than on the northwest side. The valley floor is rather narrow from one end of the creek to the other, and near Jack Wade post office it is only a few hundred feet wide.

Wade Creek was struck in 1895 and has therefore been mined for over 30 years. Two Discovery claims are said by Prindle to be recognized in the creek, but present reckoning is done from a Discovery claim on the lower part of the creek. All the claims from No. 15 below to No. 23 above Discovery are held, and many of them are operated in winter by drifting, the gravel dumps being sluiced in the spring. At the time of the writer's visit, in late August, summer mining was in progress on only two claims. No well-defined low bedrock bench is present in this valley, for the bedrock appears for the most part to slope gradually upward from the creek to higher ground. At claim 5 above Discovery and on downstream, however, higher benches appear, but these have not so far proved to be good placer ground.

Much of the best pay gravel has been taken from a pay streak called bench gravel, which follows down the valley first on one side of the creek and then on the other. The best ground on the creek was found on claims 6, 7, and 8 above Discovery, but the most gold from any one claim was recovered on No. 6 above. At claim 7 above Discovery this "bench" or rim pay streak was 100 to 120 feet wide and 12 feet deep. Such ground yielded from $1 to $1.50 to the square foot of bedrock. The valley floor itself, which is from 200 to 300 feet wide, has not been worked, except farther upstream, where open-cut methods are employed, because it is too wet for drifting. The creek ground at claims 7 or 8 above Discovery is only 8 to 10 feet deep and may run 25 cents or more to the square foot of bedrock for a considerable distance both upstream and downstream. Such ground, including also the "bench" ground, is suitable for hydraulic operations, but scarcity of water will always be a handicap to such development. In time, however, all this ground should be worked by dredging or by scraper plants. The spotted character of the pay streak also makes it desirable to work large blocks of ground.

The bedrock on Wade Creek includes several varieties of schist and also, according to Prindle, some thin-bedded ferruginous lime-

[3] Prindle, L. M., The Fortymile quadrangle, Alaska: U. S. Geol. Survey Bull. 375, pp. 39–42, 1905.

stone, all part of the Birch Creek schist. Quartzite, mica schist, and hornblende schist are the most common of the schistose rocks. The general strike of the cleavage is about northeast, thus paralleling the course of the creek; and the dip of the cleavage is variable in degree, but mainly southeastward. Several small bodies of granitic rocks have been mapped by Prindle within the basin of Wade Creek, and cobbles of these rocks are found on the gravel. Quartz veins, in part pyritiferous, derived from such granitic rocks are common in the schistose rocks.

The principal summer mining on Wade Creek is done at a hydraulic plant on claim No. 14 above Discovery, which is operated by Charles Martin. The gravel here is between 10 and 12 feet thick, with little or no overlying muck, although in places farther downstream 4 or 5 feet of muck overlies the gravel. The gravel is mined in cuts 96 feet long and 175 feet wide, and three such cuts were made during the summer of 1928. The bedrock is a blocky quartzite, in the cracks and joints of which the gold works downward to a depth of 2 or 3 feet, making it necessary to take up this much bedrock in places and to clean the bedrock by hand. This is a slow and laborious process. The strike of bedrock cleavage in these cuts is about N. 15° E. and the dip 5° E. The rock is also jointed and thus breaks into rhomboidal slabs several inches to a foot thick. The gravel ranges from small cobbles to boulders 2 feet in diameter, but no boulders large enough to require blasting are present. As mined, this ground yields about 20 cents to the square foot of bedrock.

Three nozzles are used, a 3-inch one for moving the overburden, a 3½-inch one for piping in, and another 3½-inch one for stacking tailings. The sluice boxes are set on bedrock in the middle of the cut, and when the material is being piped from one side of the cut wooden shear boards are placed on the opposite side of the sluice boxes so that the gravel will fall into the boxes. This necessitates moving the shear boards when piping is done from the other side of the cut. Water is taken from Wade Creek about a mile upstream, just below the mouth of a small tributary from the north called Gilliland Creek, and is delivered to the cut at a head of 80 feet. As work progresses upstream, this head will be reduced, and a new ditch will need to be built. The water is taken from the ditch in a 30-inch pipe, which is reduced to 10 inches at the nozzles.

The gold is fairly coarse, and some of it contains much quartz. The value is irregular, ranging commercially from $15.90 to $18 an ounce and passing on the average at $16.50. Three assays of this gold, representing material produced in 1926 and 1927, are given herewith:

Assays of gold from Wade Creek

Fineness after melting		Total value per ounce
Gold	Silver	
0.8185	0.177, at 62 cents an ounce	$17.02
.82975	.164, at 65 cents an ounce	17.25
.8075	.189, at 55 cents an ounce	16.79

The concentrates taken with the gold are nearly half barite and comprise also magnetite, ilmenite, hematite, and garnet, with smaller amounts of cinnabar, pyrite, and cassiterite. The cassiterite is found both in crystalline form and as wood tin.

This plant has been in operation eight years. The early work was done with a scraper plant, but this was not successful. The present methods are the most economical possible. Three men are required to operate the plant, which works both day and night shifts.

On claim 23 above Discovery, at the confluence of Gilliland Creek with Wade Creek, two men were engaged in groundsluicing preparatory to the operation in 1929 of a small hydraulic plant. Two automatic dams, one on Wade Creek and one on Gilliland Creek, were being used for this work. The bedrock is a quartzite schist, cut by numerous quartz stringers, some of which carry gold. About 3 to 4 feet of gravel is present, overlain by 4 to 8 feet of muck. Coarse gold has been found here in a pay streak estimated to be 80 feet wide.

FRANKLIN CREEK

Franklin Creek is the oldest producing creek in the Fortymile district, having now produced gold for 43 years. This creek is about 6 miles in length, flows almost due east, and enters the South Fork of the Fortymile River about 10 miles in an air line above the main forks. The upper valley is fairly open, but the lower valley, where placer mining has been carried on, is very narrow, with steep walls. The stream gradient in the lower 2½ miles of the creek is 170 feet to the mile. The rejuvenation of the Fortymile River is here admirably reflected in a tributary stream, which evidently is still in process of adjustment to the new and lower regional base-level.

The bedrock is made up of a number of varieties of schistose rocks of the Birch Creek schist, including mainly mica and quartz-mica schist, in part garnetiferous, hornblende schist, and some crystalline limestone. The head of the creek and some of its south tributaries also cut a body of granitic rocks, and locally the schist is cut by dikes of such material. The creek gravel consists of several varieties of schist, basalt, granite, quartz, and other types of rock and ranges in thickness from 8 to 10 feet. The gold occurs in the lower part of the gravel and the upper 2 feet of bedrock.

Franklin Creek, in the early days of its mining history, yielded good pay, some of the gravel, according to Prindle, going as high as $5 to the cubic yard. The best ground, however, has now been mined out over a width of 50 feet or more, and present operations are confined to the leaner and deeper gravel along the edges of the old pay streak. As in Wade Creek, two Discovery claims were made, but present reckoning is done from upper Discovery. Three men are still at work on Franklin Creek, one on claim 2 below, one on claims 4 and 5 below, and one on claims 6 and 7 below upper Discovery. These operations are of the shoveling-in type.

The concentrates taken with the gold on Franklin Creek are 50 per cent magnetite and include many garnets, considerable ilmenite, some limonite, and small amounts of barite and cinnabar. One piece of galena and pyrite was also observed in the concentrates. The cinnabar is not found throughout the concentrates but occurs in scattered pieces a quarter of an inch in diameter or larger. It is probably original vein material and is believed to indicate a stage of mineralization later than the main mineralization which accompanied the intrusion of the larger granitic masses in this region.

CHICKEN CREEK AND TRIBUTARIES

Chicken Creek is about 4½ miles long, runs somewhat west of south, and enters Mosquito Fork of the Fortymile River about a mile above the confluence of Mosquito and Dennison Forks. It has two good-sized tributaries from the northwest, Stonehouse Creek and Myers Fork, which make the upper valley exceptionally wide and open. The lower part of the valley is rather flat and merges gradually into the wider valley floor of Mosquito Fork. Discovery claim is just below the mouth of Stonehouse Creek. It is on this lower valley floor that the airplane landing field is built. The town of Chicken is about a mile above the mouth of Chicken Creek.

The pay streak on Chicken Creek was discovered in 1901, and mining has continued since that time, but little mining is in progress at the present time, and the writer is dependent in considerable measure on the descriptions given by Prindle some 20 years ago when active mining was in progress. A number of different kinds of bedrock are found in the basin of Chicken Creek. These include Paleozoic schists of several varieties, basalt, and little-indurated rocks of Upper Cretaceous or Tertiary age. The stream gravel is therefore of very diverse character. The schistose rocks it contains include hornblende schist, in part tuffaceous, phyllite, quartzite, mica schist, and crystalline limestone; the granitic rocks are represented by quartz diorite, granite, and vein quartz; and the Upper Cretaceous or Tertiary rocks have contributed sandstone, shale, conglomerate, and ironstone. Most of the gravel is fairly well rounded and ranges in size from small pebbles to good-sized cobbles, but a few large boulders are present. In the main valley the ground is in places as deep as 40 to 50 feet, but little of this ground has been mined because it is too wet for drifting, and insufficient water is available for hydraulicking. The low gradient of the creek would make it necessary to stack tailings, thus further increasing the amount of water that would be required for hydraulic operations.

Most of the mining has been done on the west bench of Chicken Creek from 500 to 1,000 feet from the creek, where the ground is frozen or where it is shallow enough to be worked by open cuts. The best pay gravel on Chicken Creek was found in claim 9 below Discovery, although the richest spots occurred on claim 7 below. The creek has been worked from claim 1 above to claim 11 below Discovery, as single creek claims, but at the lower end the pay streak was so much wider that claims were staked in pairs. Much of the bedrock on this west side of the creek, particularly at the upper end of the pay streak, is little if any higher than in the center of the valley. A company has recently taken options on the producing ground of Chicken Creek, and a dredge may be installed in the near future.

Drift mining was done in the winter of 1927–28 on claim 5½ below Discovery, and prospecting was in progress at the same place during the summer of 1928. The ground was mined from a shaft 34 feet deep about 175 feet from the main creek. The gravel is 12 feet thick, overlain by 22 feet of muck. The bedrock is shale, with coal beds, of Upper Cretaceous or Tertiary age. The trend of the pay streak was given as about N. 10° E. Open-cut mining was also in progress on claim 10 below Discovery. The bedrock here is also sandstone and shale, and the gravel is from 14 to 16 feet thick at the head of the cut. With a good supply of water about 24 box lengths per season can be shoveled in at this property. The gold occurs mainly on or near bedrock, and the pay occurs in narrow streaks quartering downstream and is rather spotted.

Two hydraulic plants were in operation on Myers Fork. Years ago the creek gravel of Myers Fork was worked for 1,000 feet or more upstream from the mouth, but the present operations are on benches. On the northeast side of Myers Fork the bench gravel is being mined by a combination of hydraulicking and groundsluicing. The gravel here is 4 feet thick and is overlain by about 11 feet of muck. The bedrock is partly sandstone and shale and partly basalt. The ground is mined in cuts 20 feet wide and 100 feet long, and four such cuts were expected to be made during the summer of 1928. The ground probably averages about 30 cents to the square foot of bedrock. Water is obtained from a ditch 2 miles long, with an intake on Chicken Creek above the mouth of Stonehouse Creek, and is supplied to a 2-inch giant at a head of 70 feet. The gold is not very coarse, although one piece worth $25 has been found on this property. It assays $16.40 a crude ounce and passes commercially at $16 an ounce. The concentrates taken with the gold are largely magnetite and ilmenite but include also garnet, barite, and zircon.

On the opposite or southwest side of Myers Fork, on a still higher bench, about 100 feet above the creek level, another hydraulic plant was operated in 1928 but was not in operation at the time of the writer's visit. The gravel is here about 8 to 10 feet thick, with little or no overburden, and the bedrock is the same as across the creek.

Two men were also doing open-cut placer mining on Stonehouse Creek. One was engaged in shoveling in creek gravel. Farther upstream another man was mining bench gravel on the east side of the valley, about 400 feet above the creek level. The gravel here is 3 feet thick, and the bedrock is a blocky rock resembling phyllite but possibly of tuffaceous origin, cut by stringers of quartz and calcite. Two cuts of 6 box lengths each, or about 1,728 square feet of bedrock in all, were expected to be cleaned and shoveled in at this property during the season of 1928. The ground was said to yield about $60 to the box length, or about 40 cents to the square foot of bedrock. The concentrates taken with the gold are mainly magnetite, oxidized on the surface, ilmenite, and pyrite but include also some specular hematite and numerous small grains of cinnabar.

LOST CHICKEN CREEK

On the east side of Chicken Creek almost opposite the town of Chicken is a bench about 275 feet above the creek. A small creek, known as Lost Chicken Creek, heads just east of this bench and flows southeast to the South Fork of the Fortymile River, so that this east bench of Chicken Creek is in reality also a west bench of Lost Chicken Creek. Gold placers were discovered on the west bench in 1901 and have been mined intermittently since that time. Some of this ground carried as much as $1 to the square foot of bedrock.

During the summer of 1928 three men operated a hydraulic plant on this west bench of Lost Chicken Creek, almost 75 feet above the creek level and 500 feet distant from the creek. This old bench channel had previously been worked for 1,000 feet or more, and the present operations consist of cuts 150 feet wide at the lower end of these old workings. The gravel at this place consists of 3 to 5 feet of subangular to rounded wash, mixed with hillside rubble and sand. The largest cobbles are about 8 inches in diameter. The bedrock is quartz diorite, cut at one place by a dike of basalt, and the bedrock surface is very irregular and therefore difficult to clean. Two cuts aggregating 5,000 square feet had been mined at the time of the writer's visit, in late July, and the work was still in progress. Water for hydraulicking is obtained from Chicken Creek through a ditch 3 miles long and is delivered under a head of 50 feet to a 1½-inch nozzle. The gold is in small flattened pieces but is not flaky. The largest piece recovered was worth $3. The concentrates consist mainly of magnetite, ilmenite, garnet, and zircon.

INGLE CREEK

Ingle Creek is a small stream, about 4 miles long, which lies west of Chicken Creek and flows into Mosquito Fork about 4 miles above the confluence of Mosquito and Dennison Forks. The valley of Ingle Creek is very narrow, and the walls are steep. A number of claims are held on Ingle Creek, but only two plants were in operation in late July. On claim 5 above Discovery shoveling-in operations were in progress. At this place the present creek gravel constitutes the pay streak, which is from 40 to 50 feet wide. About 2 feet of overburden is present, and the gravel consists of angular to subangular cobbles of granitic rocks, with considerable green schist and quartzite. Some large boulders, as much as 30 inches in diameter, occur in the gravel. The bedrock is green schist and quartzite cut by numerous veinlets of quartz, and about 12 inches of it has to be removed to recover the gold, which lies mainly on bedrock. The gold is rather coarse, the largest piece so far found being worth $60. Numerous pieces worth as much as $5 have been found. The gold assays $17.40 an ounce and passes commercially at $17 an ounce.

Water for sluicing is taken from three small dams upstream. The gravel is shoveled into elevated sluice boxes, and three or more box lengths are cleaned up at a time. It was estimated that 10 box lengths would be shoveled in at this property during the summer of 1928. The ground is believed to average about $75 to the box length.

Farther down on Ingle Creek, on claim 2 above Discovery, much the same type of mining is in progress. Here about 3 feet of gravel is present, and the bedrock is the same as farther upstream. Ten box lengths is also the estimated capacity at this plant for the season.

PRODUCTION

The following table gives the production of the Fortymile district for 1928 and previous years. Annual data are not available for the earlier years of this camp. The total production of placer gold and silver for the Fortymile district is to date about $6,809,000.

Gold and silver produced in Fortymile district, 1886–1928

	Gold		Silver	
	Fine ounces	Value	Fine ounces	Value
1886–1903 (estimated)	193,500.00	$4,000,000	30,553	$22,915
1904	14,851.12	307,000	2,345	1,360
1905	12,384.00	256,000	1,955	1,193
1906	9,868.50	204,000	1,558	1,059
1907	6,772.50	140,000	1,069	706
1908	6,772.50	140,000	1,069	567
1909	10,884.37	225,000	1,719	894
1910	9,675.00	200,000	1,528	825
1911	9,675.00	200,000	1,528	810
1912	10,303.87	213,000	1,627	1,000
1913	4,837.50	100,000	764	461
1914	2,418.75	50,000	382	211
1915	2,418.75	50,000	382	194
1916	2,418.75	50,000	382	251
1917	3,870.00	80,000	624	513
1918	3,628.12	75,000	573	573
1919	1,983.37	41,000	313	350
1920	1,935.00	40,000	348	380
1921	2,418.75	50,000	448	448
1922	2,418.75	50,000	423	423
1923	2,588.32	53,500	466	382
1924	1,538.46	31,800	265	177
1925	1,924.19	39,800	303	210
1926	2,902.50	60,000	454	284
1927	1,790.00	37,000	479	272
1928	3,827.00	79,100	609	356

GOLD LODES

The gold placers of the Fortymile district and contiguous territory have been derived from lode deposits, and the wide distribution of these placers indicates the general nature of the gold mineralization. The character of the concentrates recovered with the placer gold, together with the results of more or less lode prospecting, shows that ores of other metals, such as silver, lead, zinc, copper, antimony, mercury, and tin, are also present in this district. Most of these metallic elements, as well as the gold, are considered to be related genetically to the granitic intrusions and are believed to have been introduced, together with vein quartz, at the time when such rocks were intruded or shortly thereafter. The details of the mineralization and the practical application of this theory to prospecting have been given in a previous publication.[4]

The remoteness of the Fortymile district renders it impossible at the present time to undertake lode mining of any base ores which may be present. Gold lodes might possibly be mined at a profit, but the cost of supplies and equipment and the difficulty and cost of transportation into this district would require deposits of bonanza type for exploitation. As no very rich quartz lodes have so far been discovered, no quartz mining has been undertaken, although considerable prospecting has been done.

[4] Mertie, J. B., jr., The occurrence of metalliferous deposits in the Yukon and Kuskokwim regions, Alaska: U. S. Geol. Survey Bull. 739, pp. 149–165, 1923.

One gold quartz lode of considerable interest has been prospected on Lilliwig Creek, a small tributary of Ingle Creek from the west. The country rock has here been intruded by a small body of quartz diorite, and it is of interest in this connection to note that downstream from this intrusive body Lilliwig Creek has been mined for placer gold, whereas above the intrusive rock no commercial placers have been found. The relation between granitic intrusion and mineralization is thus more than ordinarily apparent. The lode consists of greatly sericitized quartz diorite, in which are numerous veinlets of quartz and calcite, together with gold-bearing sulphides. Pyrite is the principal sulphide mineral, but some chalcopyrite is also present. A shaft 55 feet deep was sunk at this place and, according to the owners, showed an ore body 42 feet wide at the surface of bedrock and 52 feet wide 14 feet deeper, at the bottom of the shaft. The lode material consists of many parallel stringers of vein quartz and calcite trending east and cut by another system of discontinuous stringers running north. The easterly stringers dip at a high angle northward. A sample of sulphides from the dump was taken by the writer and assayed by E. T. Erickson in the chemical laboratory of the United States Geological Survey. This assay shows 1.87 ounces of gold and 2.05 ounces of silver to the ton and 0.76 per cent of copper and therefore indicates a value of nearly $40 a ton. A sample of the whole ore body, however, would show a much lower value. Undoubtedly other gold quartz lodes as good or perhaps even better are present in this district, and some of these may possibly be worked at a profit in the future when operating costs shall have been materially lowered.

COAL

The Upper Cretaceous or Tertiary formations that occur on Chicken Creek and elsewhere in this district contain beds of lignitic coal, which have been utilized locally for blacksmithing and similar work. One such bed of coal has been worked at Chicken. About a quarter of a mile west of Chicken a 35-foot shaft has been sunk to such a coal bed, and a tunnel has been driven 60 feet south from the bottom of the shaft. A room 14 feet high, 10 feet wide, and 60 feet long has been excavated and discloses 22 feet of coal which stands vertical and strikes N. 65° E. Neither the top nor the bottom of the coal bed is exposed. Two samples of this coal were taken for analysis, one an average of the bed and the other from a narrow seam of bright-looking coal, apparently of higher grade than the average. Proximate analyses of these samples were made by H. M. Cooper, of the Bureau of Mines, with the following results:

Analyses of coal from Chicken Creek

Picked sample

[Air-drying loss, 2.6]

	Air dried	As received	Moisture free	Moisture and ash free
Moisture	10.3	12.6		
Volatile matter	36.4	35.4	40.6	42.6
Fixed carbon	49.0	47.8	54.6	57.4
Ash	4.3	4.2	4.8	
	100.0	100.0	100.0	100.0
Sulphur	0.5	0.5	0.6	0.6
Calorific value:				
Calories	5,906	5,750	6,583	6,911
British thermal units	10,630	10,350	11,850	12,440

Average of coal bed

[Air-drying loss, 8.9]

	Air dried	As received	Moisture free	Moisture and ash free
Moisture	15.1	23.1		
Volatile matter	33.8	30.8	40.0	46.2
Fixed carbon	39.3	35.7	46.5	53.8
Ash	11.4	10.4	13.5	
	100.0	100.0	100.0	100.0
Sulphur	0.5	0.4	0.6	0.7
Calorific value:				
Calories	5,083	4,628	6,017	6,950
British thermal units	9,150	8,330	10,830	12,510

NOTES ON THE GEOLOGY OF UPPER NIZINA RIVER

By Fred H. Moffit

INTRODUCTION

The part of the Nizina River drainage basin that lies adjacent to Nizina Glacier, including Skolai Creek, the West Fork of the Nizina River, the Chitistone River, and McCarthy Creek, has long been regarded by geologists who have worked in the Wrangell Mountain and White River districts as probably containing the key to a number of geologic problems that bear on the origin and occurrence of the copper deposits of Chitina Valley. These problems relate especially to the stratigraphy and structure of the copper-bearing formations and to the causes that resulted in the deposition of copper ores where they are now found. The district is small, is extremely rugged, and is occupied in considerable part by glaciers whose streams are difficult to cross in warm weather and are at times impassable. Obstacles to geologic mapping are therefore greater than a casual glance at a map might seem to indicate, although the difficulty of reaching the district has been greatly reduced by the successful construction of a bridge over the Nizina River.

The trails leading from McCarthy to Skolai Pass and the head of the White River traverse the valleys of the Nizina River and Skolai Creek. Consequently the district outlined has been visited a number of times by geologists, who gave it some attention in the course of travel between the Nizina and White River districts but were unable to study it carefully through lack of time or unfavorable seasonal conditions.

An opportunity to give the geology of the upper Nizina Valley some additional study arose in the summer of 1927. A party consisting of Andrew M. Taylor and the writer was organized at McCarthy about the middle of June and spent the following two and one-half months in mapping the geology of the district outlined above in as much detail as the time and weather permitted. The party was equipped with five horses and the necessary camp gear. Supplies for the summer were obtained at McCarthy, where the horses also were hired, and the first camp of the season was made on upper McCarthy Creek on, June 20. The writer feels that much of the success of the work was due to Mr. Taylor's intimate knowledge of the country and to his skill in everything connected with traveling through it and living in it. In addition to other activities Mr. Taylor assisted in making most of the fossil collections.

Geologic mapping was not done in detail, yet more time was given to the work than is possible in the usual reconnaissances that the Geological Survey makes in Alaska. Unfortunately a part of the area studied has not been mapped topographically, and a still larger part is represented only by a map which was made in the early days of exploration and which, although it has served its purpose well, is not sufficiently accurate to represent many geologic features. It was therefore necessary to use a small plane table and open-sight alidade for sketching the drainage system and locating rock outcrops and formation boundaries on upper McCarthy Creek, the Chitistone River, and the West Fork of the Nizina River.

It is not intended to give here a full account of the geology of the district but rather to present certain new features that were observed during the season, with enough of the general geology, which is already well known and fully described in other publications, to make them understandable. A comprehensive account of the geology of the Chitina Valley and other parts of the Copper River Basin is in preparation and will be published later.

PREVIOUS WORK

Previous work in this district began with the exploratory expeditions of Schwatka and Hayes[1] in 1891 and of Rohn[2] in 1899. Schwatka and Hayes crossed Skolai Pass, which they were the first white men to see, from the White River and reached the Nizina by way of the Skolai Creek Valley but had no time for making geologic observations away from their line of travel. Rohn crossed the Nizina, Rohn, and Chisana Glaciers from the Nizina River to the Chisana River, laying the foundation for much of the geologic work since done in the Chitina Valley. Schrader and Spencer[3] made a geologic reconnaissance in 1900 that covers part of the area here described. A more detailed geologic survey of part of the Nizina district was made by Moffit and Capps[4] in 1909 and furnishes some of

[1] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, pp. 117–162, 1892.

[2] Rohn, Oscar, A reconnâissance of the Chitina River and Skolai Mountains, Alaska: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 393–445, 1900.

[3] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska: U. S. Geol. Survey Special Pub., 1901.

[4] Moffit, F. H., and Capps, S. R., Geology and mineral resources of the Nizina district, Alaska: U. S. Geol. Survey Bull. 448, 1911.

the data contained on Plate 3. In 1914 Capps[5] spent several days in the Skolai Creek Valley and included his observations on a geologic map of the Chisana-White River district. The writer visited the upper part of McCarthy Creek and the Chitistone River in 1922 and made some studies whose results were not published but are included in this report. All these expeditions added something to the knowledge of parts of the district but left much to be learned, a statement which is also true of the work done in 1927, for the problems to be solved are too complicated to be worked out without detailed maps and considerable time.

PHYSICAL FEATURES

The area under consideration is on the southeast border of the Wrangell Mountains and includes over 350 square miles of extremely rugged country with a relief of more than 6,600 feet between the mouth of the West Fork and the high mountains south of Skolai Creek and of more than 8,800 feet between the West Fork and Frederika Mountain (10,820 feet), north of Skolai Creek. Regal Mountain (13,400 feet), at the head of McCarthy Creek and the West Fork, is not included in the area mapped. The five streams mentioned—the Nizina River, the West Fork, Skolai Creek, the Chitistone River, and McCarthy Creek—receive the greater part of their waters from melting glacier ice and are subject to great variations in volume depending on the temperature. In early spring and late fall they offer little trouble to travelers, but in midsummer they are sometimes crossed with great difficulty, if at all. As a rule, however, the men who know the streams ford them with their horses at the established crossings with little interruption, sometimes waiting from evening till morning to take advantage of the lower water.

The Nizina River and Nizina Glacier extend southward through the middle of the area. McCarthy Creek, which flows into the Kennicott River and thus into the Nizina, and the West Fork lie on the west side of the Nizina. The Chitistone River, which joins the Nizina 5 miles below the West Fork, flows southwestward from the vicinity of Russell Glacier and Skolai Pass. Skolai Creek flows westward from Russell Glacier, reaching Nizina Glacier opposite its tributary Regal Glacier, or about 5 miles from the south end of Nizina Glacier and 15 miles north of the mouth of the Chitistone River. Skolai Creek receives only a small part of the drainage of Russell Glacier, whose waters for the most part flow northeastward to form the White River. The principal tributary of Skolai Creek

[5] Capps, S. R., The Chisana-White River district, Alaska: U. S. Geol. Survey Bull. 630, 1916.

is Frederika Creek, a short tributary from the north that arises in Frederika Glacier. Nizina Glacier forms a dam across Skolai Creek and causes its waters to collect in a narrow lake, about 2 miles long at its maximum extent, which breaks out periodically, flooding the Nizina and sometimes causing damage to the bridge near McCarthy.

The Chitistone River Valley offers a more direct route for travel from McCarthy to the White River and the Shushana gold placers than Skolai Creek, but it involves a high climb over the so-called "goat trail" to avoid the canyon above Chitistone Glacier and is less used than the Skolai Valley during those periods when the Nizina River and the ice of Nizina Glacier are favorable for travel, a condition that is sometimes not present for several years at a stretch. The old trail by way of Skolai Creek kept to the west side of Nizina Glacier for several miles from the lower end and then took a course diagonally across the ice to the north side of Lower Skolai Lake, but a new trail along the east side of the glacier has been cut by the Alaska Road Commission and was traveled by several parties in 1927. If this trail is extended, and especially if some work can be done to make it easier to pass Lower Skolai Lake and the canyon between the lake and Frederika Creek, both of which necessitate a high climb over rough country, it will doubtless become the established route to the White River.

GEOLOGY

OUTLINE

The rocks that are most widely distributed in this district are sedimentary rocks and bedded tuffs and lava flows. Massive intrusive rocks are not well represented in the area studied and are confined to a small area near Frederika Mountain, another on Skolai Creek, and possibly one other locality. Similar rocks are found in the mountains of lower McCarthy Creek and are shown on the map (pl. 3) but lie outside the area to which most attention was given. The oldest rocks that have been recognized are of Permian age and include a great thickness of lava flows, bedded tuffs, massive limestone, shale, limy sandstone, and grit. The next younger formation is the Nikolai greenstone, of Permian or Triassic age, which is overlain by rocks of Upper Triassic age, which include the Chitistone limestone, Nizina limestone, and McCarthy shale and reach a thickness of at least 5,500 feet. Possibly the Permian rocks underwent some folding before the Upper Triassic sediments were deposited, but the evidence for this is not yet complete. However that may be, both the Permian and the Upper Triassic rocks were folded and subjected to weathering and erosion before the next younger beds, the Cretaceous sandstone and shale, were formed. The Cretaceous beds are largely of marine origin and are widely distributed in the Chitina Valley. Their thickness in the Nizina district is probably not less than 2,000 feet. They also are folded but much less so than the older formations. The folds as a rule are open and broad, and in places the beds show only a moderate tilting.

After the Cretaceous beds were deposited a period of volcanism began in Eocene time, which yielded possibly 3,000 feet of lava flows and tuffs. These surface effusive rocks and fragmental deposits are extensively developed in the Wrangell Mountains, where they make up much of the highland area. Originally they formed a continuous sheet of great extent that hid all the older rocks beneath, yet erosion has not only cut through them but has carved deep valleys in the underlying formations. In a few localities fresh-water leaf-bearing beds of sandstone and shale containing thin coal seams have been found at the base of these Tertiary volcanic rocks and furnish evidence for assigning them to the Eocene. These beds appear to be small in extent and local in their distribution. The Tertiary volcanic rocks, like the Cretaceous sediments, do not lie in their original horizontal position but are slightly tilted in most places.

Stream gravel and glacial morainic material, together with loose waste on the mountain slopes and a little volcanic "ash," complete the list of geologic formations known in the district.

STRATIGRAPHY

PERMIAN ROCKS

The Permian rocks of the Nizina district, although highly interesting geologically, have never been thoroughly studied and can not be described in much detail. They consist largely of volcanic material—lava flows and tuffs—but are interstratified with sedimentary deposits of limestone, shale, sandstone, grit, and chert of varying appearance and composition, which, however, do not appear to be distributed uniformly throughout the thickness of Permian beds but seem to form an intermediate group, dominantly of sedimentary rocks, with volcanic rocks above and below. The sandstone and grit members are limy in some localities but highly siliceous in others. The most conspicuous of the sedimentary beds is a massive limestone not less than 800 feet thick, which is locally highly crystalline and nearly everywhere is abundantly fossiliferous. It is best exposed on the north side of Skolai Creek.

The Permian rocks within the area here described occupy the valley of Skolai Creek from Frederika Glacier to Nizina Glacier, extend across to the west side of Nizina Glacier, occupying the lower slopes of Chimney (Goat) Mountain, and are exposed near Chitistone Glacier in the Chitistone Valley. In all these places the peaks of the mountains whose bases they form are capped with the younger volcanic rocks.

The base of the Permian rocks has not been recognized, but the lowest beds that have been included with them are dark lava flows and tuffs of unknown thickness that occupy most of the lower slopes of Skolai Valley from the Frederika Creek Valley to Nizina Glacier. Similar rocks crop out below the Permian limestone at the north end of Russell Glacier. These volcanic beds are everywhere folded and faulted and locally have taken on a subschistose structure.

The beds that overlie the lower volcanic rocks are dominantly sedimentary but contain tuffs and lava flows in considerable amount. The section of these beds is not uniform throughout the district. The most conspicuous difference is the absence of the massive limestone in places, but probably the variation in other members is as great, though less noticeable. Sufficient evidence to show whether this variability is an original feature of sedimentation or the result of an unconformity was not obtained. A brief description of several localities of Permian rocks will indicate the differences mentioned.

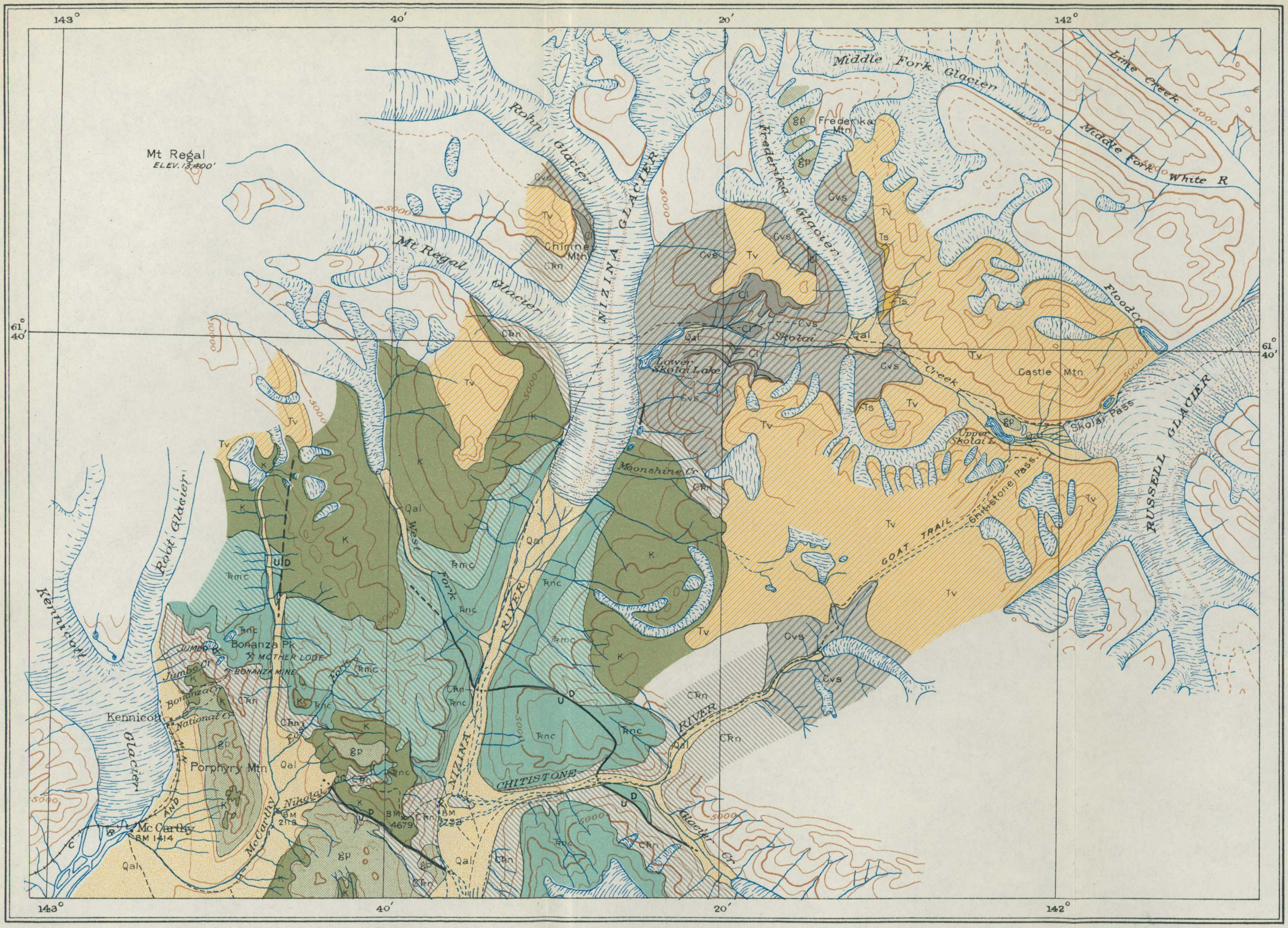
The horseshoe-shaped glacier south of Skolai Creek occupies a high valley locally known as the Hole in the Wall. Permian sedimentary rocks form the lower part of the west wall of this valley south of Frederika Creek. The vertical wall is too steep to be climbed, but the following approximate section gives some idea of the beds:

Section in west wall of Hole in the Wall

	Feet
Sandstone and quartzite	300+
Tuff and fragmental material	40
Thin-bedded shale and sandy beds	100
Basalt flow	30
Banded siliceous rock, white or yellowish white, speckled in places	50
Thick basalt flows.	

These beds are believed to be below the massive limestone that appears farther west in the Skolai Valley. The sedimentary members are all fossiliferous.

Beds of hard gray fossiliferous limestone and white crystalline limestone appear on the west side of Frederika Glacier about 2 miles northwest of the south end and extend northward a considerable but unknown distance.



EXPLANATION

QUATERNARY

Qal — Alluvium (*Stream gravel; includes beach gravel on McCarthy Cr.*)

TERTIARY — Eocene

Tv — Lava flows and tuff

Ts — Shale and sandstone with thin beds of coal

CRETACEOUS OR TERTIARY

gp — Granitic and light-colored porphyritic intrusive rocks

CRETACEOUS

K — Sandstone and shale

TRIASSIC — Upper Triassic

Ŧmc — McCarthy shale

Ŧnc — Nizina and Chitistone limestones

CARBONIFEROUS OR TRIASSIC — Permian or Triassic

CŦn — Nikolai greenstone

CARBONIFEROUS — Permian

Cvs — Volcanic and sedimentary rocks

Cl — Limestone

Fault

D, downthrow
U, upthrow

Topography by D. C. Witherspoon, 1908; C. E. Giffin, 1914; and Fred. H. Moffit, 1922-1927

GEOLOGIC SKETCH MAP OF UPPER NIZINA RIVER, ALASKA

Geology by Fred. H. Moffit and S. R. Capps, 1909
Fred. H. Moffit, 1922-1927

Scale $\frac{1}{250,000}$

2 1 0 2 4 6 8 10 Miles

Contour interval 1,000 feet
Datum is mean sea level

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

The massive Permian limestone is conspicuous in the upper mountain slopes on both sides of the Skolai Valley midway between Frederika and Nizina Glaciers. It forms the prominent limestone peak called the Golden Horn and is crossed by the trail on Tinplate Hill. The limestone of the Golden Horn is probably not less than 800 feet thick. This locality is one of the more favorable places for observing the limestone but possibly does not exhibit its full original thickness, for erosion may have removed part of the limestone as well as other overlying Permian beds. The limestone of the Golden Horn weathers to a reddish or yellowish brown, from which the name of the mountain is taken, and in places is recrystallized to a fairly coarse marble, probably as the result of intrusion. The rocks underneath the thick limestone include brownish shale and sandstone, coarse limy sandstone in lenticular beds, grit, chert, and another thin limestone bed interstratified with tuffs and lava flows, some of which have pillow structure. These beds are probably better exposed on the south side of Skolai Creek, south of the Golden Horn, but lack of time prevented a careful study of them. The lower thin limestone is exposed there in several gulches.

Permian limestone is well exposed in the lower slopes of Chimney (Goat) Mountain west of Nizina Glacier and extends for more than a mile along the glacier in a series of high bluffs. The limestone is notable for the great numbers of crinoid fragments that it contains. The top is impure and knotty and overlies white crystalline limestone containing siliceous lenses as much as several inches in thickness. A hard reddish-brown member with abundant small crinoids is also present. The limestone extends diagonally up the slope northward to a point 1,000 feet above the ice and dips southwest. At the south end of the area, near the border of the ice, the limestone is overlain by 75 to 100 feet of brown-weathering sandy or tuffaceous beds with here and there a rolled pebble or cobble. On top of this is 30 to 40 feet of soft gray tuffaceous rock, including angular blocks of white and reddish-brown limestone containing crinoids and corals together with fragments of other rocks. Then above the tuffaceous rock come lava flows which extend southward toward Regal Glacier and were not examined close at hand.

One of the most instructive sections of Permian rocks examined during the summer is on the east side of Nizina Glacier beginning about a mile from Lower Skolai Lake and extending south half a mile. A shallow box canyon through which flows a little stream lies parallel to the ice margin and is separated from it by a long, low hill several hundred yards across. The rocks exposed in this canyon range in strike from N. 50° W. to west and dip about 75° S. The stream runs S. 15° W., and consequently the canyon cuts the beds approximately at right angles. The following section is well exposed in the canyon. The youngest beds or top of the section given below are at the south end of the canyon.

Section in canyon on east side of Nizina Glacier near Lower Skolai Lake

	Feet
Amygdaloidal basalt, presumably of Nikolai age.	
Coarse tuff	75
Fine-grained brownish tuff	10
Black shale with thin beds of limy sand or grit; strike N. 50° W., dip 75° W	125
Thin lenses of brownish shale in limy grit	20
Light-gray fine-grained yellow-weathering intrusive or flow	75
Hard fine-grained white pyritiferous limestone in beds 2 feet or less thick, interstratified with black shale	30
Basalt	20
Black shale with white limy beds and knotty limestone interstratified with grit or fine conglomerate, grading downward into thin-bedded shale and sandstone in beds 2 feet thick or less	200
Thin-bedded shale and coarse limy sandstone or grit, limy conglomerate with shaly phases, and impure limestone	300
Basalt	50
Black shale	150
Basalt and tuff	50
Thin-bedded hard white crystalline limestone in beds 3 feet or less thick	25
Basalt	15
White crystalline limestone	10
White and speckled grit or fine conglomerate with a few quartz pebbles as much as half an inch in diameter; strike due east, dip 75° S	90
Basalt	20
Gray limy beds and black shale, resting on fine gray tuffaceous limy conglomerate and shale; strike N. 65° W., dip 75° S	275
Basalt and tuff with a little shale and fossiliferous limy beds	(?)
	1,505+

The thicknesses given are paced distances, measured across the edges of the beds, and are not reduced to true thicknesses, as the errors in pacing are probably as great as the errors in thickness resulting from the dip of the beds. Nearly all the sedimentary members of this section are highly fossiliferous. The beds of the lower part of the section at the north end of the canyon abut against basalt flows on the west that form the small hill and are separated from the sedimentary rocks by a fault that strikes N. 5° E. and dips 75° W. A great thickness of tuff and basalt underlies the section given and another great thickness of flows lies above it to the south of the canyon. The writer is of the opinion that the basaltic flows overlying the sediments are the lower part of the Nikolai greenstone. Unfortunately it is not possible to trace the lava flows southward to the Chitistone limestone at the lower end of Nizina Glacier, for the intervening area is occupied by Cretaceous sandstone and shale.

Another area of Permian rocks is found in the vicinity of Chitistone Glacier. This area is less satisfactory for study than that of the Skolai Valley but furnishes further evidence of the age and stratigraphic relations of the Nikolai greenstone and the Permian sediments. The extent of this area is not known. Undoubtedly the Permian beds continue northward to Skolai Creek but are covered by the younger lava flows of the intervening mountains. They were not identified in Chitistone Glacier, but they may extend a considerable distance southeastward from the head of the glacier and eastward toward Russell Glacier.

The following approximate section will give an idea of the rocks along the south side of the Chitistone River for 2½ miles southwest from the glacier. All the beds dip southwestward. The Nikolai greenstone, which forms the top of the section, occupies all the intervening area between the sedimentary Permian beds and the Chitistone limestone on the west side of Glacier Creek. The section is given to show what the beds are rather than to indicate their thickness, as careful measurements were not made.

Section on south side of Chitistone River southwest of Chitistone Glacier

Nikolai greenstone.	
Greenstone tuff, grading into lava flows above.	Feet
Thin-bedded chert containing beds or lenses of brown-weathering tuff; strike N. 45° W., dip 40° SW	75–100
Light-gray, bluish-gray, and black cherts in beds as much as 6 inches in thickness, several hundred feet.	
Basalt flows, several hundred feet.	
Black or dark-gray slate, containing local beds of sandstone as much as 6 inches in thickness and one bed of angular conglomerate 3 inches thick, overlain by 18 inches of coarse gray sandstone	300
Yellowish-weathering conglomerate, mostly fine but with a few pebbles 2 inches or less thick	20
Interbedded brownish-weathering sandstone and shale, several hundred feet.	
Basalt flows, several hundred feet.	
Yellowish-weathering chert and basalt of unknown thickness.	

The thickness of the volcanic and sedimentary beds in the section is probably several thousand feet, but because of faulting it may appear greater than it actually is. Evidence was found to indicate that the beds on the northeast side of Chitistone Glacier dip northeastward, which would put the glacier on the axis of a northwestward-trending anticline. Fossils are not numerous in the sedimentary beds of the section, but enough were found to leave no questions as to the age of the sandstone and limestone containing them. Most of the fossils were in loose fragments of rocks that were observed in place near by, but their original locality was not felt to be in doubt.

The several areas of Permian rocks bear evidence that they were formed in a time of pronounced volcanic activity. Tuffs and lava flows probably make up much the larger part of the Permian rocks of the district. They are present in all the localities where Permian sediments are known, and in many places they interrupted the deposition of sediments. The conditions under which they were formed are in contrast to those of Mesozoic time, as the beds of that age, which overlie the Permian, contain little if any volcanic material. The next period of active volcanism attended by the extrusion of lavas and tuffs did not begin till Eocene time.

The Permian sedimentary beds and the volcanic rocks associated with them were folded and faulted, and at least a part of them were raised above the sea and subjected to atmospheric erosion for a long time before the Upper Triassic sediments were laid down. The structure of the beds is imperfectly known, but in places the trend lines of folds approximate the strike of the younger sediments, extending in a more or less northwesterly direction. The different degrees of metamorphism observed are probably in part the result of intrusion by hot igneous rocks and in part the result of folding. Some of the limestone is locally so thoroughly recrystallized that it is now a coarse marble and bears a strong resemblance to the Carboniferous marble on the north side of the Wrangell Mountains.

Fossils were found in most of the sedimentary deposits referred to the Permian. In places they are exceedingly numerous so that the collector has little to do but select the specimens that come nearest to being perfect, yet the number of species is less than might be expected from the number of individuals. The fossils give definite evidence of the Permian age of the rocks.

Permian sediments are found in other parts of Alaska, especially on the upper Yukon and in southeastern Alaska. The nearest localities, however, are in the upper White River Valley near Russell Glacier and in the upper Copper River region.

PERMIAN OR TRIASSIC ROCKS

NIKOLAI GREENSTONE

The age of the Nikolai greenstone is not yet definitely known. The formation has been described many times, and a further detailed description will not be given here. It has been found in many localities on the north side of the Chitina Valley, and in the Nizina district it consists of not less than 5,000 feet of basaltic lava flows that have suffered some chemical alteration and commonly have a dark-green color. Amygdaloidal and porphyritic phases are common. Although moderately folded, the flows were strong and resisted deformation more successfully than the Triassic limestones and than most of the overlying sedimentary deposits. Fracturing and faulting took place extensively, and slickensided blocks are abundant. The presence of copper minerals and stain is so common in the Nikolai greenstone wherever it crops out that some genetic connection between the greenstone and the copper deposits of the Chitina Valley seems to be a necessary assumption.

The greenstone is present on the west side of the Nizina River opposite the mouth of the Chitistone River, in the Chitistone Valley, and on both sides of Nizina Glacier within the area under discussion. No opportunity was found to visit the area south of Regal Glacier, but the areas on the east side of Nizina Glacier and on the Chitistone River were studied. (See sections, pp. 150, 151.) In both places the sedimentary beds of the Permian dip conformably under tuff deposits, which grade upward within a short distance into basalt flows without intercalated sediments. Both of these areas appear to offer good evidence for regarding the Nikolai greenstone as the culminating deposit of a period of volcanism that continued throughout Permian time, as it is known in this district. Whether the extrusion of lava continued into Triassic time is a question on which no evidence is known to the writer. One of the most puzzling problems connected with the greenstone is its relation to the overlying Chitistone limestone. In most places where the contact of the two formations has been exposed a few inches or feet of red or gray shale is present. Faulting between the greenstone and limestone along the contact plane is common, and the shale appears to have acted as a lubricant to facilitate the motion. Aside from this bed faulting, no discordance of structure between the lava flows and the limestone beds in the Chitina Valley is known to the writer. Nevertheless the absence of Lower and Middle Triassic and the lower part of Upper Triassic sediments in the Chitina Valley—a general condition in Alaska—suggests a period of erosion between the greenstone and limestone, if the greenstone is of Permian age, or between the Permian sediments and the greenstone, if the greenstone is of Upper Triassic age.

The section of Permian sediments given on page 149 shows a bed of tuffaceous material containing angular fragments of fossiliferous Permian limestone overlying Permian limestone beds of the same kind. These angular fragments were interpreted in the field as material dragged along by the tuffs and lavas from the Permian beds through which they were ejected rather than as material from a land mass of Permian rocks undergoing erosion at the time the volcanic outbursts occurred. Limestone fragments were not seen in the tuff at the base of the greenstone on the east side of Nizina Glacier nor on the Chitistone River, and the structural conformability of sediments and lava flows was not questioned.

In view of the facts just related the writer is inclined to the belief that the lavas of the Nikolai formation were extruded in Permian rather than Triassic time, but he does not regard the question as fully settled yet.

UPPER TRIASSIC ROCKS

The Upper Triassic rocks of the Nizina district comprise the Chitistone limestone, the Nizina limestone, and the McCarthy shale. A detailed description of these formations has been given in other publications of the Geological Survey [6] and will not be repeated here.

The Chitistone and Nizina limestones were originally described as one formation, the Chitistone limestone, which has its finest exposures on McCarthy Creek and on the west side of the Nizina River at the mouth of the Chitistone River. In these localities 3,000 feet of limestone is exposed in sections of diagrammatic clearness, comprising all the beds from the Nikolai greenstone below to the McCarthy shale above. The section on McCarthy Creek shows approximately 1,900 feet of distinctly bedded limestone weathering to a light bluish-gray color, resting on greenstone and dipping about 30° NE. Above the gray limestone comes possibly 1,100 feet of limestone in somewhat thinner beds which, in larger exposures, shows a brownish color due to weathering. Examination of fresh specimens of these limestone beds shows that in general the lower section, or Chitistone limestone, is made up of light-gray, bluish-gray, or in places, generally near the top, dark-gray beds. Thin shale partings are present in places between limestone beds but are commonly absent between the thicker beds. Irregularly shaped bodies and knots of black chert are numerous in the upper part of the lower formation (Chitistone limestone) but are scarce if present at all near the base. A brownish color is seen in places on the weathered surfaces in the Chitistone but is more conspicuous on freshly exposed bedding planes. Dolomitization has taken place in some beds in the lower part of the Chitistone limestone and plays a useful part in the exploration for copper at Kennecott.

The upper brownish-weathering beds, to which Martin gave the name Nizina limestone, are commonly dark gray and as a rule are

[6] Moffit, F. H., and Capps, S. R., Geology and mineral resources of the Nizina district, Alaska: U. S. Geol. Survey Bull. 448, pp. 21–30, 1911. Martin, G. C., The Mesozoic stratigraphy of Alaska: U. S. Geol. Survey Bull. 776, pp. 6–32, 1926.

separated by thin partings of shale that become more prominent in the upper part of the section. No chert knots were noticed in the Nizina limestone in this district. The fine exposure of Upper Triassic limestone on the east side of McCarthy Creek shows a rhythmical alternation of zones of thin beds and thick beds, but the thick beds become less conspicuous at the top.

The Nizina limestone is overlain by the McCarthy shale, a fairly homogeneous formation with a thickness of at least 2,500 feet. The base of the shale is distinctly bedded, like the underlying limestone, but is darker and consists of alternating beds of hard black or gray argillite and soft black shale in which argillite predominates. The argillite beds commonly range in thickness from 1 foot to 18 inches and rarely exceed 3 feet. The shale beds as a rule are only a few inches thick. In places the argillite resembles a black chert with conchoidal fracture, but practically all the beds of this nature were found to effervesce when tested with acid. Chert beds in the lower part of the McCarthy shale are exposed at some places in the Chitina Valley but are believed to be a local phase of the formation, due to the effects of intrusion by igneous rocks, and not a continuous widespread member.

The thin-bedded basal part of the formation consists of only a few hundred feet of strata and grades above into black shale with indistinct bedding except in a few places where a thin seam of argillite or limestone is included. Erosion proceeds rapidly in the soft black shale and gives rise to numerous deep cuts into hills that probably once had a more smooth and flowing contour than now. These gulches have steep slopes of great extent on which vegetation is unable to secure a foothold.

Within the district under consideration the Upper Triassic limestone and shale are well developed on McCarthy Creek, on both sides of the Nizina River below Nizina Glacier, and on the Chitistone River. One other small area of Triassic rocks was found on the north side of the Skolai Valley, 2,000 feet above the creek and halfway between Frederika and Nizina Glaciers. At this locality a small remnant of shale with Triassic fossils that has escaped removal by erosion rests on the Permian limestone. The exposures consist of loose material scattered over an area of several acres. No undisturbed ledges were seen in place, but the loose shale fragments apparently cover too large an area to be erratic material transported from some other locality. The significance of this occurrence lies in the absence of all the Triassic limestone and the Nikolai greenstone which should be beneath the shale. This same condition holds at the north end of Russell Glacier, where, however, a much greater thickness of shale is probably present. Possible explanations for this condition are either that the greenstone and limestone never were there or that, although originally present, they were removed by erosion before the shale was deposited. No evidence to establish either one of these suppositions was obtained during the summer's work, and the question is still open in the mind of the writer.

Some structural features of the Triassic rocks are considered under the heading " Structure."

CRETACEOUS ROCKS

Geologic studies in the Chitina Valley during recent years have shown that rocks of Cretaceous age are more widely distributed than was formerly supposed. The Cretaceous rocks of the Nizina district comprise chiefly marine shale and sandstone that have a thickness of several thousand feet. They occupy the upper parts of McCarthy Creek and West Fork Valleys, several square miles on both sides of Nizina Glacier, and other small areas. Before they were deposited the Triassic sediments had been deformed, raised above sea level, and then submerged again but not till after a large part of them had been removed by erosion, as is shown by a marked structural unconformity at the base of the Cretaceous beds.

Detailed sections of the Cretaceous sediments have not been made. In a broad way the section on McCarthy Creek includes a small thickness of basal sandstone and sandy shale overlain by a great thickness of black shale. The shale in turn is overlain by brown-weathering sandstone that forms the highest beds exposed. A massive bed of conglomerate several hundred feet thick on the east side of McCarthy Creek near its head is included with the Cretaceous rocks, although its age is not yet proved. The Cretaceous sandstones of the upper part of the section include a few thin beds or lenses of coal. All the beds show deformation in some degree, but the soft black shales show much more folding than the stronger sandstones that are associated with them.

The section of Cretaceous beds on the West Fork and on the west side of Nizina Glacier resembles that of McCarthy Creek but was not studied carefully, as time was lacking. Apparently the Cretaceous sandstone rests on Nikolai greenstone south of Regal Glacier, and the beds exposed there reach a thickness of about 3,000 feet. Cretaceous rocks are well exposed east of Nizina Glacier. About 3 miles south of Skolai Lake the Cretaceous rocks overlie the Nikolai greenstone. They extend southward along the glacier for a mile or more but find their greatest development in the mountains to the east, where at least 3,000 feet is exposed. The basal beds include a conglomerate of no great thickness with scattered pebbles 3 inches or less in diameter, 75 feet of gray sandstone overlain by 20 feet of coarse black grit and then brown-weathering sandstone that dips gently south. A mile south of this locality, on the north side of Moonshine Creek, the brown Cretaceous sandstone and sandy shale contain numerous round concretions as much as 3 feet in diameter. These beds, which are overlain by about 600 feet of horizontally bedded soft gray shale that contains thin sandstone beds and concretions, form the lower slopes of the flat-topped mountain south of Moonshine Creek. The soft shale weathers easily to form soft mud. The top of the mountain has an altitude of a little more than 6,000 feet, and its precipitous north side gives a fine exposure of nearly horizontal beds that are the basis of the following highly generalized section. The thicknesses given are based on estimates of the proportionate parts of the section made up by the different members as viewed from a distance.

Generalized section in north side of mountain south of Moonshine Creek

	Feet
Brown-weathering sandstone	400
Brown-weathering shale and sandy shale with sandstone beds	800
Brown-weathering sandstone	800
Soft gray shale with local sandstone beds and concretions	600
Brown-weathering sandstone and sandy shale with large sandy concretions	100?
Conglomerate	?
	2,700+

A vast amount of Cretaceous shale and sandstone has been removed by erosion, and areas that once were certainly occupied by such rocks show no evidence of them now. On the other hand little patches of sandstone appear unexpectedly in many places as a thin veneer on ridges and capping on mountain tops.

The Cretaceous sediments show less folding than the Upper Triassic limestone and shale but more than the overlying Tertiary volcanic rocks, although in places the parallelism between the bedding planes of the sandstone and of the Tertiary tuff beds and lava flows is practically perfect.

TERTIARY ROCKS

The Tertiary volcanic rocks have received less attention than almost any other rocks of the Wrangell Mountains and are probably less known. This fact does not appear strange when it is realized that they occupy the highest and most inaccessible parts of the mountain group and in most places can not be reached without much difficulty. Furthermore, they are not known to contain valuable mineral deposits and thus have not been commercially important.

The Tertiary rocks within the area under discussion are dominantly andesitic and basaltic lava flows intercalated with tuff beds. Black glassy obsidian is abundant in the morainal débris on the west side of Frederika Glacier but was not seen elsewhere. It probably belongs among the latest outpourings of volcanic material and may possibly be younger than the Tertiary, as is the thick deposit of white volcanic "ash" that caps some of the mountains north of lower Skolai Creek. Included among the Tertiary rocks also is a comparatively small thickness of fresh-water leaf-bearing clay, sandstone, and conglomerate containing thin beds of coal, which lies at the base of the volcanic rocks on Frederika Creek.

The lavas and tuffs form the tops of all the high mountains north of a line drawn from McCarthy Creek Glacier to Chitistone Glacier. They are conspicuous in the landscape even at a distance because of the fine development and regularity of their bedding and because of the variation in color, which emphasizes the bedding. The beds have a low northerly dip that is so small as to be almost unnoticeable, and they therefore appear to be practically horizontal. Another striking feature of the volcanic rocks is the marked development of columnar structure in some of the lava flows. This structure is well exhibited in the upper part of Chimney Mountain, on the west side of Nizina Glacier, where the columns form a vertical wall around three sides of the mountain. Precipitous steplike slopes and impassable walls are characteristic of the volcanic deposits wherever they are seen.

Most of the lava flows are highly vesicular and in places are porphyritic, the most conspicuous phenocrysts being large tabular crystals of amber-colored feldspar. Vesicular lavas are, however, much more abundant than the porphyritic varieties and in many places are even more striking in appearance because of the irregular nodules of blue and white chalcedony and the crystalline quartz which were deposited in the vesicles.

One of the most interesting features connected with the volcanic deposits is the presence of leaf-bearing fresh-water beds and coal beds at their base in at least one locality. These beds are found along the lowest slopes of the east side of the Frederika Valley, extending from the glacier to Skolai Creek, and in a small area in their line of strike south of Skolai Creek. They bear further evidence to support the opinion of earlier workers that the lava flows and tuffs were poured out on a land surface and not into the sea.

The best exposures for studying the fresh-water beds are in the gulches near the lower end of Frederika Glacier, where the following section was measured:

Section in gulches near lower end of Frederika Glacier

	Feet
Basalt, great thickness.	
Light-yellowish tuffaceous bed	12–15
Gray sandy shale splitting into thin sheets	5
Black shale	15
Black sandy shale splitting into thin sheets	5
Coarse gritty tuff or sandstone, thin sandstone beds, variegated fine clay, black shale, and thin coal beds; abundant fossil leaves	150
Gray, yellowish-weathering conglomerate, finer above, containing local beds of shale	100
Brown-weathering conglomerate with well-rounded pebbles 2 inches or less in diameter	20
Basalt (Permian?).	
	310

In a near-by gulch on the south the upper part of the section is as follows:

	Feet
Basalt, great thickness.	
Tuff	20
Gray sandstone	20
Basalt flow	60
Tuff	18
Sandstone	4
White and gray fine-grained clay	10
Black and gray shale	4

All the sedimentary members of the first section, above the conglomerate, and of the second section also contain fossil leaves, which are especially abundant and well preserved in the beds just above the coal beds.

The fresh-water beds strike from north to N. 25° E. and dip gently to the east under the lavas and tuffs that make up the mountains on the east side of the Frederika Valley.

The section of fresh-water deposits is difficult to study, except in gulches where water exposes a fresh surface of the beds, for the soft clays wash over and hide everything on the hill slopes. These clays make up most of the middle part of the general section. They are gray or light gray or white, have a uniform fine grain, and when wet become a sticky mass like hard grease. The coal is in thin beds that range from an inch or less to a foot in thickness and has no commercial value.

Outcrops of the fresh-water beds continue north for about 2 miles and possibly farther, but the exposures are too poor to give much additional information. Apparently the thickness of beds grows less in that direction. Between Frederika Glacier and Skolai Creek the exposures are poor. No exposures were seen in the canyon of Skolai Creek, but outcrops of gray and black shale and white to light-gray clay beds, including thin lenses of coal, are found south of Skolai Creek at the base of the Tertiary volcanic rocks east of the glacier opposite Frederika Creek. The beds contain well-preserved leaves and so far as could be determined do not exceed 75 feet in thickness.

The collections of fossil leaves from the fresh-water sedimentary beds were submitted to E. W. Berry for identification and determination of their age. Mr. Berry says that "All lots appear to be of approximately the same age and are doubtless to be correlated with the Kenai." They are therefore assigned to the Eocene and thus fix a more definite time for the beginning of the latest period of volcanism in this district. In a geologic sense this period has apparently continued without interruption to the present time, although no outpouring of lavas has taken place in the Wrangell Mountain district within the observation of white men.

LIGHT-COLORED GRANITE AND PORPHYRITIC INTRUSIVE ROCKS

The preceding descriptions have made evident the fact that a large proportion of the rocks of this district are igneous. Most of them, however, are lava flows and tuffs that were poured out or ejected on the surface, and because of their bedded structure they possess some of the characteristics of sedimentary deposits. They predominate so greatly over the intrusive rocks that those rocks are relatively insignificant in amount. The intrusive rocks were not studied in detail and do not require an extended description. Moreover, the order of their presentation here is not an indication of their relative age. They occur mostly in the form of dikes and sills and may be divided into light-colored quartz diorite porphyry, which is abundant in some localities, as in the black shales of lower McCarthy Creek, and dark, more basic rocks, which cut both the sedimentary and the volcanic rocks and supposedly were to a large extent the feeders that supplied molten rock for the surface flows, and if so must be of Tertiary age. The light-colored dikes are not numerous within the area studied, except on lower McCarthy Creek, where they cut shale of Cretaceous age. However, they are believed to have a genetic connection with the gold deposits of the Nizina district and possibly also with the copper deposits and are consequently of economic importance. A small area of related rocks much like those of McCarthy Creek was noted on the west and southwest sides of Frederika Mountain at the north edge of the area under consideration. These rocks consist of light-gray hornblende granite of medium grain but with finer-grained light-colored porphyritic phases that show feldspar phenocrysts and with dark fine-grained phases that show hornblende phenocrysts. In places on the east side of Frederika Glacier the moraines are made up almost wholly of these rocks. Another small area is the low knob north of Upper Skolai Lake, which apparently is a thick sill of light-gray granitic rock.

The form and color of a prominent two-peaked mountain between Nizina Glacier and the Chitistone River suggests that this mountain also may be made up of the granitic rock, a conclusion that is somewhat strengthened by the presence of light-colored dikes in the near-by Cretaceous sandstone and shale.

The dark basaltic dikes and sills are numerous in the black Cretaceous shale that underlies the Tertiary volcanic rocks of McCarthy Creek and are present in Tertiary fresh-water sedimentary beds east of Frederika Glacier but are most abundant in the Tertiary volcanic rocks themselves, where it is evident that the overlying flows had to break through the tuff deposits and the chilled lavas to reach the surface.

STRUCTURE

One of the outstanding problems connected with mining and the search for copper deposits in the Nizina district is the structure of the beds in which the ore bodies occur. This problem has a bearing on the development of any new deposits that may be discovered, as well as on the exploitation of known deposits like those of Kennecott. So far as the copper deposits are concerned, only the structure of the Nikolai greenstone and the Chitistone limestone is of immediate concern, although the structure of the other formations may have a bearing not yet recognized. As it is impracticable, if not impossible, to map most of the smaller structural details that are met in mine development, the account of the structure given here will deal only with the major features.

In a large way the rocks under consideration form a broad, shallow syncline that trends a little south of northwest. The Permian rocks of Skolai Creek and Rohn Glacier are the oldest known rocks on one flank of the syncline—the northeast side—and the Nikolai greenstone is the oldest on the other, although if the section were carried somewhat farther south, rocks of lower Carboniferous (Mississippian) age would be met. The Nikolai greenstone, moreover, appears on both sides of the syncline but is not continuously exposed. If the Nikolai greenstone is assumed to be of Permian age, then it appears probable that the greenstone formed a land mass exposed to erosion in early Triassic time, for no rocks of Lower and Middle Triassic age are known in this region. On the other hand, the seeming structural conformity of the greenstone with both the underlying Permian sedimentary beds and the overlying Chitistone limestone (Upper Triassic) and the failure so far to find any surface that can be definitely recognized as a weathered or eroded land surface make the problem a difficult one to solve. The Permian sedimentary rocks were folded and eroded before part of the Upper Triassic beds were deposited, as is shown by remnants of McCarthy shale that rest on Permian limestone on Skolai Creek, both the Nikolai greenstone and the Triassic limestones being absent. In connection with this fact, it should be kept in mind that the Upper Triassic sediments represent a gradual transgression of the sea on the land and that the Permian limestone, on which are found Upper Triassic shale north of Skolai Creek, may still have been above water while the Triassic limestones were being formed in a basin to the south. The general trend of folds in the Permian and Upper Triassic rocks is practically the same, so far as is known, but the older rocks appear to be more faulted. Some of the Permian rocks have locally become schistose.

After the deposition of the Upper Triassic McCarthy shale there came a period of folding and elevation, when the Triassic beds and the greenstone were raised above the sea and a great part of them were removed by erosion, so that later, when another transgression of the sea took place, the Cretaceous sediments were laid down upon the truncated beds of the older rocks. The Cretaceous sediments, in turn, were folded and elevated above the sea and, as would be expected, show less folding than the Triassic beds but more than the overlying Tertiary volcanic rocks.

All these facts find expression in the structure of the district. In general, the Chitistone limestone along its southern boundary between the Nizina River and Kennicott Glacier strikes northwest and dips 30°–35° NE., but toward the northeast as is apparent on the Nizina River, McCarthy Creek, and Kennicott Glacier, it flattens out and becomes practically horizontal. The north limb of the synclinal fold is not known and probably is buried beneath the younger sediments and volcanic deposits. South of the Chitistone River the limestone appears to be less disturbed and has a lower dip than west of the Nizina River.

The structure of the Chitistone limestone is made more complicated by the presence of numerous faults, the most striking of which is the great thrust fault that appears in the limestone wall of the Nizina River a short distance below the West Fork. This fault has nearly the same strike as the bedding of the limestone and follows the same course as Glacier Creek and the lower valley of the West Fork. The fault dips southwest, and the limestone and greenstone on that side have been thrust over the limestone on the northeast for many hundreds if not thousands of feet. This fault is plainly visible on both sides of the Nizina River but was not recognized on McCarthy Creek. Another fault of large displacement is indicated by the relations of the Permian rocks of the Skolai Creek Valley, where the scarp of the southwestward-dipping limestone bed, high above the creek on the south side of the valley, is discordant with the limestone of the north side and suggests that the Permian rocks south of the creek have been raised with reference to those on the north along an east-west fault that follows much the same course as the creek itself. Failure to find evidence of this fault in the Tertiary volcanic rocks of upper Skolai Creek suggests further that this fault, if present, is of pre-Tertiary age. Most of the faults, however, are of smaller displacement and are less readily observed. One large system includes faults with steep dips and with strikes that range from about north to northeast. Faults belonging to this system carry some of the most valuable ore bodies in the mines at Kennecott and may have had a controlling influence in determining the location of the upper Nizina River, McCarthy Creek, and the east fork of Kennicott Glacier. A fault of this kind on the east side of Nizina Glacier below Skolai Lake brings the fossiliferous Permian beds into contact with the volcanic rocks along their strike. Several such faults may be seen on McCarthy Creek. One on the west side of that stream faults Chitistone limestone against Nikolai greenstone about 2 miles above the East Fork. Another on the east side brings Chitistone limestone against black Cretaceous shale and can be traced for 4 or 5 miles in the upper valley.

Another variety of fault, which is much more difficult to recognize but is widely prevalent in the limestone, consists of those known as bed faults. These faults indicate movement of one bed on another along the bedding planes and seem to indicate an adjustment of beds like that which occurs when the leaves of a book are bent. Some of these folds break across diagonally from one bedding plane to another, cutting the bed at an angle so small that the fault plane is almost parallel to the bed plane. A movement of the Chitistone limestone on its contact plane with the Nikolai greenstone is an example of the bedding-plane faults that has been recognized in many places. The one important influence which the bedding-plane faults have long been known to have had on the deposition of the ores at Kennecott is that of directing the course of the copper-bearing solutions and thus, in some places, preventing the extension of an ore body from one limestone bed to the adjacent one. Some of the copper-bearing veins of the Bonanza mine terminated below at a bedding-plant fault a short distance above the limestone-greenstone contact, and at this place a notable expansion of the ore body took place. A vertical cross section thus showed a more or less wedge-shaped mass of ore with its base at the bedding-plane fault and its thin edge pointed upward. S. G. Lasky,[7] of Kennecott, has pointed out in a paper recently prepared for publication that the bedding-plane faults probably also had a strong influence in the production and location of cross faults, which he finds hold a definite relation to the changes in strike and dip of the bedding-plane faults.

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[7] Lasky, S. G., Transverse faults at Kennecott and their relation to the main fault system: Am. Inst. Min. and Met. Eng. Yearbook, 1929, pp. 303–317.

INDEX

SELECTED LIST OF GEOLOGICAL SURVEY PUBLICATIONS ON ALASKA

[Arranged geographically]

All these publications can be obtained or consulted in the following ways:

1. A certain number of copies are delivered to the Director of the Geological Survey, from whom they can be obtained for a limited period free of charge (except certain maps) on application.

2. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at the price indicated. No copies are available of those marked with an asterisk (*); they may be consulted at many public libraries.

3. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

The maps whose price is stated are sold by the Geological Survey and not by the Superintendent of Documents. On an order for maps amounting to $5 or more at the retail price a discount of 40 per cent is allowed.

GENERAL

REPORTS

* The geography and geology of Alaska, by A. H. Brooks. Professional Paper 45, 1906, 327 pp.

The Alaskan mining industry in 1928, by Philip S. Smith. In Bulletin 813, 1930. Free on application. The preceding volumes in this series are Bulletins 259, 1904, 15 cents; 284, 1905, 25 cents; 314, 1906, 30 cents; 345, 1907, 45 cents; 379, 1908, 50 cents; 442, 1909, 40 cents; 480, 1910, 40 cents; 520, 1911, 50 cents; 542, 1912, 25 cents; * 592, 1913 (592–A, 15 cents); 622, 1914, 30 cents; 642, 1915, 35 cents; 662, 1916, 75 cents; * 692, 1917 (692–A, 5 cents); * 712, 1918; * 714, 1919; 722, 1920, 25 cents; 739, 1921, 25 cents; 755, 1922, 40 cents; 773, 1923, 40 cents; 783, 1924, 40 cents; 792, 1925, 25 cents; 797, 1926, 80 cents; 810, 1927, free on application.

Railway routes from the Pacific seaboard to Fairbanks, Alaska, by A. H. Brooks. In Bulletin 520, 1912, pp. 45–88. 50 cents.

Geologic features of Alaskan metalliferous lodes, by A. H. Brooks. In Bulletin 480, 1911, pp. 43–93. 40 cents.

The mineral deposits of Alaska, by A. H. Brooks. Bulletin 592–A, 1914, pp. 18–44. 15 cents.

Alaska coal and its utilization, by A. H. Brooks. Bulletin 442–J, reprinted 1914, pp. 47–100. 10 cents.

The preparation and use of peat as a fuel, by C. A. Davis. In Bulletin 442, 1910, pp. 101–132. 40 cents.

* Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 273 pp.

* Geographic dictionary of Alaska, by Marcus Baker (second edition, prepared by James McCormick). Bulletin 299, 1906, 690 pp.

Tin mining in Alaska, by H. M. Eakin. In Bulletin 622, 1915, pp. 81–94. 30 cents.

Antimony deposits of Alaska, by A. H. Brooks. Bulletin 649, 1916, 67 pp. 15 cents.

The use of the panoramic camera in topographic surveying, by J. W. Bagley. Bulletin 657, 1917, 88 pp. 25 cents.

Mineral springs of Alaska, by G. A. Waring. Water-Supply Paper 418, 1917, 114 pp. 25 cents.

The future of Alaska mining, by A. H. Brooks. Bulletin 714–A, pp. 5–57. 25 cents.

Preliminary report on petroleum in Alaska by G. C. Martin. Bulletin 719, 1921, 83 pp. 50 cents.

The Mesozoic stratigraphy of Alaska, by G. C. Martin. Bulletin 776, 1926, 493 pp. 75 cents.

In preparation

The Upper Cretaceous flora of Alaska, by Arthur Hollick, with a description of the Upper Cretaceous plant-bearing beds, by G. C. Martin. Professional Paper 159.

Tertiary flora of Alaska, by Arthur Hollick.

Igneous geology of Alaska, by J. B. Mertie, jr.

Mineral industry of Alaska in 1929, by Philip S. Smith.

TOPOGRAPHIC MAPS

Map of Alaska (A); scale, 1:5,000,000; 1927. 10 cents retail or 6 cents wholesale.

Map of Alaska (C); scale, 1:12,000,000; 1929. 1 cent retail or five for 3 cents wholesale.

Map of Alaska, showing distribution of mineral deposits; scale, 1:5,000,000; 1925. 20 cents retail or 12 cents wholesale.

Index map of Alaska, including list of publications; scale, 1:5,000,000; 1929. Free on application.

Relief map of Alaska (D); scale, 1:2,500,000; 1923. 50 cents retail or 30 cents wholesale.

Map of Alaska (E); scale, 1:2,500,000; 1923. 25 cents retail or 15 cents wholesale.

SOUTHEASTERN ALASKA

REPORTS

• The Juneau gold belt, by A. C. Spencer, pp. 1–137, and A reconnaissance of Admiralty Island, by C. W. Wright, pp. 138–154. Bulletin 287, 1906, 161 pp. 75 cents.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin 314, 1907, pp. 82–88. 30 cents.

The Ketchikan and Wrangell mining districts, by F. E. and C. W. Wright. Bulletin 347, 1908, 210 pp. 60 cents.

• The Yakutat Bay region, Alaska, by R. S. Tarr and B. S. Butler. Professional Paper 64, 1909, 183 pp. 50 cents.

Occurrence of iron ore near Haines, by Adolph Knopf. In Bulletin 442, 1910, pp. 144–146. 40 cents.

• Geology of the Berners Bay region, by Adolph Knopf. Bulletin 446, 1911, 58 pp. 20 cents.

The Eagle River region, southeastern Alaska, by Adolph Knopf. Bulletin 502, 1912, 61 pp. 25 cents.

The Sitka mining district, by Adolph Knopf. Bulletin 504, 1912, 32 pp. 5 cents.

The earthquakes at Yakutat Bay, in September, 1899, by R. S. Tarr and Lawrence Martin. Professional Paper 69, 1912, 135 pp. 60 cents.

*A barite deposit near Wrangell, by E. F. Burchard. In Bulletin 592, 1914, pp. 109–117.

Geology and ore deposits of Copper Mountain and Kasaan Peninsula, by C. W. Wright. Professional Paper 87, 1915, 110 pp. 40 cents.

*The structure and stratigraphy of Gravina and Revillagigedo Islands, by Theodore Chapin. In Professional Paper 120, 1918, pp. 83–100.

* Geology and mineral resources of the west coast of Chichagof Island, by R. M. Overbeck. In Bulletin 692, 1919, pp. 91–136.

The Porcupine district, by H. M. Eakin. Bulletin 699, 1919, 29 pp. 20 cents.

Notes on the Salmon-Unuk River region, by J. B. Mertie, jr. Bulletin 714–B, 1921, pp. 129–142. 10 cents.

Marble resources of southeastern Alaska, by E. F. Burchard. Bulletin 682, 1920, 118 pp. 30 cents.

Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 722, 1922. 25 cents. Similar previous reports in Bulletins 642, 1916, 35 cents; 662, 1917, 75 cents; *692, 1919; *712, 1920; 714–B, 1921, 10 cents.

Ore deposits of the Salmon River district, Portland Canal region, by L. G. Westgate. In Bulletin 722, 1922, pp. 117–140. 25 cents.

Mineral deposits of the Wrangell district, by A. F. Buddington. In Bulletin 739, 1923, pp. 51–75. 25 cents.

Mineral investigations in southeastern Alaska in 1924, by A. F. Buddington. In Bulletin 783, 1927, pp. 41–62. 40 cents. Similar report for 1923 in Bulletin 773, 1925, pp. 71–139. 40 cents.

Aerial photographic surveys in southeastern Alaska, by F. H. Moffit and R. H. Sargent. In Bulletin 797, 1929, pp. 143–160. 80 cents.

Geology of Hyder and vicinity with a reconnaissance of Chickamin River, southeastern Alaska, by A. F. Buddington. Bulletin 807, 1929, 124 pp. 35 cents.

Geology and mineral deposits of southeastern Alaska, by A. F. Buddington and Theodore Chapin. Bulletin 800, 1929, 398 pp. 85 cents.

In preparation

Geology and ore deposits of the Juneau district, by H. M. Eakin.

TOPOGRAPHIC MAPS

Juneau gold belt, Alaska; scale, 1:250,000; compiled. In Bulletin 287, 1906. 75 cents. Not issued separately.

Juneau special (No. 581A); scale, 1:62,500; 1904, by W. J. Peters. 10 cents retail or 6 cents wholesale.

Berners Bay special (No. 581B); scale, 1:62,500; 1908, by R. B. Oliver. 10 cents retail or 6 cents wholesale. Also contained in Bulletin 446, 1911, 20 cents.

Kasaan Peninsula, Prince of Wales Island (No. 540A); scale, 1:62,500; by D. C. Witherspoon, R. H. Sargent, and J. W. Bagley. 10 cents retail or 6 cents wholesale. Also contained in Professional Paper 87, 1915, 40 cents.

Copper Mountain and vicinity, Prince of Wales Island (No. 540B); scale, 1:62,500; by R. H. Sargent. 10 cents retail or 6 cents wholesale. Also contained in Professional Paper 87, 1915, 40 cents.

Eagle River region; scale 1:62,500; 1912, by J. W. Bagley, C. E. Giffin, and R. E. Johnson. In Bulletin 502, 25 cents. Not issued separately.

Juneau and vicinity (No. 581D); scale, 1:24,000; 1918, by D. C. Witherspoon. 20 cents retail or 12 cents wholesale.

Hyder and vicinity (No. 540C); scale, 1:62,500; 1927, by R. M. Wilson. 10 cents retail or 6 cents wholesale. Also published in Bulletin 807, 1929, 35 cents.

Revillagigedo Island; scale, 1:125,000; by R. H. Sargent (preliminary edition). Free on application.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS

REPORTS

* Geology of the central Copper River region, by W. C. Mendenhall. Professional Paper 41, 1905, 133 pp. 50 cents.

Geology and mineral resources of Controller Bay region, by G. C. Martin. Bulletin 335, 1908, 141 pp. 70 cents.

Mineral resources of the Kotsina-Chitina region, by F. H. Moffit and A. G. Maddren. Bulletin 374, 1909, 103 pp. 40 cents.

* Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf, with a section on the Quaternary, by S. R. Capps. Bulletin 417, 1910, 64 pp. 25 cents.

Reconnaissance of the geology and mineral resources of Prince William Sound, by U. S. Grant and D. F. Higgins. Bulletin 443, 1910, 89 pp. 45 cents.

Geology and mineral resources of the Nizina district, by F. H. Moffit and S. R. Capps. Bulletin 448, 1911, 111 pp. 40 cents.

Headwater regions of Gulkana and Susitna Rivers, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit. Bulletin 498, 1912, 82 pp. 35 cents.

Coastal glaciers of Prince William Sound and Kenai Peninsula, by U. S. Grant and D. F. Higgins. Bulletin 526, 1913, 75 pp. 30 cents.

The McKinley Lake district, by Theodore Chapin. In Bulletin 542, 1913, pp. 78–80. 25 cents.

Geology of the Hanagita-Bremner region, Alaska, by F. H. Moffit. Bulletin 576, 1914, 56 pp. 30 cents.

* Mineral deposits of the Yakataga district, by A. G. Maddren. In Bulletin 592, 1914, pp. 119–153.

* The Port Wells gold-lode district, by B. L. Johnson. In Bulletin 592, 1914, pp. 195–236.

* Geology and mineral resources of Kenai Peninsula, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp.

The gold and copper deposits of the Port Valdez district, by B. L. Johnson. In Bulletin 622, 1915, pp. 140–188. 30 cents.

The Ellamar district, by S. R. Capps and B. L. Johnson. Bulletin 605, 1915, 125 pp. 25 cents.

* A water-power reconnaissance in south-central Alaska, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 372, 1915, 173 pp.

Copper deposits of the Latouche and Knight Island districts, Prince William Sound, by B. L. Johnson. In Bulletin 662, 1917, pp. 193–220. 75 cents.

The Nelchina-Susitna region, by Theodore Chapin. Bulletin 668, 1918, 67 pp. 25 cents.

The upper Chitina Valley, by F. H. Moffit, with a description of the igneous rocks, by R. M. Overbeck. Bulletin 675, 1918, 82 pp. 25 cents.

*Platinum-bearing auriferous gravels of Chistochina River, by Theodore Chapin. In Bulletin 692, 1919, pp. 137–141.

*Mining on Prince William Sound, by B. L. Johnson. In Bulletin 692, 1919. Similar previous reports in Bulletins *592, 1914; 622, 1915, 30 cents; 642, 1916, 35 cents; 662, 1918, 75 cents.

*Mineral resources of Jack Bay district and vicinity, by B. L. Johnson. In Bulletin 692, 1919, pp. 153–173.

*Nickel deposits in the lower Copper River Valley, by R. M. Overbeck. In Bulletin 712, 1919, pp. 91–98.

The Kotsina-Kuskulana district, by F. H. Moffit and J. B. Mertie, jr. Bulletin 745, 1923, 149 pp. 40 cents.

The metalliferous deposits of Chitina Valley, by F. H. Moffit. In Bulletin 755, 1924, pp. 57–72. 40 cents.

The occurrence of copper on Prince William Sound, by F. H. Moffit. In Bulletin 773, 1925, pp. 141–158. 40 cents.

In preparation

Notes on the upper Nizina River, by F. H. Moffit. In Bulletin 813.

Geology of the Chitina quadrangle, by F. H. Moffit.

TOPOGRAPHIC MAPS

Central Copper River region; scale, 1:250,000; by T. G. Gerdine. In Professional Paper 41, 1905, 50 cents. Not issued separately. Reprint in Bulletin 498, 1912, 35 cents.

Headwater regions of Copper, Nabesna, and Chisana Rivers; scale 1:250,000; by D. C. Witherspoon, T. G. Gerdine, and W. J. Peters. In Professional Paper 41, 1905, 50 cents. Not issued separately.

Controller Bay region (No. 601A); scale, 1:62,500; 1907, by E. G. Hamilton and W. R. Hill. 35 cents retail or 21 cents wholesale. Also published in Bulletin 335, 1908, 70 cents.

Headwater regions of Nabesna and White Rivers; scale 1:250,000, by D. C. Witherspoon, T. G. Gerdine, and S. R. Capps. In Bulletin 417, 1910, 25 cents. Not issued separately.

Latouche Island, part of; scale, 1:21,120; by D. F. Higgins. In Bulletin 443, 1910, 45 cents. Not issued separately.

Chitina quadrangle (No. 601); scale 1:250,000; 1914, by T. G. Gerdine, D. C. Witherspoon, and others. Sale edition exhausted. Also published in Bulletin 576, 1914, 30 cents.

Nizina district (No. 601B); scale, 1:62,500; by D. C. Witherspoon and R. M. La Follette. In Bulletin 448, 1911, 40 cents. Not issued separately.

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Prince William Sound; scale 1:500,000; compiled. In Bulletin 526, 1913, 30 cents. Not issued separately.

The Bering River coal field; scale, 1:62,500; 1915, by G. C. Martin. 25 cents retail or 15 cents wholesale.

The Ellamar district (No. 602D); scale, 1:62,500; by R. H. Sargent and C. E. Giffin. In Bulletin 605, 1915, 25 cents. Not issued separately.

Nelchina-Susitna region; scale, 1:250,000; by J. W. Bagley, T. G. Gerdine, and others. In Bulletin 668, 1918, 25 cents. Not issued separately.

Upper Chitina Valley; scale, 1:250,000; by International Boundary Commission, F. H. Moffit, D. C. Witherspoon, and T. G. Gerdine. In Bulletin 675, 1918, 25 cents. Not issued separately.

The Kotsina-Kuskulana district (No. 601C); scale 1:62,500; 1922, by D. C. Witherspoon. 10 cents. Also published in Bulletin 745, 1923, 40 cents.

Valdez and vicinity (No. 602B); scale, 1:62,500; 1929, by J. W. Bagley. 10 cents retail or 6 cents wholesale.

In preparation

Prince William Sound region; scale, 1:250,000; by J. W. Bagley, D. C. Witherspoon, and others.

COOK INLET AND SUSITNA REGION

REPORTS

Geologic reconnaissance in the Matanuska and Talkeetna basins, by Sidney Paige and Adolph Knopf. Bulletin 327, 1907, 71 pp., 25 cents.

*The Mount McKinley region, by A. H. Brooks. Professional Paper 70, 1911, 234 pp.

A geologic reconnaissance of the Iliamna region, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp. 35 cents.

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Seward Peninsula, northeastern portion, reconnaissance map (No. 655); scale, 1:250,000; 1905, by D. C. Witherspoon and C. E. Hill. 50 cents retail or 30 cents wholesale. Also in Bulletin 247, 1905, 40 cents.

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