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MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN 1929

BY
PHILIP S. SMITH AND OTHERS

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MINERAL RESOURCES OF ALASKA, 1929

MINERAL INDUSTRY OF ALASKA IN 1929

By PHILIP S. SMITH[1]

INTRODUCTION

The mineral industry of Alaska was for many years the dominant incentive for the development of the Territory. Later, as the other possibilities of the Territory became better known, other industries sprang up and partly reduced the preeminence formerly held by mining, though they have by no means displaced the hold that mining still has on the welfare of the people. It is probably safe to say that to-day, although the annual value of the minerals produced in Alaska is second to that of the fish products, mining developments still hold first place in the general interest of most of the residents. Assistance to the mining industry of Alaska has therefore long been recognized as a Federal obligation, and through the Geological Survey efforts have been made to determine the distribution and extent of these resources and to disseminate pertinent information on them to the miner, prospector, or business man who might undertake their development. As a result several hundreds of reports have been issued by the Geological Survey describing the different mineral commodities or mining camps and setting forth, both in the text and by illustrations and maps, the facts that have been determined and the technical inferences that may be drawn therefrom. Among the significant activities relating to the mineral industry is the collection from time to time of facts regarding the kinds and quantities of minerals produced and the places from which they came. To obtain this information the Geological Survey conducts an annual canvass of the mineral production of Alaska and makes the results available through reports published shortly after

[1] The canvass of producers, the tabulation of their replies, and the general compilation of the statistics set forth in this report have been conducted principally by Miss L. H. Stone, of the Alaskan branch of the U. S. Geological Survey.

the end of the year to which the records relate. The present report, which is of this type, is the twenty-sixth of the series.[2]

The collection of the facts requisite for the preparation of these annual statements involves difficulties, because the great size of the Territory, the diversity of its mineral products, and the large number but small size of many of the enterprises make it impracticable to gather all of the desired information at first hand. The information used is therefore derived from many sources, which necessarily vary in reliability and completeness. Every effort is made, however, to verify all the statements and to give only those that appear to be well substantiated. Among the most reliable sources of information are the field engineers and geologists who are sent out each year to conduct surveys in different parts of Alaska and who acquire not only much accurate information regarding the mineral production of the regions in which they work but also 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, the Alaska Railroad, the Bureau of Foreign and Domestic Commerce, 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 collecting 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, though some of this information is confidential and is not released for publication.

Most of the larger Alaskan newspapers and 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 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

[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, 725, 739, 755, 773, 783, 792, 797, 819, and 813.

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 should be realized, however, that the data collected from one source, although strictly accurate, are likely to be computed on a different basis from equally reliable reports received from another source, so that considerable editing and revision must be undertaken to bring them to one standard. To illustrate: The operator of a small placer property reports producing so much gold dust, for which he was paid so much by the local storekeeper. If we could follow this individual lot of gold through its various travels before it comes to its ultimate goal in a mint or Government assay office, we would probably find that the original figures did not long hold. For instance, the dust as originally received was probably not thoroughly cleaned, so that when it was melted up in a bank or mint its weight after melting was considerably different from the weight given by the producer. Furthermore, every parcel of gold, even from the same creek, differs in its assay value from every other, but of course the storekeeper can not determine this value by examination, so that to protect himself he generally pays an extremely conservative price. Furthermore, the storekeeper or bank official realizes that there will be charges for melting the dust, for shipment, for insurance, etc., and he needs to make a profit on the transaction, so that the price set must include all these different items if he is not to suffer loss. The original operator's statement that he received $16 an ounce for his 100 ounces of gold dust (that is, $1,600), though true, may relate to the same lot of gold that a bank would accept as 96 ounces before melting and pay for at the rate of $17.50 an ounce (that is, $1,680) or that would be reported by a mint or assay office as 94½ ounces having a theoretical value of $18.25 an ounce (that is, $1,724). The spread in this example between the price paid by the original storekeeper and the true value reported by the mint is less than 8 per cent for all the handling incident to bringing out the gold from some remote camp. It is not possible to compute exactly all the factors involved so as to reduce the reports of production to a strictly uniform standard. However, though some minor uncertainties necessarily remain, the attempt is made to eliminate differences, so that the reports may be consistent within themselves and with the other reports of this series.

Another reason why the totals used in this volume for certain mineral commodities may differ from the reports received from the producers is that all values here printed are based on the average selling price for each of the individual mineral commodities for the year, as determined by the Bureau of Mines, and not on the prices actually received by the individual producers. It is recognized that this method of computation obscures the amount received by individual mines, but it is believed to afford a better representation of the industry as a whole. Furthermore, it probably does not introduce any material error in the totals, inasmuch as higher prices received by the more shrewd and efficient mine operators are about balanced by the lower prices received by the 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 Alaska mineral industry and urges them to communicate any 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 facts 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 it relates. So scrupulously is this policy followed that in this volume 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, and other materials produced in small quantity or by only one producer, whose output would otherwise be obvious.

Special acknowledgment is due to Frank J. Katz and other officers of the Bureau of Mines and the Bureau of Foreign and Domestic Commerce of the Department of Commerce; the collectors and other officers of the Alaska customs service and of the Bureau of the Mint, of the Department of the Treasury; Col. O. F. Ohlson, and other officers of the Alaska Railroad; F. H. Moffit, S. R. Capps, J. B. Mertie, jr., B. D. Stewart, R. H. Sargent, and Gerald FitzGerald, of the Geological Survey; the agents of the American Railway Express Co. in Alaska; Maj. Malcolm Elliott and other members of the Alaska Road Commission; the Pacific Coast Cement Co., the Alaska Weekly, and Volney Richmond, of the Northern Commercial Co., of Seattle, Wash.; the Solar Development Co. (Ltd.), of Ketchikan; the Hyder Weekly Herald, of Hyder; the Hirst-

Chichagof Mining Co. and the Chichagoff Mines (Ltd.), of Chichagof; the Alaska Juneau Gold Mining Co., the Daily Alaska Empire, and J. C. McBride, of Juneau; the Cordova Daily Times, of Cordova; the Kennecott Copper Corporation, of Kennecott; J. B. O'Neill, of McCarthy; Thomas Larson, of Kotsina; the Seward Gateway, of Seward; H. N. Evans, of Kanatak; A. F. Stowe, of Kodiak; the Anchorage Weekly Times and Alex Liska, of Anchorage; Ivan L. Peterson and son, of Chickaloon; H. W. Nagley, of Talkeetna; Charles Zielke, of Nenana; the First National Bank, the Fairbanks Exploration Co., G. E. Jennings, F. B. Parker, Henry Cook, Heath & Kearns, and Joe Henderson, of Fairbanks; A. J. Griffin, of Richardson; J. J. Hillard, of Eagle; C. E. M. Cole, of Jack Wade; A. W. Amero, of Beaver; Chris Thyman, of Rampart; Jessie M. Howard, of Tanana; George Jesse, of Ruby; Frank Speljack, of Ophir; the Miners and Merchants Bank, of Iditarod; H. S. Wanamaker and Capt. E. G. Rowden, of Wiseman; John W. Chapman, of Anvik; J. W. Wick, of Russian Mission; John Haroldson and J. L. Jean, of Quinhagak; C. M. Link, of Bethel; E. M. Whelan, of Medfra; S. M. Gaylord, of Casadepaga; Hammon Consolidated Gold Fields, R. W. J. Reed, the Miners and Merchants Bank, Lomen Bros., and C. W. Thornton, of Nome; A. S. Tucker, of Bluff; Arthur W. Johnson, of Hayeock; T. P. Roust, of Candle; T. A. Peterson, of Teller; Art M. Hansen, of Kotzebue; 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 1929 was $16,066,000. This was furnished by a number of mineral products, of which the most valuable were gold and copper, these two accounting for more than 92 per cent of the total. This total was $2,000,000 greater than that of the preceding year and is attributable to the increased selling price of copper and a very notable increase in the output of gold from both lodes and placers. This increase in value of somewhat more than 14 per cent indicates the generally upward trend of the industry as a whole, though, as will be discussed in more detail later, there were notable changes in the trends of production of the individual mineral commodities that contributed to this total.

On the whole the market prices of most of the metals that enter 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, copper brought 17.6 cents a pound in 1929, against 14.4 cents in 1928, and lead 6.3 cents a pound

in 1929, against 13.8 cents in 1928. On the other hand, the prices of some of the metals that enter less largely into the total were somewhat lower in 1929 than in 1928. Thus silver, which sold at an average price of 58.5 cents an ounce in 1928, brought only 53.3 cents in 1929; tin, 45.19 cents a pound in 1929, against 50.48 cents in 1928; and platinum, $67 an ounce in 1929, against $75 in 1928. The net result of the fluctuation in prices was to increase materially the value of the output in 1929; the increase of 3.2 cents a pound for copper affording an increased income of $1,296,000 over what would have been received at the price prevailing in 1928.

Although there were no outstanding new developments during the year that directly affected the mineral output, the general conditions were encouraging and distinctly pointed to the conclusion that mining activities were on the up grade. General facilities for transportation throughout the Territory are constantly showing improvement. The vessels plying between the States and Alaska to-day are far more attractive, commodious, and speedy than heretofore. The management of the Alaska Railroad is displaying more and more alertness and zeal in studying the needs of the community it serves and making the railroad an important agency in the development of the country. The Alaska Road Commission each year is extending its construction of roads and trails and maintaining more effectively those already built, thus making outlying parts of the Territory more accessible and lowering costs of prospecting. The development of commercial aviation is playing a marvelous part in linking together the distant parts of Alaska and, through the saving of time effected by the use of airplanes, lengthening the working season so that properties which otherwise might perforce remain dormant can be successfully mined. The tragic deaths during the year of two of the most efficient aviators, C. B. Eielson and R. H. Merrill, while engaged in flights, have been most serious losses but have served to stimulate rather than lessen popular interest in aviation throughout the Territory, and new organizations and new facilities are springing up in different parts of Alaska to meet the growing demand for airplane transportation of persons and freight.

All these improvements in general conditions are stimulating prospectors and others to search for new mineral deposits or undertake the development of deposits that were too difficult to exploit under less favorable conditions. Such improvements are constantly being made and are bound to exert a continuing and growing force, so that each year Alaska is becoming less and less of an unknown frontier, and the hazards of mining under pioneer conditions are being reduced. Furthermore, the mere accumulation of experience produced by successful mining ventures builds up confidence and interest that induce the undertaking of other new enterprises and thus creates an ever-widening circle of stimulation.

TOTAL MINERAL PRODUCTION

From the time of the earliest records of mining in Alaska to the end of 1929 minerals to the value of practically $616,000,000 have been produced in the Territory. The distribution of this large total among the individual years is set forth in the following table and is graphically represented by the curves in Figure 1. From this table and diagram it will be evident that prior to about 1898 the annual production ranged from negligible amounts to a maximum of about $2,000,000. After the discovery of the Canadian Klondike and the entrance of a swarm of prospectors and miners into Alaska the production quickly mounted, until in 1906 it reached a high point that marks the mining of many of the rich placers in the Nome and Fairbanks regions. For the next eight years the annual production fluctuated somewhat but ranged around $20,000,000. Then the production mounted by leaps until it reached a maximum of more than $48,000,000 in 1916. This rapid increase was due to the growth of copper production under the stimulation of the World War, when prices advanced to unprecedented heights. By 1919 the war stimulation was over, and the annual production from Alaska dropped again to about $20,000,000. During the postwar period Alaska has suffered through the fact that in the States scales of wages and opportunities for the employment of capital have offered more advantages, and as a result there has been a more or less gradual decline in the mineral output from Alaska until in 1928 it fell to a total of only a little more than $14,000,000. In 1929, however, the total was more than $16,000,000, and it is believed that the decrease shown during the period from 1920 to 1928 does not necessarily mark a permanent downward trend. In fact, as will be noted elsewhere in this report, there is direct evidence that the mining of certain of the metals is decidedly on the increase.

Value of total mineral production of Alaska, by years, 1880–1929

1880	*$6,826	1898	$2,329,016	1916	$48,386,508
1881	*15,000	1899	5,425,262	1917	40,694,804
1882	*23,000	1900	7,995,209	1918	28,218,935
1883	*67,146	1901	7,306,381	1919	19,626,824
1884	*72,000	1902	8,475,813	1920	23,330,586
1885	*425,000	1903	9,088,564	1921	16,994,302
1886	*540,000	1904	9,627,495	1922	19,420,121
1887	*657,000	1905	16,490,720	1923	20,330,643
1888	*667,181	1906	23,501,770	1924	17,457,233
1889	*847,490	1907	20,840,571	1925	18,220,692
1890	*873,276	1908	20,992,501	1926	17,666,800
1891	1,014,211	1909	21,140,810	1927	14,404,060
1892	1,019,493	1910	16,875,226	1928	14,061,069
1893	1,164,982	1911	20,720,480	1929	16,066,000
1894	1,339,332	1912	22,581,943		
1895	2,588,832	1913	19,547,292		615,501,000
1896	2,885,029	1914	19,109,731		
1897	2,589,294	1915	32,790,344		

* $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.

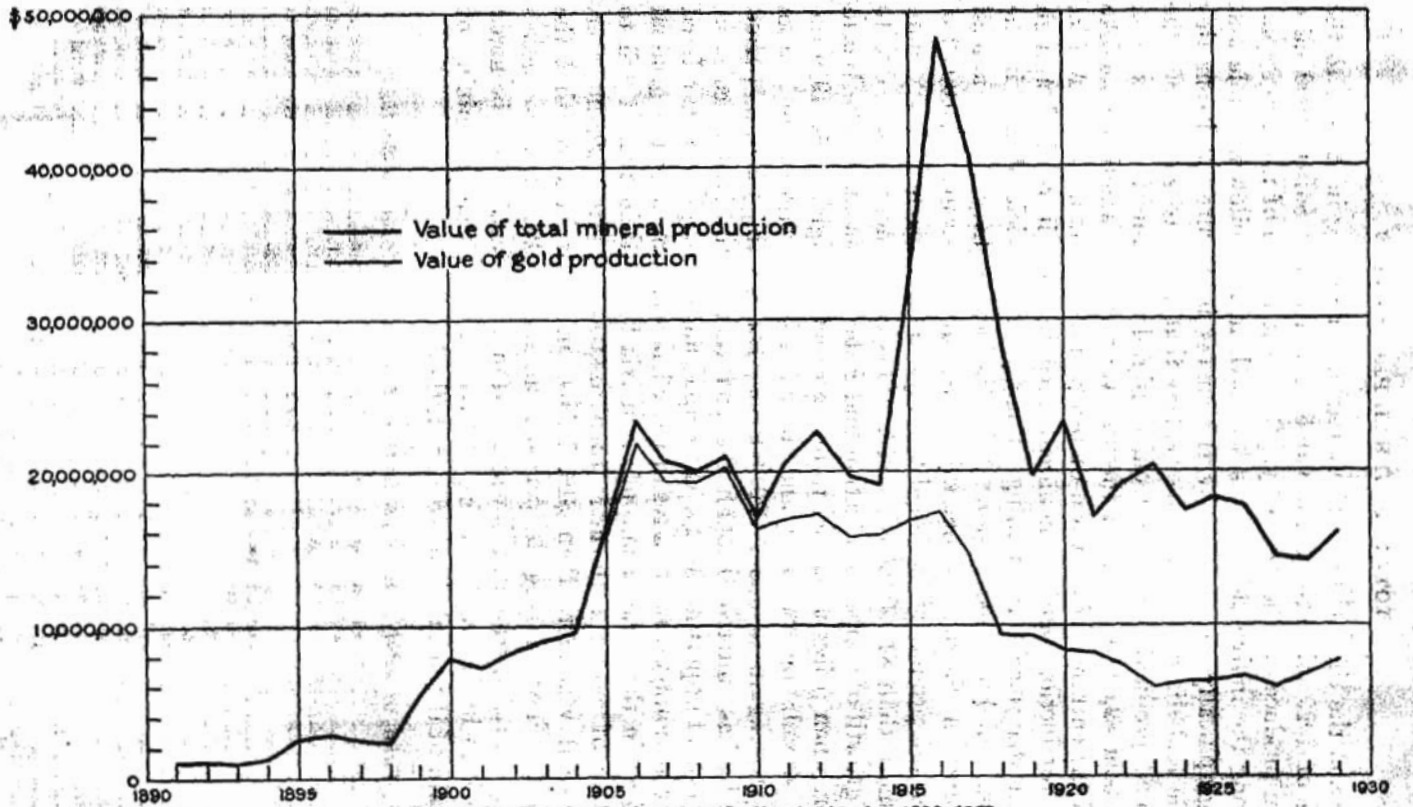


FIGURE 1.—Trends of mineral production in Alaska, 1890–1929

In the following table the value of the total mineral production from Alaska is distributed among the metals and nonmetallic products. From this table it will be seen that gold accounted for approximately 62 per cent of the total production and that gold and copper together accounted for more than 95½ per cent.

Total value of mineral production of Alaska, by substances, 1880–1929

Gold	$380,841,000
Copper	208,008,000
Silver	11,738,000
Coal	6,742,000
Tin	1,083,000
Lead	1,606,000
Marble and other products (including platinum metals)	5,483,000
	615,501,000

Each mineral product is discussed in more detail in the following pages, in which are set down such facts as are available regarding the amount of each product, the places from which it came, and any new developments. The following summary table shows the production for 1929 and 1928, distributed by quantity and value among the main kinds of substances, so that a comparison between the two years may be readily made. Increases in value are shown for gold, copper, lead, and miscellaneous mineral products, and slight decreases in value for silver, tin, and coal. The same relation also holds with respect to quantities produced except that the quantity of silver was greater in 1929 than in 1928, though its value was less, and the quantity of copper produced was less in 1929 than in 1928, though its value was much greater.

Mineral output of Alaska, 1929 and 1928

	1929		1928		Increase or decrease, 1929	
	Quantity	Value	Quantity	Value	Quantity	Value
Gold.....fine ounces	375,438	$7,761,000	331,140	$6,845,000	+44,298	+$916,000
Copper.....pounds	40,510,000	7,130,000	41,421,000	5,965,000	−911,000	+1,165,000
Silver.....fine ounces	472,900	252,000	454,700	266,000	+18,200	−14,000
Coal.....short tons	100,600	528,000	126,100	662,000	−25,500	−134,000
Tin, metallic.....do	38.6	35,000	41.0	41,000	−2.4	−6,000
Lead.....do	1,315	166,000	1,019	118,000	+296	+48,000
Miscellaneous mineral products, including petroleum, platinum metals, marble, gypsum, etc.	.....	194,000	.....	164,000	.....	+30,000
	.....	16,066,000	.....	14,061,000	.....	+2,005,000

GOLD

GENERAL FEATURES

The total value of gold produced from Alaska mines in 1929 was $7,761,000, as contrasted with $6,845,000 in 1928, an increase of $916,000. The general trend of gold mining in Alaska since 1890 is graphically represented by one of the curves in 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 World 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 1929.

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 14 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. The same information, except that the annual production for each year from 1880 is also included, is graphically represented by Figure 2. Of the $380,841,000 worth of gold that has been produced from Alaska mines, $254,125,000, or about 67 per cent, has come from placers and $126,716,000, or about 33 per cent, from lodes. The relation between the outputs from these two sources of gold 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 annual 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 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.

FIGURE 2.—Trend of value of gold production of Alaska, 1880–1939

Gold and silver produced in Alaska, 1880–1929

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	4,928,196	$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	1,289,150	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	963,546	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	739,945	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	358,000	2,982,000	2,945,000
1928	331,140	6,845,000	454,700	286,000	3,347,000	3,498,000
1929	375,438	7,761,000	472,900	252,000	4,117,000	3,644,000
	18,428,198	380,841,000	15,891,600	11,738,000	254,125,000	126,716,000

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 afford considerable additional return from the sale of their 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 undesirable 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 1929, all the ores from lode mines that yielded gold have been included, and the gold recovered from placers has been stated separately. It is a noteworthy feature that no gold is recovered from the Alaskan ores that are principally valuable for their copper content, though these ores are the sources of most of the silver that is recovered.

Gold and silver produced in Alaska, 1929, by sources

Source	Gold		Silver	
	Fine ounces	Value	Fine ounces	Value
Gold ores	176,278	$3,644,000	94,379	$60,300
Copper ores	199,160	4,117,000	351,730	187,400
Placers			26,800	14,300
	375,438	7,761,000	472,900	252,000

GOLD LODES

Alaska lode mines in 1929 yielded $3,644,000 in gold, or about $150,000 more than in 1928. This gold derived from lodes was approximately 47 per cent of the entire gold production of the Ter-

ritory for 1929. The proportion of lode gold to placer gold was somewhat less in 1929 than in 1928, in spite of the increase in the output from the lode mines. The gold was recovered from widely distributed mines, but more than 96 per cent came from southeastern Alaska, as shown in the following table:

Gold and silver produced from gold-lode mines in Alaska in 1929 by districts

District	Gold		Silver	
	Fine ounces	Value	Fine ounces	Value
Southeastern Alaska	169,312	$3,500,000	92,560	$49,335
Willow Creek	581	12,000	169	85
Fairbanks district	4,015	83,000	985	525
Other districts	2,370	49,000	665	355
	176,278	3,644,000	94,370	50,300

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 more than 93 per cent of the total lode-gold output of the Territory in 1929. 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 1929 was 3,836,440 tons, an average of 10,510 tons a day. Of this amount 1,815,970 tons of coarse tailings were rejected and 2,020,470 tons were fine milled. The average gold content of all the material mined was $1.12 a ton. The amount of gold in that part of the rock which was rejected was about 19 cents a ton, and the value of the gold content of the rock that was further treated was about $1.94 a ton. Of this content gold worth 28 cents was lost during the treatment, $1.29 was recovered as bullion, and 37 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, 1893–1929

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
1914–15	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	121,379
1917	677,410	677,410		429,262	13,248	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	359,782	542,774
1920	942,870	637,321	305,549	732,570	22,348	487,574	791,339
1921	1,613,600	904,323	709,277	969,703	40,619	550,913	1,066,251
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	2,038,067	56,971	1,288,974	2,184,384
1926	3,329,700	1,549,678	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	1,513,398	2,468,262
1928	3,718,140	1,795,191	1,922,949	3,142,808	77,491	2,098,655	3,316,019
1929	3,836,440	2,020,470	1,815,970	3,419,408	90,635	2,391,832	3,627,247
	32,437,538	16,613,714	15,823,824	21,606,972	695,744	13,499,101	22,997,885

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 1929 the cost of mining is stated by the company to have been 27.05 cents for each ton of ore trammed to the mill, the cost of milling was 23.19 cents, and all other operating and marketing costs and expenses, including interest, amounted to 10.44 cents, making the entire cost for each ton of ore trammed only 61.58 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 somewhat higher. As a result the value of the gold recovered from each ton of rock mined in 1929 was 89 cents, as against 84 cents in 1928 and 55 cents in 1927; in fact, the tenor of the ore and the gold recovery were the highest since 1915—that is, during the entire period of enlarged operations by this company.

In addition to the operations of the Alaska Juneau Gold Mining Co. on its properties at Juneau, the company during the year has taken an active part in the development of lode prospects in British Columbia, about 50 miles east of Juneau, in the newly discovered Taku district. At this place extensive indications have been found of ore carrying gold, silver, copper, lead, and zinc, and active prospecting has been in progress. The work, however, has not progressed far enough to warrant the company making a more definite statement of the results than the following: "The results obtained so far by diamond drilling, drifting, and crosscutting must await interpretation until more information is available as to the habits of the ore occurrence." The site where the company is carrying on the greatest amount of prospecting lies east of the international boundary, but it has also acquired options on properties on the Alaska side of the line, where some work is in progress, and there is geologic evidence to suggest that a considerable tract near Taku but in Alaska may be well worth prospecting. In practically all these prospecting ventures by the Alaska Juneau Co. the Treadwell Yukon Co. (Ltd.) is also participating. The early Geological Survey maps were in error in indicating that the eastern limit of the great Coast Range batholith in this part of southeastern Alaska lay to the east of the international boundary and thus suggesting that mineral deposits were probably not to be expected west of the boundary. Instead the eastern margin of the batholith in the Taku district makes a considerable westward jut, so that a strip of country 10 miles or so wide in Alaska now appears to have considerable likelihood of justifying careful search for indications of mineralization. Not only is the direct effect of this revival of prospecting by these large companies in the Taku region beneficial to that region, but its indirect effect in

stimulating search for ore deposits is having an even wider significance by the encouragement it gives to others to realize that opportunities still await earnest, energetic exploration.

The Alaska Juneau Gold Mining Co. also took part in the exploration of gold-lode claims adjacent to the international boundary north of Haines, both in Canada and in Alaska. Work on this group of claims, which is known as the Stampede group, has been in progress for some time. The report of the company for 1929, however, makes the following statement: "After prospecting the Stampede group of mining claims throughout the past summer with unsatisfactory results this option was dropped." No indication was given as to the respect in which the results were unsatisfactory, so that it is uncertain whether the tenor proved too low or whether the extent of the mineralization was too small to make the project attractive to a large company or whether some other reasons determined the decision.

The next most productive gold mines in southeastern Alaska were those of the Hirst-Chichagof Mining Co. and of the Chichagoff Mines (Ltd.). The Hirst-Chichagof is near the head of Mine Bay, on the west coast of Chichagof Island, about 60 miles northwest of Sitka, and the Chichagoff Mines are in the same general region, at the head of Klag Bay. In the past these and the other gold mines on Chichagof Island have produced gold to the total value of more than $18,000,000, but in 1928 and again in 1929 the larger mines were engaged chiefly in reconstruction and development work, so that there was a marked falling off in production. This condition is believed to be temporary, for the dead work that has now been done will put the properties into better operating condition. Thus at the Hirst-Chichagof the installation of a modern mill, with additional power facilities, which was completed during 1929, gives promise of a greatly increased production for 1930. Among the more notable improvements made at this property during the year were the construction of a power line 2½ miles long from Chichagof, which will supply electric power to replace the former Diesel plant, the remodeling of the old mill and the installation of a tube mill, the building and equipping of a new compressor plant, and the driving of nearly 1,000 feet of drifts and crosscuts and over 300 feet of raises.

At the Chichagoff Mines practically the only ore milled during the year was that derived in the course of prospecting and development work, so that the output was small. The exploratory work which has been in progress there for the last two years is proving up the extent and distribution of the ore and according to the operators is yielding results that are satisfactory to them, so that in the near future this mine may resume work on a scale as large as in

the boom period, some 8 to 15 years ago. Elsewhere on Chichagof Island there are several other gold mines or prospects, among them the formerly highly productive property of the Apex-El Nido Mining Co., but most of them are only small prospects. Work was said to have been in progress at some of these properties during the year, but none of them reported having made any material production.

In the Admiralty Island region, at Funter Bay and Hawk Inlet, development work was continued at the properties of the Admiralty Alaska Gold Mining Co., the Williams Mining Co., and the Alaska Dano Mines Co. At the Admiralty Alaska property the year was spent in underground development work, the erection of an aerial tram, and the construction and installation of a ball mill for the treatment of the ore. No production from this property was reported, but the improvements enumerated above were completed, so that production should commence shortly. At the Williams mine negotiations were in progress early in the season for the lease and option of the property. This project was later carried through, and a company was organized under the name of Hawk Inlet Mining Co. to make the necessary developments. A study of the best measures of handling the property will be made, and then plans will be laid for its development, so that probably it will be some time before the mine will be brought to a productive stage. At the property of the Alaska Dano Mines Co. a little development work, resulting in driving some 76 feet of tunnel, was done during the year. Rumors continue to be heard of the opening up of the old Kensington and Jualin mines, north of Juneau, but so far as known no active work on the ground with that end in view was undertaken. South of Juneau, in the vicinity of Windham Bay, at the property of the Jacob Marty Mines, little new work was reported. A new bond was taken on the property, and arrangements were made for carrying on considerable further development work in 1930.

The Hyder district, which embraces that part of southeastern Alaska lying at the head of Portland Canal and west of the international boundary, was the scene of continued prospecting during the year, but only a little gold was produced from any of its mines. According to the records of the commissioner, as reported in the local newspaper, about 132 new claims were staked in the district in 1929, and assessment work was recorded as having been done on 271 claims. The latter figure, however, must not be regarded as indicating the total number of claims on which work was done, because doubtless many of the owners neglected to record their assessment work, and many other properties have been patented and therefore are not required by law to have annual assessment work done on

them. The additions and improvements on the road leading up the valley of Texas Creek have stimulated interest in that valley, and several new propects have been disclosed by the work that has been in progress there during the year. Probably the greatest amount of work accomplished in the Texas Creek region was at the property of the Hyder Lead Mining Co., near the head of the valley of the West Fork, but the greatest general interest was afforded by the reported finding of especially rich ore west of the head of the West Fork, on Banded Mountain, which forms part of the area tributary to the Chickamin River. This find by Metcalf & Finley resulted in a small rush of prospectors into the near-by hills. The region is a difficult one to traverse because of the high, steep mountains and the large glaciers and snow fields, so that even to transport the necessary supplies and equipment needed for its exploration is costly and time consuming. Between Texas Creek and the Salmon River a considerable group of claims has been acquired and consolidated as a unit by the Cantu Mining Co. The plans announced by this company include extensive development work and the installation of the equipment necessary to put the property on a producing basis. Farther south in the valley of the Salmon River, at the properties of the Riverside Mining & Milling Co., the American Mining & Milling Co., and the Mountainview Gold Mining Co., prospecting and development work was carried on, and test shipments are said to have been sent to smelters in the States from at least one of them. The general opinion as to the outlook for the future held by most of the operators in the camp was one of healthy optimism.

In the Ketchikan district of southeastern Alaska lodes have long been known and up to a few years ago have yielded considerable gold, as well as other metals. During the last few years, however, there has been little production from any of the mines, though prospecting has been carried on at some of them. Probably the most significant event of the year as regards mining was the entry into this field of the Solar Development Co., which acquired under option the Salt Chuck and Rush & Brown properties on Kasaan Peninsula, Prince of Wales Island. Early in May the company began the active work of pumping out the Rush & Brown mine and preparing it for the preliminary work of sampling and examination. In November a development program was begun to determine the distribution and extent of the mineralization, and an adit 1,500 feet long was started to connect with the mine workings at the 300-foot level. Although the new company mined no new ore during the year, there was in the bins some ore that had been mined and sorted by earlier owners, and this was shipped to the Anyox smelter of the Granby Consolidated Mining, Smelting & Power Co. (Ltd.), in

British Columbia. It is also reported that considerable exploratory work was done under the direction of J. L. Freeburn and others on a lode property near Moth Cove, Revillagigedo Island, about 15 miles southeast of Ketchikan. If the conditions prove favorable, this will probably lead to extensive development work in 1930. A little development work leading to the mining of a small quantity of ore was also done on at least one of the old properties near Helm Bay, north of Ketchikan. A small shipment of ore from the Maid of Mexico Mining Co.'s property, near Petersburg, in the Wrangell district, was sent to one of the smelters in the States, mainly to serve as a test run. According to the reports of the operators the properties of the Kassan Gold Mining Co., near Hollis, and the Dolomi Gold Mines (Inc.), near Dolomi, both on Prince of Wales Island, which produced some ore in 1928, were either entirely shut down or the scene of only development or assessment work in 1929.

The Willow Creek district, at the head of Cook Inlet, has long been one of the productive gold-lode camps of the Territory and yielded some gold in 1929, though there was a very marked falling off in the amount reported by the different operators. The following notes regarding mining developments in this district are abstracted from data submitted by B. D. Stewart, supervising mining engineer, who received much information from E. F. Wann, collected in the course of his professional work at the Thorpe, Gold Mint, and Gold Cord properties. In spite of the falling off in production there was considerable mining activity that assures increased output as soon as the development work in progress has been completed. Thus at the properties of the Willow Creek Mines, on Craigie Creek, where the destruction of the mill by fire late in 1928 put a stop to milling, the company was busy throughout the open season in cleaning the site and erecting the concrete foundations for a new mill building. Underground and on the surface further search for ore was carried on, apparently with encouraging results. In connection with this property it is of interest to note that Paul Hopkins, chemist of the Bureau of Mines station in Fairbanks, definitely identified the presence of tellurides in samples of ore from the Lucky Shot mine. There have been numerous reports of the finding of tellurides at different points in the Willow Creek region in the past, but up to the time of Hopkins's report they have not been authenticated. This determination is therefore not only of immediate value but may have considerable economic significance in guiding developments. At the property of the Marion Twin Co., at the head of Craigie Creek, some ore was mined, and several tons of selected ore was shipped to a smelter in the States and yielded high returns. It is reported that the owners plan to install a portable compressor

and to erect a cable tram about 1,500 feet long from the mine to the Gold Bullion road. At the Gold Mint property of the same company, on the Little Susitna River, underground work consisted principally in driving on No. 5 tunnel a distance of about 40 feet to intercept a vein that is believed to lie some 75 feet still farther ahead. The Gold Cord mine was operated in 1929 by the Golden Bear Mining Co. A 20-ton Herman mill, operated by a 15-horsepower gas engine, and a small compressor operated by a 20-horsepower Diesel engine, were installed. The underground developments consisted mainly in crosscutting in the vicinity of a fault which had offset the vein, in order to find the displaced ore body. A crew of 10 to 12 men were employed for a large part of the open season, and some ore was treated. At the Mabel mine work was carried on throughout the year on about the same scale as during 1928. The Independence and Martin properties, on Fishhook Creek, were examined and sampled during the summer by engineers and a crew of three or four men, currently reported to have been sent in the interests of a Canadian mining company. A little ore was mined by Charles Bartholf from the Rae Wallace property. The work done during 1929 on the Thorpe property consisted almost entirely in digging numerous open cuts on the surface in order to trace out the course of the veins. The discovery of a rich vein about half a mile above the Gold Cord, on Fishhook Creek, was reported to have been made by Herman Kloss. This vein is said to be very narrow but to have been traced on the surface definitely for a distance of 1,500 feet and possibly may extend for an additional distance of 1,500 feet. A compressor run by power furnished by a Diesel engine and other equipment necessary to carry on the development work were installed, and a small test shipment of ore from the property was sent to the Tacoma smelter. Numerous smaller lode properties are reported at other places in the Willow Creek region, but at practically none of them was more than the required assessment work done.

In the vicinity of Fairbanks gold-lode mining was continued in 1929 in both the Ester Dome and Pedro Dome areas on practically the same scale as in 1928. In the vicinity of Ester Dome the greatest amount of gold came from the Mohawk mine, on the north flank of the dome, and from the Ready Bullion mine, on the southwest flank. Both these mines maintain their own mills, but the owner of the Mohawk mine made his mill available during part of the season for custom work and as a result treated several hundred tons of ore from some of the near-by prospects. This service enabled several of the smaller operators to obtain a reliable mill test of their ore and gave them gold with which they could pay for further development

work. The Elmes mine, on Happy Creek, a short distance west of the Mohawk mine, was idle during most of the season, owing to inability of the owners to agree on a satisfactory plan of operation. As a result Earl Pilgrim, the former manager, in the course of examinations in the same general region, discovered a considerable showing of lode mineralization at the bottom of an old shaft that had been sunk to prospect for placer ground. Mr. Pilgrim and associates took hold of the task of tracing out the course of the vein underground and doing the other necessary work. The work proceeded slowly because of gases encountered in the shaft, but when the property was visited in August, 1929, a strong vein had been disclosed that justified further explorations. This prospect was locally known as the Irishman claim. No active steps had been taken up to the end of 1929 in the opening up of the old Ryan lode, on Ester Dome, which it was reported had been taken over late in 1928 by an English company that proposed to carry on large-scale operations there. The current reports indicated that this project was only deferred and that probably in 1930 the necessary preliminary steps would be taken to open up the property.

In the vicinity of Pedro Dome the greatest production of lode gold was reported from the Hi Yu mine of Crites & Feldmann and the McCarty mine of the McCarty & Ewers Gold Mining Co., both of which are in the valley of Fairbanks Creek; from the Wild Rose mine of Heath & Kearns, on Dome Creek; from the Wyoming mine of Wackowitz Bros. & Nelson and the old Rhoads-Hall mine of the Cleary Hills Mines, both in the valley of Bedrock Creek, a tributary of Cleary Creek. Although all these mines are small, the returns on the capital involved or on the effort put forth in their development seems highly remunerative and encourage a belief that even larger returns might be received if the country were more thoroughly explored and developed on a larger scale. In addition to the productive mines specifically mentioned above there were other prospects widely scattered through the district at which some work was done during the year, though at most of them it amounted to but little more than the assessment work required by law.

Among the gold-lode producing districts grouped in the table on page 13 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; in the Kuskokwim region at the old Pearson & Strand mine, on a tributary of Nixon Fork; and in the vicinity of Valdez, in the Prince William Sound region. In the Nuka Bay region the greatest amount of gold was recovered from the Sonny Fox mine, operated by Babcock & Downey. The showings on this property

continued to be very encouraging, and the plant was in operation from the later part of May to early in October. The ore is a sulphide which is oxidized as far down as the developments have been carried. The ore is tested in an Ellis mill having a capacity of about 4 tons in 24 hours; the tailings from the mill are concentrated, and the concentrates are shipped to a smelter in the States. The amount of stoping ground that has been opened up and the small capacity of the mill have led the owners to consider enlarging the plant, and according to late reports a larger mill was to be ordered and placed in commission as early in 1930 as practicable. At the Alaska Hills mine only the usual assessment work was done during the year. At the property of the Nuka Bay Mining Co. about 95 feet of tunnel was driven in the course of development work, but the mill was not in operation.

In the vicinity of Girdwood some prospecting and development work for gold lodes was in progress at several places near the head of Crow Creek, but the projects were all small and yielded only a little ore or gold. Farther south on Kenai Peninsula proper the Lucky Strike mine, on Palmer Creek, under the management of John Hirshey, reported the greatest activity. The mill at this property was in operation from June 20 to October 4 and not only recovered much of the gold in the battery and on the plates but also produced several tons of concentrates on the table. The concentrates were shipped to a smelter in the States. Most of the tailings were impounded so as to be available for further treatment by cyanide or some other process at a later time. Several small lode-gold prospects at which a little work was done during the season were also reported at a number of points near the Alaska Railroad in that part of its course that crosses Kenai Peninsula. At most of these places, so far as known, the work amounted to practically no more than the annual assessment work required by law. Among the largest of these properties may be mentioned that of the Lakeview Mining Corporation, near Seward, where considerable underground work was accomplished, necessary changes were made in the mill, and new machinery installed, and the Baughman & Swetmann claims, near Moose Pass, where about 140 feet of adit was driven.

In the Kuskokwim Valley the only lode-gold production reported came from the old Pearson & Strand mine, on Ruby Creek, in the Nixon Fork district, which was operated by Charles Mespelt. No details regarding the recent developments at this mine are available, but apparently from the output of gold the work must have been carried on at approximately the same rate as in 1928. Although no other mine in this district reported having produced any lode gold in 1929, it was learned that prospecting was in progress at the old

Whelan mine. This work consisted mainly in the digging of several surface trenches in search of veins worthy of more intensive examination. It is reported that in the course of this work some ore was found that appeared of sufficiently high grade to justify the owner in undertaking its development during the winter.

In the western part of the Kuskokwim Valley some prospecting was done by Henry Oman on quartz lodes that are said to carry some gold and to have been traced for several hundred feet. A company known as the Golden Butte Mines (Inc.) is reported to have been formed to develop this property.

Interest in the development of quartz lodes was revived in the Valdez and near-by parts of the Prince William Sound region by the entry of several new companies to undertake the operation of some of the old properties and by the finding of several new occurrences of ore. In addition to the prospecting and development work being carried on by the Solar Development Co. on certain copper deposits on Knight Island, the taking of the old Granite mine, in the Port Wells district, by a company known as the Port Wells Granite Mines was probably the most noteworthy mining event in this district. A crew of more than 20 men were employed during most of the open season in installing a hydroelectric plant, erecting new buildings, and putting in the necessary equipment for extensive underground developments. This preliminary work was nearly completed before the end of the year, so that the mine should return to the list of producers in 1930. On Mineral Creek, at the Little Giant mine, operated by William Quitsch, a little ore was mined and milled. Some excellent ore was disclosed by Devenney & Dolan in the course of prospecting their property on Mineral Creek. The ore is composed largely of galena but carries considerable gold also. Development work was also reported to have been done on the Ramsay-Rutherford property, near Valdez Glacier; at the Mayfield property, near Shoup Bay; and at a prospect at Portage Bay. Prospecting for gold lodes was continued in the Tiekel region, but no report has been received as to the results accomplished. The results of the season's work throughout the Valdez region have been such as to give good promise of an even greater increase in mining activities there in 1930.

Prospecting for gold lodes was also continued at many places throughout the Territory, though at none of them, so far as known, was any ore produced. In the Copper River region several prospects were under development in the Kotsina-Chitina area. On the property of the Nabesna Mining Corporation, under the management of Carl Whitham, prospecting by shafts and drifts was continued in 1929, and the company proposes to undertake a more extensive

development program in 1930, with the aim of putting the mine on a producing basis in 1931. In the McKinley Lake district the Lucky Strike Co. rebuilt several of the buildings that were destroyed by fire in 1928 and continued driving the crosscut, which is now estimated to have a length of 320 feet but whose breast is still 470 feet from the vein that the owners are seeking. In the Chandalar region no work was reported to have been done on the gold-lode properties during the year, but the owners stated that they planned to freight in a 4-stamp mill during the winter of 1929–30 and to erect it during 1930. In the hills west of the Chulitna River, between Ruth and Eldridge Glaciers, Roy and Elmer Boedeker report finding several ledges of mineralized rock carrying considerable gold. The leads are from 10 inches to 2 feet wide, trend southeast, and stand vertical in a country rock of slate and graywacke. The country is extremely difficult of access, so that the prospectors ran out of supplies and could not spend much time in their examinations. The assays of the specimens they brought out showed so high a tenor in gold that they plan to return in 1930 and carry on more extensive prospecting. No work was done at the Mint Ruby Silver mine during the year, but some prospecting was done in its general neighborhood.

A little prospecting was done on the Garnet claims, near Flat, in the Iditarod region, and a narrow stringer of gold-bearing quartz was found. In Seward Peninsula further development work was carried on at the Hed & Strand mine, north of Nome, but no reports have been received as to the work accomplished. 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. Rumors were afloat that steps might be taken shortly to reopen the old Big Hurrah mine, in the Solomon district, but so far as learned nothing was done in 1929 to effect this purpose.

Announcement has been made in the newspapers of a discovery of rich leads of gold-bearing quartz on Popof Island, in southwestern Alaska. In addition to the gold the ore is said to contain sulphides of lead and zinc. In the period from 1890 to 1905 several million dollars in gold was recovered from mines on Unga Island, which lies not more than a few miles west of Popof Island, so that there is good likelihood of the geology of parts of the two islands being similar. Furthermore, in the past considerable gold has been won from the beach placers on Popof Island, which confirms the belief that mineralization has occurred there. No detailed information regarding the find has been received, so that fuller data regarding its character and location, as well as the results of its exploitation will be looked forward to with interest.

GOLD PLACERS

GENERAL CONDITIONS

Placer mining in Alaska in 1929 returned gold worth about three-quarters of a million dollars more than the amount produced in 1928, 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 about $5,000,000, and in the 11 years since that time it has fluctuated between that amount and $3,000,000; in 1929 it was $4,117,000.

The increased production of placer gold in 1929 is to be attributed to the generally favorable weather conditions that prevailed in most of the placer districts of the Territory and to the realization upon the preparatory work that had been in progress through the preceding year. The success of so many of the placer operations depends upon an adequate supply of water that weather conditions which afford abundant rainfall are regarded by the placer miner as especially fortunate. During the open season of 1929 throughout most of the interior of Alaska, in which many of the placer camps are situated, the rainfall was especially good, so that the streams were maintained at a high stage. The times of break-up of the streams in the spring and freeze-up in the fall were normal.

The early cessation of work in the fall of 1928 by one of the large mining companies on Seward Peninsula, caused by adverse weather conditions in 1927, which prevented the company from preparing enough ground in advance to keep its dredges running late in 1928, was indirectly the cause of the rather large increase in the production in 1929, because the company began work that year with large areas of ground that had been well prepared for dredging. It was therefore able to keep its dredges at work with less interruption and drive them at fuller capacity throughout the open season.

In accounting for the increased production of placer gold the fact must not be overlooked that some of the increase must be attributed to the several years of preparatory work that had been done in developing the extensive project of the Fairbanks Exploration Co., in the Fairbanks district. Although this project began to yield some gold in 1928 it really had its first full season of mining in 1929, and even during part of that season two of its five dredges were in course of construction. There is therefore every reason to believe that an even greater output from this enterprise will be reached with no additional equipment in 1930.

There appears to be some revival of interest in prospecting, though there are still only a few prospectors of the old-fashioned type in the hills. Many of the former prospectors who were the builders of the mining business in Alaska have grown too old to accomplish much, and many of the younger generation that might follow in their footsteps prefer the higher wages, lighter physical labors, and social attractions of the town to the lure of the hills. There seems to be an increasing interest among capitalists in the mining development of the Territory, and doubtless as they hold out incentives for finding workable properties they will discover men ready and willing to undertake the quest. Anyone who remembers the difficulties of the early days and sees the present enormously better facilities, however, has little sympathy with the laments that are often heard as to the difficulties of carrying on prospecting work in remote tracts. It sometimes seems as if we had become so tied to automobiles, railroads, and wagon roads that we forget that the bulk of the placer gold of Alaska was produced practically without dependence on these facilities. It is believed that there are still large tracts of Alaska that 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, it must be admitted, wages appear to be relatively higher and costs lower in the States than in Alaska, so that the wages obtainable offer no keen inducement for a new generation of prospectors to come to Alaska and take part in the search for new placers. This condition, however, is not regarded as permanent, and when conditions change active prospecting will be renewed in the Territory, for the opportunities that await the earnest worker still seem to be very great.

PRODUCTION BY DISTRICTS

The description already given as to the methods used in collecting and interpreting the information that forms the basis of this report indicates 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. 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 largest 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 1929 and 1928

Region	1929	1928	Decrease or increase, 1929
Southeastern Alaska	$10,000	$9,800	+$200
Copper River region	83,000	110,000	−27,000
Cook Inlet and Susitna region	98,000	72,800	+25,200
Yukon Basin	2,058,000	1,876,800	+181,200
Kuskokwim region	165,000	257,300	−92,300
Seward Peninsula	1,698,000	1,056,300	+641,700
Northwestern Alaska	5,000	4,800	+200
	$4,117,000	$3,347,000	+$770,000

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 geologic processes, sorting action such as is 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.

As shown in the table on page 26, the entire placer production from southeastern Alaska in 1929 was worth only $10,000, or approximately the same as in 1928. As in 1928 it came principally from camps in the Porcupine River and Yakataga districts. The chief work in the Porcupine River district was done on the property of the Porcupine Mining Co., which embraces some 65 claims. A crew of 35 men are reported to have been employed during the open season in building flumes and otherwise making the ground ready for hydraulic mining. Most of the preliminary work is now reported to have been completed, so that productive mining can soon be undertaken and carried on continuously through the open season. At four or five small camps, having a total population of eight or ten men, there was some prospecting and development work during the year, but the amount of gold recovered by them was small. These small camps were reported to be situated on Nugget Creek; on the Klehini Flats, near the mouth of the Porcupine River, and on Marble Creek.

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 1929 for several years.

The only other place in southeastern Alaska at which some production of placer gold was reported in 1929 was on Montana Creek, a tributary of the Eagle River, a short distance north of Juneau. Two men were employed at this place, but most of their time was spent in prospecting and preparatory work, so that they produced only a little gold.

COPPER RIVER REGION

In the Copper River Valley there are four 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, Nelchina, and Tiekel districts. As will be noted from the table on page 26, the value of the placer gold produced from the Copper River districts in 1929 was $83,000, or nearly $27,000 less than in 1928. In the Nizina district the bulk of the placer gold came from the properties of the Chititu Mines, on Chititu and Rex Creeks, and the Nicolai Placer Mines, on Dan Creek. At both these properties there was a slight falling off in production from that of 1928. Some difficulty was experienced and some damage was done by high water during the season. About 30 men were employed at these two properties, and there were a few others engaged in prospecting work on their own account elsewhere 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. The production from this camp was somewhat less in 1929 than in 1928. 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. In the Tiekel district one property on Fourth of July Creek reported having taken out a little gold in the course of its development work.

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 generally favorable conditions in 1929 the output of placer gold from this region showed an increase of about $25,000 above that reported in 1928 and was approximately $98,000.

In the Yentna-Cache Creek district there was considerable revival of prospecting, and new localities that appear to afford workable placers were found. Equipment of these properties, however, will be undertaken during the good period for freighting in the winter, so that it will be 1930 before some of them become productive. Heavy rains in the fall caused a freshet that is said to have been the greatest that has visited the Cache Creek district in years, and it caused many operators to cease their operations some three weeks earlier than usual. This high water was particularly disastrous on Cache, Falls, and Dollar Creeks and badly damaged the hydraulic plants and pipes on them. Altogether some 19 separate camps employing a total of 39 men are reported to have been active in the district in 1929. By far the largest operation was that of J. C. Murray, who was hydraulicking benches on Cache and Nugget Creeks. Two other small outfits did some mining on Cache Creek and one on upper Cache Creek. On Falls Creek, a tributary of Cache Creek, H. W. Nagley and associates did considerable work, and on Thunder Creek, also a tributary of Cache Creek, one small camp was reported. A new pay streak was reported to have been found in the creek bed on Dollar Creek, and that property, which has remained idle for several years, will probably be operated in 1930 by a crew of at least five men.

On Peters Creek two camps, consisting of one or two men each, were engaged in placer mining. Mining camps of one to three men each were reported as active on Bird, Poorman, Willow, and Long 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. Southwest of the Yentna River, in the Kahiltna Valley and the Fairview district, there were only two or three small camps, consisting of one or two men each, and the production was little more than was recovered in the course of panning. This Fairview district has been very inaccessible, but it is now reached by trail from the Yentna River, and cable crossings have been installed across four of the dangerous streams between Cache Creek and Fairview Mountain.

The producing placer camps on the Kenai Peninsula are situated mainly in the vicinity of Hope, Sunrise, and Girdwood. All of these are small operations, the largest yielding only a few thousand dollars annually and some of them only a few hundred dollars. In the vicinity of Hope the only productive mining reported was on claims worked by Charles Harper and associates on the Resurrection River, which flows into Turnagain Arm near the town. The ground worked lies a few miles south of Hope and is part of the property formerly known as the St. Louis claims. The placer is mined by hydraulicking with water that is brought down by flume and ditch from a point some distance up the Resurrection River. Two or three nozzles were used for driving the pay gravel into the boxes and for stacking the tailings. Many large boulders are found in the deposits and seriously interfere with mining.

Near Sunrise mining was carried on by eight or nine small camps. On Sixmile Creek, near Sunrise, a small amount of placer gold was produced by two small camps, the northern one of which was worked mainly by prospecting methods and the southern one by means of a hydraulic plant. On Canyon Creek, which joins East Fork to form the Sixmile River, the largest camp was that of Plowman, Tolson, Miller & Davies, who were working ground that had been leased from the Canyon Creek Development Co. Farther up Canyon Creek, on the claims formerly owned by Wilson, it was reported that a placer camp was established by Oscar Dahl. About 10 miles above the large camp on Canyon Creek Michaelsen and others were hydraulicking gravels at the head of Blue Gulch. Only one group of miners were mining on Lynx Creek, which is 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 recovered at the Holmgren property. Near Girdwood, on California Creek, Dawson and associates were engaged in prospecting and preparatory work required in opening up a tract of placer ground that will probably be mined in 1930. During the year this group cleared a considerable tract of lowland that is to be mined, constructed a dam about 3,000 feet above the bridge on Crow Creek, and built the necessary buildings, which include a sawmill. The hydraulic pipe and other required equipment will probably not be shipped in until 1930.

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. Although no new finds were reported to have been made during 1929,

the returns to the few placer operators who were in the district appear to have been especially satisfactory, and plans were formulated for a much more extended program of mining in 1930. The supply of water was abundant through the open season, and as a result the output from that district was 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. Some 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. Considerable agitation has been started to induce the Alaska Road Commission to construct a road into the district from Cantwell, on the Alaska Railroad, and several petitions to further this object have been circulated. Such a road would doubtless be of great service in opening up this country, which can be reached during the summer time only over a trail that makes haulage charges almost prohibitive.

A small amount of placer gold was recovered from Grubstake Gulch, in the Willow Creek district. A very small amount was also recovered from beach placers on Kodiak Island. This may be significant as marking the renewal of prospecting of these beaches, which in the past have yielded considerable gold.

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 18 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 Yukon 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 1929 was worth $2,058,000, an increase of more than $180,600 over the corresponding figure for 1928. The increase is largely attributable to the extensive 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 1929. In the following table the districts are arranged in order of their placer production in 1929, and for comparison the production from the same districts in 1928 is given. The total is believed to be correct as stated, but the distribution of this total among the districts is open to some 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, 1929 and 1928, by districts

District	1929	1928	District	1929	1928
Fairbanks and Richardson	$1,145,080	$947,500	Ruby	$36,000	$21,800
Iditarod	277,000	296,200	Eagle	16,000	16,500
Innoko	142,000	133,300	Kantishna and Bonnifield	10,000	11,800
Tolovana	118,000	151,000	Chisana	7,000	16,000
Circle	109,000	80,500	Marshall	5,000	3,560
Hot Springs	82,000	77,000	Rampart and Gold Hill	5,000	7,500
Fortymile	68,000	79,100			
Koyukuk and Chandalar	38,000	54,900		2,058,080	1,876,500

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 other 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 the Chatanika River and Goldstream; the Fairbanks Gold Dredging Co., on Fairbanks Creek; the Tanana Valley Gold Dredging Co. (Ltd.), 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 noteworthy mining feature of the Fairbanks district was the work accomplished on the extensive project of the Fairbanks Exploration Co., embracing the dredging of extensive tracts on Goldstream and Cleary Creeks and the Chatanika River, as well as ditch maintenance and operation from water supplies as far distant as Faith Creek, near the head of the Chatanika. The actual mining operations on this project began in 1928 with the construction of three dredges, the last of which was not completed until September. Two of these dredges were built during the winter and one during the summer. The experience gained in the assembly of these dredges led the company to conclude that the work could be done more economically during the summer, and as a consequence the two dredges that were assembled in 1929 were both built during the summer but not completed early enough to have much more than trial runs during that year. All five of the dredges, however, have now been broken in and should be in excellent condition to put in a full season's work in 1930. One of the two new dredges was built in the Wagner pit, in Goldstream Valley a short distance above Fox, and the other was built on Cleary Creek a short distance below the old town of Cleary and just downstream from the point where the large siphon crosses the creek. In addition to the productive work on this property there was necessarily a great deal of preparatory work that was in progress. In order to prepare the ground which is to be dredged in 1930, extensive equipment for cold-water thawing had to be installed, and scores of miles of pipe required in this work maintained and operated. The long main ditch and even the shorter lower ones had to receive constant attention, as is necessary with any new construction of this sort. The general work of building these ditches had been so well done that no unusual difficulty in their maintenance was experienced, though in a few places where they crossed frozen ground some breaks occurred which, though troublesome, were quickly repaired. The whole development of this project has been

so thoroughly analyzed, carefully planned, and efficiently conducted that little of its success has been left to chance, and it is an illuminating example of sound modern mining practice.

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. Four small camps on Tenderfoot Creek employed a total of four men during the season. Two small camps of two men each 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 practically all of them were only development work. In the vicinity of the Jarvis Creek Basin, however, prospectors were at work on Savage Creek and on McCumber Creek and its tributary, Morning Star, and are said to have taken out a small amount of gold. On Rainy Creek and its tributaries, which in turn are tributary to Big Delta Creek, two men did some work on four claims, but so far as reported this consisted of little more than prospecting and preliminary development.

Placer mining in the Iditarod region was carried on in 1929 at practically the same rate as in 1928, and both years mark an especially high production. The large output was due to the extremely favorable weather whereby there was an abundance of water for sluicing and other mining purposes. The bulk of the gold recovered was mined by the dredges of the J. E. Riley Investment Co. and the North American Dredge Co., the former situated on Otter Creek about 2 miles from Flat, and the latter digging on the site of the old town of Flat. In addition to the dredge at Flat, four other outfits were mining on Flat Creek. The largest of these was the hydraulic plant of Strandberg & Son, near the head of the creek. The largest hydraulic and open-cut placer mining in the district was that of the Chicken Creek Mining Co., under the management of William Duffy, who employed about 20 men. Several camps were maintained on Willow Creek, the largest of which were those of Manley and of Manley & Loranger. Two placer camps were hydraulicking on Otter Creek, the larger of which was that of Peter Miscovich, and the other was that of Martin W. Roslund. Two or three camps on other creeks in this same general district, including those of Olsen & Co. on Happy

Creek, Sakow & Co., Frank Lusher, and Frank Salen, are reported to have produced some placer gold during the season. Throughout the district there was a feeling of satisfaction with the mining results achieved in 1929 and a conviction that if the water supply was as good in 1930 an equal or even greater output would be maintained.

Reports from the Innoko district indicate that placer mining there in 1929 yielded considerably more gold than in 1928. A considerable part of this output came from the four dredges that were mining on streams in the district—two on Ganes Creek and one each on Yankee and Little Creeks. The Little Creek dredge and the one near the head of Ganes Creek were run for only a short part of the season. The company mining with the dredge on Little Creek, however, carried on extensive cold-water thawing operations so as to prepare the ground for further dredging in 1930. Altogether about 75 men were mining in the district in 1929. In addition to the dredges, there were several camps mining on Little and Ganes Creeks, three camps on Ophir and Cripple Creeks, and one each on Anvil and Spruce Creeks and Victor Gulch, as well as one camp in the Tolstoi district, which in this report is considered part of the Innoko district. Most of the larger plants in the Innoko district other than the dredges used various forms of dragline scrapers or hydraulic methods. Near the lower end of Ganes Creek two prospectors have for several years been doing some extensive testing with a drill, in an attempt to determine whether that tract is suitable for dredging. No decision in this matter has yet been reached, but current reports indicate that the ground tested in 1929 was somewhat better than had been found heretofore.

In the Tolovana district, which in this report as well as in the preceding volumes of the series has been extended to include Nome Creek, a tributary of Beaver Creek, there was a falling off in placer-gold production in 1929 of over $30,000 from that of 1928. This decrease is attributed to the fact that whereas most of the placer camps of interior Alaska had a plentiful rainfall in 1929, the Tolovana district seems to have received very little rain, and as a result very little water was available for use in mining. The greater part of the placer gold produced in the Tolovana district was mined by the dredge of the Nome Creek Dredging Co., under the management of Sam Godfrey. This dredge is reported to have handled much more gravel in 1929 than in 1928, but the average tenor was lower, so that not quite as much gold was produced as in the earlier year. The difficulty and cost of bringing wood to the dredge for fuel has led the owners to plan to install Diesel engines on it next season. Exclusive of the gold mined by this dredge, about half of the placer gold produced by mines in the Tolovana district comes from drift

mines, which are worked mainly during the winter and the pay dirt sluiced during the summer, and the other half comes from hydraulic or open-cut mines. 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.

The production of placer gold from the Circle district in 1929 was almost $30,000 more than in 1928, although this was considerably less than in the preceding years when the dredge of the Berry Dredging Co. was in operation and there were many more miners in the region. From all accounts the water supply was unusually large, so that there was an abundance for mining. The largest mining operations in the district were those of the Berry Holding Co., on Eagle Creek, and of the C. J. Berry Dredging Co. and J. A. Anderson, on Mastodon Creek. In addition to these the hydraulic plants of Knutson & Larson, on Deadwood Creek, and of Langlow & E. Larsen, on Switch Creek, a tributary of Deadwood Creek, produced considerable placer gold. There were also eight or ten small camps on Bonanza, Miller, North Fork, Harrison, and Independence Creeks, where the ground was worked mainly by open-cut methods and the production from few if any of the individual claims exceeded a thousand dollars. 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 in part by the highway from Fairbanks to Circle, which now makes the district much more accessible, as it joins the formerly remote town of Circle with Fairbanks by less than a day's automobile travel.

The value of the placer gold produced in the Hot Springs district in 1929 was about the same as in 1928, though the source of the gold differed considerably in the two years. For instance, in 1928 the gold came largely from the dredge of the American Creek Dredging Co., on American Creek, and the production from mines of other kinds was rather small, whereas in 1929 the conditions were reversed. The lessened production from the dredge was by no means to be attributed to the exhaustion of the available ground but was due rather to difficulties of management whereby during a large part of the effective open season internal controversies as to the best plan to be followed tied up or hampered progress. Perhaps the most noteworthy news relating to the Hot Springs district was that an English company, which late in 1928 acquired options on large tracts

in the vicinity of Sullivan Creek after carrying on an extensive drilling program to prove up the gold and tin content of the tract, decided that the tenor was not high enough to warrant further work and abandoned the enterprise. In the vicinity of Tofty the largest operations were those of Bock & Hansen and of Tillison & L'Heureux. In the Eureka Creek section of the Hot Springs district the largest operation was that of J. R. Frank & Co., on Eureka Creek, where considerable gold was recovered by hydraulicking. This company also has extensive holdings on Doric, Seattle, and Skookum Creeks. In addition to these larger camps there were a number of others of only one or two men each, which produced some gold, though the output of most of the individual claims was valued at not more than a few hundred dollars.

Placer mining in the Fortymile district yielded somewhat less gold in 1929 than in 1928, but this decrease is in part attributable to the amount of development work in progress, which curtailed production this year but will bring results in 1930. All reports indicate an especially large volume of water available throughout the Fortymile district during most of the summer. In fact, some of the miners who usually work on the bars of the Fortymile River report that most of the bars were under water and therefore could not be mined during the greater part of the season. About 24 separate camps, employing a total of about 50 men, were mining in the Fortymile district in 1929. During the winter some drift mining is done, but most of the gold is produced during the summer by open-cut or hydraulic methods. 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, under the management of Lee Steele, 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 the Chicken River, Franklin Gulch, and Napoleon Creek.

In the Ruby district there was considerable active mining during 1929 which resulted in recovering about two-thirds more gold than was produced from the same district in 1928. Altogether about 13 camps, employing from 30 to 35 men, were engaged in this work. The greatest amount of gold was recovered from placers on Poorman Creek, where four camps, employing a total of 15 men, were at work. The next most productive creeks were Flat, Greenstone, and Moose, but small amounts of gold were recovered from Tamarack, Solomon, Meketchum, Bear Pup, and Big Creeks. Although not properly pertaining to the year covered by this volume, it may be significant to note that early in 1930 the local papers and some published in

the States carried reports of a rich strike having been made on some of the creeks 10 to 20 miles below Poorman, and for a time there was a small stampede of miners into the district. The amount of gold that will be taken from this new strike in 1930 can not of course be determined until the end of the year, but on March 25, 1930, the Geological Survey issued the following statement regarding these reported discoveries:

> The reported finds of new productive ground in the vicinity of Poorman, in the Ruby district, have been made in the same general neighborhood where placer-mining operations have been carried on for many years. To judge from the meager details available the new discoveries seem to have disclosed placers formed under essentially the same conditions as those already known in the region. Although reports from this camp of pans of gravel carrying many dollars are probably true, it is likely to be several months before any real estimate of the production from this find will be available. * * * From what is known of the Ruby region it seems likely that there remain workable placers that have not yet been discovered and probably will repay thorough and intelligent prospecting.

The later newspaper reports from this camp have become much less glowing than those that were printed soon after the new finds were first announced.

There was a very marked shrinkage in the output of placer gold from the Koyukuk district in 1929—so great, in fact, that the production appears to have been less than at any time during the last 30 years. 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 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 area near the head of the Koyukuk indicate that about 20 different camps, employing about 40 men, were engaged in mining there in 1929. By far the largest amount of work was done on Nolan Creek and on the benches near its mouth and for some distance upstream. Some gold was also recovered from placers on the Wiseman River, Lake and California Creeks, tributaries of the Bettles River, Smith, Vermont, Porcupine, and Myrtle Creeks, and the Wild River. Some excitement was caused in the late summer by the finding on Summit Creek of a small boulder of float quartz that was liberally spangled with gold. As the bedrock source from

which this material came may be remote from the place where the boulder was found, it furnished no justification for more than local interest. It does, however, give further proof of the long-known fact that in the upper Koyukuk there are many indications of rich gold mineralization and that diligent search is likely to disclose workable lodes or placers. This fact has led to many attempts to prospect the district more thoroughly, but as it lies in one of the more remote and inaccessible parts of Alaska the accomplishment of that purpose will almost certainly be expensive and call for the persistence and hardihood of the best pioneers. It is reported that plans are under consideration for undertaking the prospecting of part of this area by using airplanes as the means of transportation of the prospectors. The saving of time that could be effected by this means would be of especially great importance in the success of this venture, because the open season in this highland region is so short.

In the Eagle district the production of placer gold in 1929 was slightly less than in 1928. There were 10 camps, employing about 25 men, engaged in mining. The largest amounts of gold appear to have been produced by the July Creek Mining Co. on Fourth of July Creek and by Froelich, Kummer, Ott & Scheele on Crooked Creek, but some gold was recovered from Dome, Alder, American, Nugget, and Broken Neck Creeks, and the Seventymile River. According to local reports much of the season was spent by the miners on Crooked and Dome Creeks in dead work, preparing their ground for more productive development in 1930 and thus curtailing their production in 1929. It is also said that in 1930 a hydraulic plant will be installed on Barney Creek and mining will be more active on Broken Neck and Fox Creeks. The water supply throughout most of the Eagle district was large during 1929—in fact, one prospector reports "floods unlimited."

The Geological Survey has received very little first-hand information regarding mining developments in the Chisana (locally called Shushanna) district. Apparently mining was in progress on not more than five properties during the year, and only about 12 men were employed. The water supply of the district is said to have been especially good, but in spite of this favorable condition the production from the district appears to have been only half as large as in 1928, a year when the supply was rather small. No new discoveries were reported from this district, and the production appears to have come from the less accessible patches of ground that were passed over in the boom days of the camp. The largest amount of gold recovered from this district in 1929 appears to have come from placers on Little Eldorado Creek, owned by Carl F. Whitham and mined under lease by B. J. Lewis. A method of removing the over-

burden through two lengths of sluice boxes with riffles is reported to have worked especially satisfactorily in handling the ground of Bert McKinney on Gold Run Creek in this district.

In the table on page 32 the placer-gold production of the Chandalar district has been combined with that from Koyukuk. The amount of gold that comes from the Chandalar is much less than that from the camps in the Koyukuk Valley. So far as reported practically all the placer gold recovered from the Chandalar district in 1929 came from two properties—those of Bart C. Buckley on Little Squaw Creek and of A. L. Newton on Big Creek. At these properties only about five men were employed. Work at the property on Little Squaw Creek was mainly of a prospecting character, consisting in crosscutting the valley to determine the position and extent of the old channel. No new developments were reported to have resulted from the work of the season.

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 Tatlanika River. The smaller camps were on Marguerite, Daniels, Moose, and Gold Run Creeks and the Bonnifield River, and produced not more than a few hundred dollars in gold each. The production from this district has been combined in the table on page 32 with that from the Kantishna district, but it may be stated that the placer gold from each district was approximately 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 Martin Creeks. None of these camps, however, recovered gold worth as much as $2,000, 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 six or eight camps were active during 1929, and most of these were small 1-man operations that recovered only a few hundred dollars' worth of gold. The greatest amount of gold was recovered from the placers on Little Minook Creek, where there were three camps. Other camps that reported producing some gold were two on Hunter Creek, one on Little Minook Jr., and one each on Slate and Quail Creeks. In the Gold Hill district, which lies west of the town of Tanana and in this report has for convenience been grouped with the Rampart district, a little prospecting was done in 1929 on Grant, Mason, and Moraine Creeks. Only a little gold was recovered in the course of this work, but it is significant as indicating a renewal of mining interest in this district.

Willow Creek was the source of most of the placer gold that was mined in the Marshall district in 1929. 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 annual work that they accomplish in thoroughly prospecting this large tract of country is small. Some placer gold was also recovered from the gravel of Montezuma Creek. About 50 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 has been received by the Geological Survey.

KUSKOKWIM REGION

Included in the Kuskokwim region are four principal districts where gold placers were mined in 1929. 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-gold production from the Kuskokwim region in 1929 was about $50,000 less than in 1928. The falling off was in large measure due to decreased production from the dredge in the Tuluksak-Aniak district, for apparently there was an increase in the production of placer gold by other mining methods. The decreased dredge production appears to have been due to the closing up of the project, for it is reported that that company intends next season to mine in the Fairhaven district of Seward Peninsula, as that district appears to afford an opportunity for much larger operations. No other dredges were in operation elsewhere in the Kuskokwim region in 1929. The dredge that for many years has been so productive in the district near McGrath was again idle, as it was in 1928, and ap-

presently no plans are now under consideration for its early reconditioning. In fact, it is reported that some of the machinery from this dredge has been removed to be used in one of the dredges in the Innoko district.

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 1929 may be mentioned Candle, Ruby, Hidden, and Eagle Creeks and Holmes and Riddle Gulches. There were less than a dozen men employed in this work, and no notable new finds appear to have been made. The greatest amount of gold was recovered from the properties of F. E. Matthews on Hidden Creek and of Pearson & Strand on Ruby Creek. Mining is carried on only during the summer, and most of it is done by ordinary open-cut or simple hydraulic methods. The vast slightly explored or even totally unexplored area that is embraced in the Mount McKinley district is regarded as country that well deserves more thorough examination and intelligent prospecting, not only for workable gold placers but also for other mineral deposits.

Mining in the Georgetown district appears to have been restricted to work on Donlin Creek, where one camp was engaged in mining a bench deposit by means of a small hydraulic plant. Although only a small amount of gold was recovered, the returns in relation to the amount of work and expense involved appear to have been very satisfactory to the operators. 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. Six 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 indicated any notable increase in the output of placer gold. The mine on Canyon Creek was on ground owned by Koamme & Co., which was worked by open-cut methods by two men.

Placer gold mining activities in the Goodnews Bay region were largely suspended during 1929. No mining was reported to have

been done on Wattamuse Creek, though one man did a little sluicing on Bear and Olympic Creeks. The test drilling of a large tract in the Arolie Valley that was in progress in 1928 was not resumed in 1929, and apparently the conditions that were found were not regarded as favorable for undertaking extensive development of the tract at this time. The interest that has been awakened in searching for placers carrying platinum in the country to the south of Goodnews Bay has evidently called away many of the prospectors who heretofore have been searching for gold. As a result the production of gold from this district has gone down while the production of platinum has gone up. As has been noted heretofore in these reports, very little gold is found closely associated with platinum in the placers that are being worked, notably on Clara, Squirrel, Platinum, and Fox Creeks, which are all tributary to Salmon Creek, which in turn empties into Chagvan Bay. Further notes on this work are given in the section of this report which treats of platinum.

SEWARD PENINSULA

The production of placer gold from Seward Peninsula in 1929 was $1,698,000, or about two-thirds of a million dollars more than in 1928. With the exception of 1926, this year marks the greatest production of placer gold since 1917 and has consequently given rise to much optimism as to the revival of mining in Seward Peninsula—a feeling that is by no means unjustified when all the conditions that contributed to this large output are considered. The weather conditions affecting the water supply in the peninsula throughout the open season were good, though by no means abnormal. No new strikes of bonanzas that quickly swell the output and then as suddenly drop off were made. Instead, the greatly increased production seems to have been due mainly to the fact that adequate quantities of ground had been thawed in advance of the large dredges in the Nome region, so that they could be kept running at their full capacity during most of the season. Part of the reason why so much ground had been prepared lies in the fact that, owing to a shortage of adequately prepared ground in 1928, the dredges had been compelled to close down early in the fall, and this and the good supply of water in 1928 gave an opportunity for thawing operations in that year to get ahead and thus prepare more ground for the dredges to mine in 1929.

Approximately $1,519,000, or nearly 90 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 1929 the mining districts of Seward Penin-

ranked as follows: Nome, Fairhaven (including the Candle and Inmachuk districts), Council, the Koyuk River region, Solomon (including the Casadepaga 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 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 ditches and other equipment for properly conducting its work. The sound mining practice and experimental research into the mining problems that arise in connection with its operations make the work of this company watched with great interest by all mining engineers who have to contend with analogous conditions. Near Nome there were three other dredges that reported some production of placer gold in 1929—those of the Dry Creek Dredging Co., the Bangor Dredging Co., and the Osborn Mining Co. The Dry Creek dredge has long been in operation in the district, but it was compelled to stop work early in September because of a conflict as to the ownership of the ground it was mining. The dredge of the Bangor Dredging Co., which for the last few years has been mining on Anvil Creek, completed work there and closed down early in the season. It is understood that the owners are negotiating for the removal of this dredge to a new locality, but the site has not been made public. The Osborn dredge was formerly operating on the Solomon River but was dismantled in 1928 and moved to Osborn Creek, in the Nome district, and reconstructed. It began mining in July and continued throughout the rest of the open season, with satisfactory results. Work on rehabilitating the old dredge on Hastings Creek that has laid idle for many years was continued throughout the year, and at the end of the season that work was reported to be 90 per cent completed, so that it should be ready to resume mining early in 1930. 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 8 to 10 men were employed for most of the open season. The generally favorable stage of water throughout most of the district caused many of these smaller operators to produce somewhat more gold than in the preceding year, and although the production from many of the individual mines did not exceed a few hundred dollars each, they collectively contributed a considerable amount to the total production of the district.

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. Reports received in March, 1930, indicate that the company which has heretofore operated the dredge on Bear Creek in the Kuskokwim region has taken a long lease on the property of the Keewalik Mining Co. and if present plans are carried through will operate the dredges there in 1930. 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, a little productive placer mining was done, and on Gold Run, which enters the Kiwalik River from the west a few miles below Quartz Creek, some prospecting was in progress. In the Inmachuk Valley the principal producer was the hydraulic mine of A. V. Cordovado, on the Pinnell River a short distance upstream from its junction with the Inmachuk. At this property about 24 men were employed throughout the open season, and mining was carried on for 157 days. On the main Inmachuk River, R. Hoogendorn carried on considerable productive placer mining. 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. It was reported that a drilling outfit was shipped to Deering during the summer and was to be used to prospect a tract on Humboldt Creek, which is a tributary of the Goodhope River and which has produced considerable gold in the past, though it has been mined only by simple open-cut methods. The third tract in which placers were mined in the Fairhaven district, that on Bear Creek, lies east of the hills that form the divide between the Buckland and Kiwalik Rivers. No specific reports have been received as to the individual mining operations in that tract, but the absence of news indicates that there have not been any notable developments during the year and that the production was probably maintained at about the same rate as the last few years, when not more than a few thousand dollars was produced annually.

In the Council district, as in the other larger producing districts of Seward Peninsula, most of the placer gold produced in 1929 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, and small outfits were working on Melsing Creek and its tributary Benson Gulch. A little gold was also recovered from Rock and Aggie Creeks, which are tributaries of the Fish River. Although there were several individual prospectors scattered through the region adjacent to Council, the amount of mining has been so reduced that in 1929 the office at Council for recording claims was officially closed, the district was formally made part of the Nome district, and all the records were removed to Nome. In the report for 1928 attention was called to the finding of some showings of gold on June Creek, a small stream that rises in the conglomerate hills between the Kwik and Tubutulik Rivers. Apparently further prospecting in this valley failed to disclose workable placer ground, for in 1929 the stream was reported to be deserted.

The Koyuk district, as the term is used in this report, 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. One camp, employing 3 men, was mining during the winter, and 5 camps employing a total of about 12 men, during the summer. All these camps were situated on Dime Creek except one on Sweepstake Creek. No mining was in progress on the right fork of Sweepstake Creek, although some work had been in progress there during 1928.

Only one dredge was engaged in placer mining in the Solomon district in 1929. This was the dredge of the Goldsmith Dredging Co., on the Solomon River near Coal Creek. The dredge of the Shovel Creek Mining Co., which for several years had been mining on Shovel Creek, a western tributary of the Solomon River, was sold to an organization composed of Fred Jones and others, who have dismantled it and are moving it to a tract of placer ground on Spruce Creek, where it will be rebuilt and, it is hoped, will be in condition to mine during the season of 1930. Spruce Creek lies some 6 to 7 miles east of Solomon and flows directly into Bering Sea. The dredge of the Casadepaga Mining Co., formerly known as the Peck dredge, which mined in the main valley of the Casadepaga River near the mouth of Canyon Creek, was practically the only producer of any appreciable amount of gold in the entire Casa-

depaga region in 1929. 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 a few small placer mines were operated in 1929. 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 1929 on the beach claims at Bluff, which had been equipped during an earlier year with a novel scraping plant.

Placer mining in the Kougarok district, in central Seward Peninsula, was done entirely by hydraulic and open-cut methods. Most of the camps in the Kougarok district were small one or two man affairs, and the largest employed only three or four 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 rather remote properties is that of the Dick Creek Mining Co., on Dick Creek, which lies north of the Kougarok and flows into the Serpentine River. At this place a unique method of stacking tailings has been in use for several years. The ground for most of the season was of very low grade, but just before the end of the season it prospected much better, and the owners look forward to a much larger production in 1930. One of the items of general interest regarding the Kougarok district was that the Coffee Creek Mining Co. spent much of the summer in surveying for patent a tract of some 1,400 acres of placer ground on Coffee Creek and its tributary Camp Creek. The lower 2 miles of Coffee Creek and much of the bench ground near it had already been patented several years ago, so that with the newly surveyed ground the company will hold more than 2,000 acres in that valley. No plans for the development of this tract have yet been announced. 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 employing several men was engaged in constructing a ditch to lead water for use in hydraulicking placer ground on that stream. The entire production of gold from the Iron Creek region, however, was so small that it amounted to little more than wages for the men concerned.

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 few years reports have been current that a dredge was to be installed on an extensive tract of placer ground on the Bluestone River. No further steps appear to have been taken during 1929 to carry out this plan. Several other projects to build dredges in the Port Clarence district have been rumored. Thus, it is stated that a company was dismantling one of the old dredges in the Nome region preparatory to transporting it to Deese Creek, some 4 miles east of Teller, where it would be reconstructed and commence mining. Another area where it was reported that dredging might be undertaken in the near future was on Budd Creek, a tributary of American Creek, which in turn is a tributary of the Agiapuk River, which flows into Imuruk Basin.

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 several 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 slate and sandstone 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 the ancient beaches will prove to be gold bearing, however, depends on the occurrence 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 1929. 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 two separate patches of placer ground on Klery Creek and its tributaries. The proved occurrence of gold in this area 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 little more than a meager grubstake 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 that 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 1929 there were five small camps, employing a total of 14 men, established on streams in the vicinity of Shungnak. Two 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 about five men are employed and mining is carried on by hydraulicking. 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. This work was done by the Northwest Alaska Mines under the general direction of Col. G. W. Rathjens, formerly of the Fairbanks Exploration Co. This company recognizes the fact that the Shungnak region is in general so inaccessible that an extensive tract of placer ground must be found if a mining enterprise in that region is to be successful, and therefore the company is not interested in finding small local deposits. Though no official statement has been given out by the company as to the results of its tests, the fact that it proposes to continue its prospecting of the area in 1930 indicates that the results so far have been encouraging. The most serious difficulty apparently has been that

of developing adequate transportation facilities to the region. Airplanes have been extensively used in transporting the men and equipment from Fairbanks, but with the breaking down of the regular airplane service to assist in the search for Col. C. B. Nielson a delay of several months in transporting one of the men resulted.

Near the head of the Kobuk a little prospecting is said to have been carried on by three men on the Reed River, but no report has been received as to the results of their search. The party of miners that visited the Walker Lake region in 1928 apparently did not return to that region in 1929, and so far as learned no prospecting was in progress there during the year. A group of natives is said to have gone into the Lucky Six region, at the head of the Noatak, for the purpose of prospecting that area, but no news has been received as to the work they accomplished.

DREDGING

Over 71 per cent of all the placer gold produced in Alaska in 1929 was mined by dredges. The total gold recovered by dredges was $2,932,000, of which the greater part came from 12 dredges in the Seward Peninsula region and the rest from 18 dredges in other parts of Alaska, notably in the Fairbanks district of the Yukon region. This total exceeds by nearly three-quarters of a million dollars the amount recovered by dredges in 1928, and the increase is largely due to increased production from the Nome dredges and to the new large dredges installed in the Fairbanks region. In fact, this total exceeds the amount heretofore produced by dredges in any year since this method of mining was started in Alaska. 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, 1903–1929

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	24	2,679,000	3,900,000	$0.69
1917	36	2,800,000	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	1,582,820	2,709,519	.57
1922	23	1,767,753	3,188,343	.55
1923	26	1,848,596	4,648,053	.40
1924	27	1,563,361	4,342,667	.36
1925	27	1,572,312	3,144,624	.50
1926	32	2,291,000	5,720,000	.40
1927	28	1,740,000	6,094,000	.29
1928	27	2,155,000	6,371,000	.34
1929	30	2,932,000	8,709,000	.336
		39,008,000		

The total value of the gold produced by dredges since 1903 is about 15.3 per cent of the total value of gold produced from all kinds of placer mining since 1880, and lately there has been a constant tendency each year for a greater and greater percentage of the placer production to be mined by dredges. During 1929 the ratio of dredge production to the output from all other kinds of placer mining was 71 to 29, 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 subject 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 $2,729,257 in gold, or a little more than 98 per cent of the total mined by dredges, report that that amount came from 8,107,276 yards of gravel. The average yield thus shown is about 33⅔ cents in gold to the cubic yard. Applying this average to determine the unreported yardage gives a total of 8,709,600 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 six years, so that the quantities and values given for 1929 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 average tenor of the ground dredged in 1929 was slightly less than the average of the ground dredged in 1928, though considerably lower than the average for most of the preceding years.

The length of time that the different dredges were operated varied widely. The longest season reported was 232 days for one of the dredges of the Fairbanks Exploration Co., which was operating in the Fairbanks district of the Yukon-Tanana region. This stands as the record for the longest working season that has been attained by any of the dredges operating in Alaska. The longest season reported for any of the Seward Peninsula dredges in 1929 was for one of the dredges of the Hammon Consolidated Gold Fields, at Nome, which mined for a period of 158 days. The earliest date for beginning work in the spring and the latest date for ending work in the fall

were reported by the Fairbanks Exploration Co., which began mining May 8 and did not stop its last dredge until December 22. The earliest date for beginning dredging on Seward Peninsula in 1929 was May 18 and the latest date for ending was October 24, both reported by the Hammon Consolidated Gold Fields. The average length of working season of the 14 dredges for which information is available (and in determining this average only one dredge each is counted for the Fairbanks Exploration Co. and the Hammon Consolidated Gold Fields, instead of the five and three operated by these companies, respectively) was 109 days. Obviously, the shorter average season was not imposed by climatic conditions but was due to breakage or some purely personal reasons at the different dredges. The lesson that is demonstrated by the record of the long working season of the dredge at Fairbanks is that for moderate-sized dredges handled skillfully a season of more than 200 days may be achieved at almost any camp in interior Alaska, and that under ordinary conditions a working season of more than 175 days may be attainable by most modern dredges almost anywhere in the Territory south of the Arctic Circle.

Although, as stated, the longest working season for any one dredge so far reported was attained in 1929, it must not be inferred that climatically this was an exceptional season. The records for 1926 show that in that year a dredge began work in the Cache Creek district on May 5 and a dredge in the Nome region did not shut down until December 4. In other words, in 1926 these two dredges spanned a working period of 213 days.

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

Yukon Basin:
- Fairbanks district—
  - Chatham Gold Dredging Co. — Chatham Creek.
  - Fairbanks Exploration Co. (5) — Goldstream and Chatanika River.
  - Fairbanks Gold Dredging Co. (2) — Fairbanks Creek.
  - Tanana Valley Gold Dredging Co. (Ltd.) — Fish Creek.
- Hot Springs district—American Creek Dredging Co. — American Creek.
- Iditarod district—
  - North American Dredge Co. — Otter Creek.
  - J. E. Riley Investment Co. — Do.
- Innoko district—
  - Flume Dredge Co. (2) — Yankee and Little.
  - Gibbs & Elson — Ganes Creek.
  - Innoko Dredge Co. (Hans Erickson, lessee) — Do.
- 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—Conner, Erichinger & Hanot — 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.
- Nome district—
  - Bangor Dredging Co — Anvil Creek.
  - Dry Creek Dredging Co — Dry Creek.
  - Hammon Consolidated Gold Fields (3) — Old beach line.
  - Osborn Mining Co — Osborn Creek.
- Solomon district—Goldsmith Dredging Co — Solomon River.

During 1929 one dredge that had been active in 1928 was idle, but some mining was done by three old dredges that had not been in operation in 1928 and by two new dredges that were constructed in 1929. The net result of these changes was that the total number of active dredges in 1929 was 30. The dredge that was active in 1928 but idle in 1929 was that of the Shovel Creek Mining Co. on Shovel Creek, in the Solomon district of Seward Peninsula. This dredge was sold during the year and was being dismantled and moved to Spruce Creek in the same district. It was being reerected in 1929 and should be in operation in its new location before the end of 1930. The three old dredges that renewed mining in 1929 were one of the dredges of the Flume Dredge Co. and the second dredge on Ganes Creek, in the Innoko district, and the dredge of the Osborn Mining Co. on Osborn Creek, in the Nome district. The Osborn dredge was formerly on the Solomon River and was moved to its new location and reconstructed during 1928, so that by July, 1929, it was ready to resume mining at the new tract.

The two new dredges were both the property of the Fairbanks Exploration Co. and were erected during 1929 on the company's property near Fairbanks. One of the dredges was built in the old Wagner mining pit, a short distance east of the town of Fox, and the other was built just opposite the old settlement of Cleary, on Cleary Creek below the point where the large siphon crosses that stream. Both of these dredges were built during the open season of 1929, so that it was late in the fall before they were completed and began mining. Evidently the experience that the company gained in 1928, when it built two of its dredges in the winter and early spring and one in the summer, had proved that construction during the summer was much more economical than during the winter, even if by so doing the company lost the use of the dredge for most of that season. All the five dredges now owned by the Fairbanks Exploration Co. are models of up-to-date, efficient machines so designed as to be adapted to the special conditions that will be met in the indi-

vidual places they are to mine. Much of the placer ground at practically all the places where dredges are now working in Alaska is more or less completely frozen, so that extensive plants for thawing it must be available. This adds heavily to the cost of the work, and unless the thawing has been done adequately, it slows up or actually checks mining. Most of the dredge camps are now using cold water for thawing, though in the past steam or hot water was thought to be necessary. At any large dredging operation, such as at Nome or Fairbanks, miles of pipe are used for the thawing process, and the largest force of workmen required comprises those employed in the various tasks connected with the thawing of the ground in advance of mining. Another large expense connected with most of the dredging camps in interior Alaska and Seward Peninsula is the obtaining of an adequate water supply. In places it has been necessary to go scores of miles to get water under sufficient head and then lead it by means of long ditches and siphons to the mining ground. The regulation of this water and the maintenance of the ditches requires the constant attention of a considerable force of men throughout the working season, especially if the construction is new and adjustment has not taken place.

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 a tendency to regard the dredge as a magic method by which even worthless deposits may be mined at a profit, so that a word of caution may not be amiss to those who are considering investment in some of the projects. The amount of money needed to finance the building of a dredge and furnish the necessary equipment 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.

Among the places where prospecting is said to have been in progress recently with a view to determining their suitability to dredging operations may be mentioned the tracts in the vicinity of the Bluestone River, in the Port Clarence district of Seward Peninsula; in the vicinity of Shungnak, in northwestern Alaska; on the Goodhope River, in Seward Peninsula, a short distance west of Deering; in the northern part of the Nome River and adjacent parts of the Beaver River, in the Yukon-Tanana region; on Budd Creek,

north of Imuruk Basin in Seward Peninsula; and near Bonanza, on the coastal plain east of Norton Sound. It is reported that the New York Alaska Dredging Co. proposes to drill extensively in the Livengood region with a view to testing out a tract that may be suitable for dredging. The prospecting for dredging ground that has been going on for some time in the Arolic Basin in the lower Kuskokwim region appears to have been suspended, and no further drilling was done there in 1929. 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, 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. Besides the copper recovered from these mines a few tens of thousands of pounds of copper was reported to have been recovered in 1929 at a smelter in the States from ores and concentrates shipped from southeastern Alaska. Also some placer copper was shipped to the smelter from the gold placers in the Nizina district. The total amount of copper recovered from Alaskan ores in 1929 has been taken as 40,510,000 pounds, valued at $7,180,000. The bare statement of the quantity of copper produced is more or less meaningless, however, 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 40,000,000 pounds a loss of only 1 per cent is equivalent to 400,000 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.,[3] are significant. This

[3] Mother Lode Coalition Mines Co. Eleventh Ann. Rept., for 1929, 7 pp., 1930.

company in 1929 mined 57,177 tons of ore that assayed on the average 11.14 per cent of copper, which would be equivalent to 12,738,935 pounds of copper. Shipments to the smelter from the mine, however, were reported to contain only 12,242,740 pounds of copper. Evidently nearly 500,000 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 less than 3.9 per cent, which really indicates a very high mill recovery and exceptionally good practice.

The total copper-bearing ore mined in Alaska in 1929 is estimated to have been 590,400 tons and to have had a copper content of about 43,340,000 pounds. When this ore had been concentrated and was ready for shipment to the smelter it had been reduced so that it had a copper content of 40,510,000 pounds, which represents a recovery of nearly 93.5 per cent of the copper that was contained in the original ore as mined. For the purposes of the present report this has been adopted as the amount of copper yielded by Alaska mines during 1929.

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 1929, according to computations by the Bureau of Mines, was 17.6 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 $7,130,000. 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 that part of its copper which it sold is stated in its annual report to have been 18.157 cents a pound, and the other large company apparently received approximately as much. 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 1928 and that of 1929 there was a decrease of about 911,000 pounds in quantity, though because of the higher price received in 1929 the smaller amount of that year was valued at $1,165,000 more than the larger amount of the earlier year.

Copper and silver produced at Alaska copper mines, 1880, 1900–1929

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	57,011,397	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
1929	590,400	40,510,000	7,130,000	351,730	187,400
	10,387,200	1,189,989,000	208,008,000	11,373,260	8,577,400

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 1929. 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 55,348,000 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.

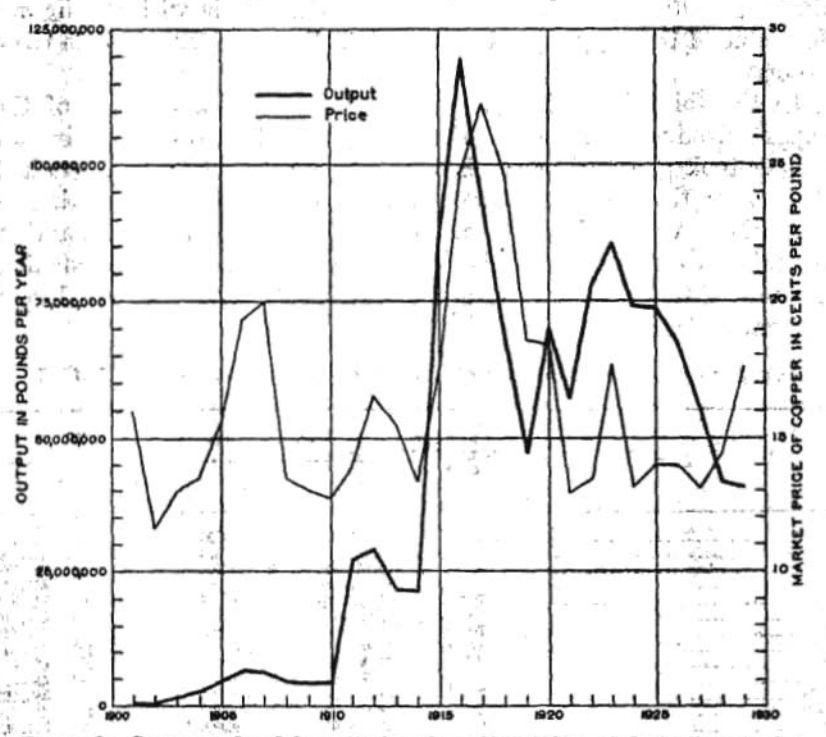


FIGURE 3.—Copper produced from Alaska mines, 1900–1929, and fluctuations in the price of copper during that period

No new developments of note were reported at the productive mines of the Kennecott Copper Corporation at Kennecott, in the Copper River region, during 1929. 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 [4] 79,955 tons of ore was mined during

[4] Kennecott Copper Corporation Fourteenth Ann. Rept., for 1929, p. 7, 1930.

the year, which was estimated to have an average content of 11.86 per cent of copper and 2.25 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 report of this company[5] shows that during the year 57,177 tons of ore was mined, which had an estimated content of 11.14 per cent of copper and 1.85 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[6] 452,962 tons of ore was produced in 1929, which had an estimated content of 1.28 per cent of copper and 0.243 ounce of silver to the ton.

One new company was added to the list of Alaska mines that produced a significant amount of copper in 1929. This was the Solar Development Co., which has recently taken over the old Rush & Brown and Salt Chuck properties on Kasaan Peninsula, Prince of Wales Island, in the Ketchikan district. Some notes regarding this property are given on page 17, in the descriptions of the places where lode gold was produced. This company during 1929 was engaged principally in development work and did not mine any ore. However, the operators found considerable ore in the bins that had been mined and sorted by the earlier owners, and this ore they shipped to the Anyox smelter in British Columbia. From this ore gold, silver, and several tons of copper were recovered. As plans were in progress for the active reopening of this mine, it seems probable that an increasing output of copper from this part of the Territory may be looked for in the near future, unless the decreased price paid for copper dissuades the operators from pressing on the development until better prices prevail.

Some of the copper produced in Alaska in 1929 came from float copper nuggets recovered in placer-mining operations. Copper nuggets of this sort have been found for many years in the course of gold-placer mining in the Nizina district, and at some of the properties the copper is put aside when the gold is being separated from the concentrates of the other heavy minerals. In the course of time

[5] Mother Lode Coalition Mines Co. Tenth Ann. Rept., for 1929, p. 3, 1930.
[6] Kennecott Copper Corporation Fourteenth Ann. Rept., for 1929, p. 7, 1930.

these accumulations of copper nuggets are shipped to the smelter and the copper recovered. During 1929 several tons of copper was recovered from this source, and it has been credited to the production of that year, though probably the material was collected during a period of several years.

Probably the most active prospecting for copper lodes that was in progress during 1929 was at the Nelson prospect on Glacier Creek, in the Chitistone region, and at the Dickey property, on Knight Island, Prince William Sound. The ore found on the Nelson property was of the same general type as that being mined at the large producing mines near Kennecott. An arrangement was entered into whereby the Kennecott Copper Corporation was to undertake the exploration of this ground. As a result a crew of 15 to 20 miners were employed throughout most of the year in carrying on the necessary investigations. No statement as to the results of this work has been given out by the company, and it will doubtless take considerable outlay of time and money to determine the true value of the deposit. The keenness of the Kennecott Copper Corporation to find and develop ore deposits in the region tributary to the Copper River & Northwestern Railroad gives assurance that a thorough test will be given to the property and that every effort will be expended in trying to develop it into a producing mine.

The prospecting of the Dickey property has been carried on by the Solar Development Co., a subsidiary of the Consolidated Mining & Smelting Co., a Canadian company. Prospecting and development work has been proceeding at this place for more than a year with a considerable crew. Although no authoritative statement regarding the results so far obtained has been given out, the continuation of the work indicates that the finds have been adequate to encourage the operators to complete a thorough examination of the property.

More or less prospecting and development work is reported to have been done at several of the mines in the Copper River region and adjacent country that have produced some copper in the past, but so far as learned none of them shipped any ore during 1929. Among these more or less inactive properties may be mentioned the Copper Creek mines, in the Kotsina district, and the property of the Alaska Nabesna Corporation, north of the Alaska Range. Plans for more active development at both these properties are contemplated in the near future. No work was reported to have been in progress during the year at the Green Butte mine, on McCarthy Creek. Considerable renewal of interest in mining of all kinds was manifested in the Valdez district, and as a result not only have some of the old gold mines been reopened, as already noted, but prospecting for lodes of copper and other metals has been stimulated.

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 metal. Thus, as shown by the table below, silver to the value of $187,400 was received in 1929 from ores that are valuable principally for the copper they contain. This source alone accounts for nearly 75 per cent of all the silver that was produced in Alaska in 1929. 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 two-thirds of an ounce to a ton of ore, and the ore from the mine that reported the highest average silver content contained only 2.25 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 90,635 ounces of silver in 1929, according to the company's published report.[7] The silver from all the gold-lode mines amounted to 94,370 ounces, and it was worth $50,300. 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 26,800 ounces, worth $14,300.

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 1929 and 1928 are set forth in the following table:

Silver produced in Alaska in 1929 and 1928

Source	1929		1928	
	Ounces	Value	Ounces	Value
Gold lodes	94,370	$50,300	80,340	$47,000
Gold placers	26,800	14,300	23,930	14,000
Copper lodes	351,730	187,400	350,430	205,000
	472,900	252,000	454,700	266,000

It is evident from the table that the total output of silver in 1929 was worth about $14,000 less than the output in 1928, in spite of the fact that the quantity produced in 1929 exceeded that produced in 1928 by nearly 20,000 ounces. The explanation of this condition lies

[7] Alaska Juneau Gold Mining Co. Fifteenth Ann. Rept., for 1929, p. 13, 1930.

in the selling price of silver in the two years. According to the computations of the Bureau of Mines the average market price of silver in 1929 was 53.3 cents an ounce, as against 58.5 cents in 1928. If the price of 58.3 cents had prevailed in 1928 the value of the silver production of that year would have been nearly $24,000 less than the value stated, so that the production of 1929 would have shown an increase of $10,000 over that for 1928 instead of a decrease of $14,000. It should be remembered that the bulk of the silver is merely an accessory to the other metals, notably copper and gold, so that its output fluctuates more or less widely, being dependent on the production of the other metals. This does not always hold true in detail, for, as has already been pointed out, the production of copper decreased somewhat over 900,000 pounds in 1929, and yet the amount of silver recovered from the copper ores was about 1,300 ounces greater than in 1928. On the other hand, the rule holds regarding the production of silver from the gold-lode ores as well as for that recovered from the gold placers. In the lode gold there was an increase in silver produced of more than 14,000 ounces and in the placer gold of nearly 3,000 ounces. The increase in value of the silver from these two sources was not great, owing to the lower price of silver in 1929, as explained above, so that the increase in value of the silver recovered from the gold lodes was only about $3,000 and from the gold placers only about $300.

The development in Alaska of ores that 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 are 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 Alaska none of them have been very thoroughly examined or seriously considered 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 bound-

ary. In 1929 no shipments other than small test lots 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 Alaska side of the boundary. During 1929 one of the mines in the Hyder district that had been brought to a producing stage in an earlier year was closed, but the suspension was reported to be only temporary, and it should soon be operating again. A summary statement regarding general mining activity in this district is made in the section of this report describing the gold lodes (pp. 16–17).

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 1929. 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 encourage 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. The current low price of silver acts as a strong deterrent against attempting to mine silver deposits at this time. In spite of talk of legislative action to raise the price of silver, there seems to be little likelihood that action of this sort will be taken in the near future, and as a result silver mines even more advantageously situated than those now known in Alaska are closing down or materially curtailing their output.

LEAD

The lead produced from Alaska ores in 1929 amounted to 2,630,000 pounds, an increase over the production of 1928 of about 590,000 pounds. This stands as the greatest quantity of lead that Alaska has ever produced in a single year. The value of the output at 6.3 cents a pound, the average market price of the lead sold in the States in 1929, according to the Bureau of Mines, was $166,000. This was a large increase and was due both to a great increase in quantity produced and in the price per pound, for in 1928 the average market price of lead was only 5.8 cents a pound, or half a cent less than in 1929.

Lead produced in Alaska, 1892–1929

Year	Tons	Value	Year	Tons	Value	Year	Tons	Value
1892	80	$2,400	1906	30	$3,420	1920	875	$140,000
1893	40	2,040	1907	30	3,180	1921	759	68,279
1894	35	2,310	1908	40	3,360	1922	377	41,477
1895	20	1,320	1909	69	5,934	1923	410	57,400
1896	30	1,800	1910	75	6,000	1924	631	100,899
1897	30	2,160	1911	51	4,590	1925	789	140,571
1898	30	2,340	1912	45	4,050	1926	778	124,400
1899	35	2,150	1913	6	528	1927	1,008	127,000
1900	40	2,440	1914	28	1,344	1928	1,019	118,000
1901	40	2,440	1915	437	41,118	1929	1,315	166,000
1902	30	2,460	1916	820	113,160		12,145	1,606,000
1903	30	2,220	1917	852	146,584			
1904	30	2,580	1918	564	80,088			
1905	30	2,620	1919	687	72,822			

In Alaska no ores are mined solely for their lead content. Practically all the lead produced 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 different metals they contain. The larger part of the lead that is reported in the foregoing table as produced in 1929 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 1929 it produced 2,501,832 pounds of lead in addition to other metals during that year. This represents a recovery of a little less than two-thirds of a pound of lead from each ton of ore that is mined and trammed to the mill, or about 1¼ pounds of lead from each ton of ore that is fine milled.

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. These statements show that lead ores are widely known throughout the Territory, and in the past shipments valuable in part at least for their lead content have been made from many areas in southeastern Alaska, especially the Hyder district; from the Yukon-Tanana region, especially from the Kantishna district; and even from far-away Seward Peninsula at the Omalik mine, and from the

Kobuk in the vicinity of Shungnak. Lead is, however, 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 in lodes and in placers in Alaska. The total quantity of platinum metals produced in Alaska in 1929 is estimated to have been approximately 528¼ crude ounces, or 475.4 fine ounces, which at $67, the average market price for platinum as computed by the Bureau of Mines, was worth about $32,000.

The only occurrence of a metal of this group in a lode that has produced any appreciable quantity was at a mine formerly operated by 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. This mine is part of the property taken over during 1929 by the Solar Development Co., and although no work was done on it during the year it will undoubtedly be included in the general plans of that company for developments on Kassan Peninsula.

The only platinum metals that were mined in Alaska in 1929 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 several years, but interest in the deposits was especially keen during 1928, when for a time it appeared that a small stampede was in progress, and this interest was maintained during 1929. In spite of exaggerated statements regarding the richness of these deposits that have been made from time to time in the press, it is true that placer deposits containing platinum, worth continued careful prospecting, occur in this district, and that several men were engaged during the summer in the search for places where concentration has been great enough to form deposits that can 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 accurately known to the writer. According to local reports, however, the camps that produced some platinum were on Clara, Squirrel, and Platinum Creeks and Fox Gulch. What little is known about the geology of the district appears to encourage the belief that conditions favorable for the presence of platinum minerals may exist there. Nothing has yet been found, however, that justifies any rush of prospectors into the region in the hope of finding easily won riches. The recovery of so much platinum by so small a force of men as are now mining in the region certainly warrants a complete survey and examination to determine its mineral possibilities. Some difficulty has been experienced by the platinum miners in disposing of their product at satisfactory prices. This condition was especially marked during 1929, when the prices paid for platinum fluctuated widely but on the whole tended downward. As is probably not generally known, none of the Government mints or assay offices pay for platinum sent to them, so that the seller must sell to private purchasers, and the transaction becomes one of bargaining, which at the distance that separates the Alaskan producer from the purchaser in the eastern United States is time consuming to conduct and rather disadvantageous to both parties.

Although no other places in Alaska are known to have produced platinum metals that were sold in 1929, 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 in other years 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 in 1929 showed a slight falling off in both quantity and value from 1928, but they were both in excess of the production for any of the years from 1920 to 1927, though far below the production for 1911 to 1919, when the industry was at its height. In spite of the smaller amount produced in 1929 than in 1928, it appears that, on the whole, the tin industry is growing, and developments already in progress may result in the near future in yielding quantities comparable with those during the period of high tin production. The decrease in quantity was only about 2½ tons of metallic tin, but the decrease in value represented not only the lessened output but also a decrease of over 5 cents a pound in selling price. The output of tin was all derived from placers, and consequently the ore reported represents really concentrates running from 68 to 76 per cent of metallic tin. The output of tin ore was 51.6 tons, containing a metallic tin content of 38.6 tons. The average price of metallic tin for the year as computed by the Bureau of Mines was 45.19 cents a pound, so that the value of the Alaska production was $35,000. 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, 1902–1929

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	9	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	1929	51.6	38.6	35,000
1915	167	102	78,846		1,806.2	1,130.6	1,083,000
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 1929, however, did not come from lodes but from placer deposits, principally in the York district, of Seward Peninsula, and the Hot Springs, Ruby, and Gold Hill districts, 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 Yukon Valley districts 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 on Deep and Miller Creeks, in the vicinity of Tofty. In the Ruby district the tin ore was produced in connection with mining operations on Cox Gulch, and in the Gold Hill district, west of Tanana, the placer tin was collected in connection with placer mining on Grant Creek.

Revival of interest in the development of the tin lodes of western Seward Peninsula was noted during the year, though so far as reported no ore was mined. Some prospecting and development work was done at the old Crim, Randt & O'Brien property, near the Lost River, which has been taken over by the National Tin Mining Co. Although no active field work was undertaken on the property of the Empire Tin Mining Co., near Cape Mountain, it is understood that negotiations were in progress to get this property opened up again, and possibly some work will be started there in 1930.

Considerable interest in tin mining was revived in the Hot Springs district by the acquisition, late in 1928, 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 so late in the open season 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. These tests were followed in 1929 by more complete examinations, and as a result the project was abandoned. No specific reasons for this decision have been made public, but evidently the returns were not such as to encourage the large expenditures that would be necessary to put the property on a producing basis. Although the withdrawal of this company was a severe disappointment to the people of the district, it is believed to be more advantageous in the long run for all concerned if projects are not undertaken unless they appear to hold good promise of successful accomplishment.

During 1929 considerable activity was shown in searching for tin in the Ruby district. This work was being carried on at a score or more claims on Cox Gulch, a tributary of Big Creek, and on the contiguous tracts 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

The amount of coal produced from Alaska fields in 1929 showed a falling off from the high mark established in 1928, but otherwise in the whole period that Alaska coals have been mined the production in 1929 was exceeded only by that of the years 1923 and 1927. In other words, the production of coal in Alaska is showing a fairly constant increase, with only minor declines. It must be remembered, however, that the industry is still only small, for a total production of around 100,000 tons a year is not as much as many of the moderate-sized mines in the States produce individually, and the Alaska product does not even supply the local markets. Thus about 57,000 tons of coal was imported from fields outside of Alaska in 1929, 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 following table:

Coal produced and consumed in Alaska, 1880–1929

Year	Produced in Alaska, chiefly subbituminous and lignite		Imported from States, chiefly bituminous coal from Washington * (short tons)	Imported from foreign countries, chiefly bituminous coal from British Columbia* (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
1924	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
1929	100,600	528,000	32,762	24,172	157,544
	1,213,154	6,742,000	1,236,768	1,650,568	4,087,349

* Compiled from reports from 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 1929 is stated to have been $528,000. 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 1929 was approximately $5.25 a ton, which is the same as in 1928 and is about 50 cents a ton less than the average for the entire period shown in the table.

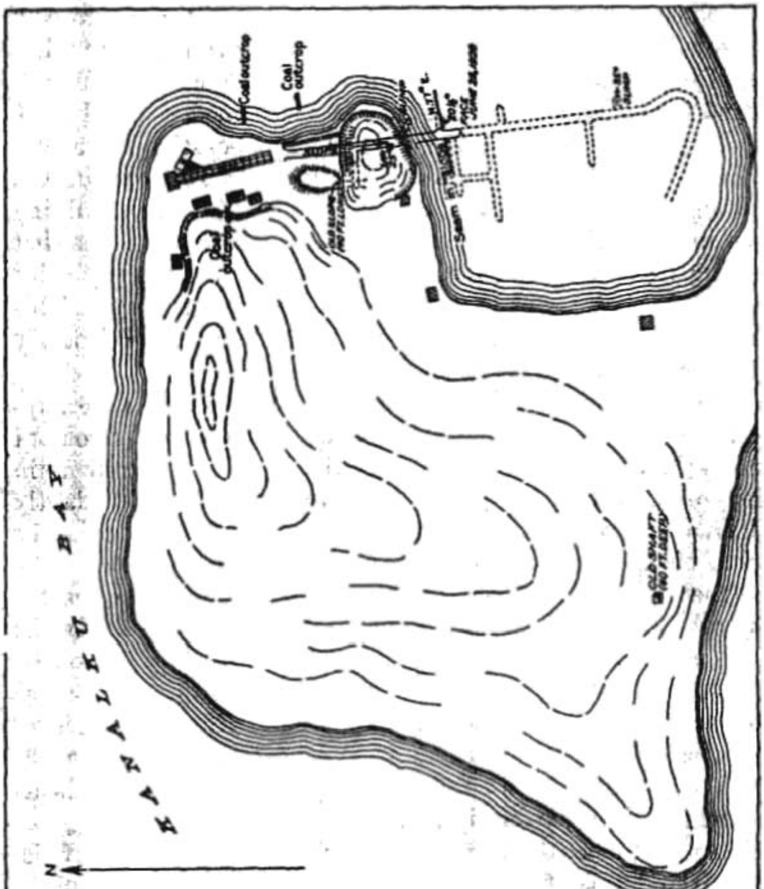
The Alaska coal came principally from three mines—two in the Matanuska field and one in the Nenana or Healy River field. The two mines in the Matanuska field were those of the Evan Jones Coal Co., at Jonesville, and that of the Alaska-Matanuska Coal Co. in the valley of Moose Creek. The Evan Jones mine was active throughout the winter and early months of 1929, but its production graddally tapered off until in July it amounted to only a few hundred tons, and after August until the end of the year it was idle. Mining at the Premier and the Alaska-Matanuska property, which were being worked essentially as a single unit, was practically at a standstill throughout the early part of the year, but beginning in July the company again began work to fill the new contract that it had obtained for furnishing the larger part of the coal used by the Alaska Railroad. The litigation regarding the Premier property, which had been in course of settlement for several years, was still pending at the end of the season. In addition to the 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 homemade 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 that 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 steel bridge. Unfortunately, during the spring high water and break-up this bridge was so seriously damaged that it was out of commission for nearly two months, thus severely handicapping this company in making its shipments. During this delay the company was able to utilize some of the time in improving conditions underground and on the surface. 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 1929 and yielded nearly half of all the coal mined in Alaska that year.

The coal claims of Roth & Manley, farther up the Healy River, apparently lay dormant throughout the year. That there is coal of good quality in this part of the Healy River Valley, as well as in the valley of Lignite Creek, to the north, has been abundantly proved. That it is of better quality than the other coals and can be mined more cheaply has not been demonstrated. Furthermore, the one mine that is now operating seems to have ample facilities for supplying all of the market that is now in sight. Consequently the expense of opening up additional mines, with the construction of the accompanying haulage and transportation facilities, as well as the extra haul necessary to bring the coal to market, would place an additional charge against it without any adequate compensating offset, unless the coal can be mined more cheaply or has a higher heating value, which seems extremely doubtful.

A small amount of coal was mined in 1929 on the property of the Admiralty Island Coal Co., in southeastern Alaska, but difficulties in management and finances caused the cessation of productive work early in the summer. This development was at 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. A sketch map showing the general developments at this place is shown by Figure 4. This map was prepared by B. D. Stewart, who supple-

mented his own surveys by notes furnished by R. S. Donaldson, formerly manager of the company, and by Louis Bridges, foreman. Several small shipments of coal have been taken to Juneau from this mine 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 ade-



0 100 200 300 400 FEET

FIGURE 4.—Sketch map of coal property at Harkrader, Admiralty Island, Alaska. By B. D. Stewart. Developments later than June, 1928, shown by dotted lines and plotted from notes furnished by R. S. Donaldson and Louis Bridges

quately 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 some coal to the people living in that region. According to reports, more than 100 tons of coal from these deposits was mined in 1929, 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 Office of Education, and delivered to a few 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 is that lying 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 inferiority 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 apparently at a standstill in 1929. 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 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 to bear 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. According to the published report of this company [a] it did no new drilling during the year, and the only significant new development was the granting by the Secretary of the Interior of several new permits covering an area of 1,347 acres.

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, 1905–1929, 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	568,083	83,992
1907	9,104,300	636,881	510,345	100,145
1908	11,891,375	939,424	566,598	94,542
1909	14,119,102	746,930	531,237	85,687
1910	19,143,091	788,154	620,972	104,512
1911	20,878,843	1,288,866	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	732,360	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	3,515,748	977,703
1920	21,981,569	1,764,302	887,942	412,107
1921	9,209,102	1,403,683	2,021,033	282,784
1922	15,441,542	1,436,059	2,095,675	343,400
1923	12,285,808	4,882,015	473,820	454,090
1924	14,412,120	5,534,859	566,491	508,364
1925	16,270,746	6,993,560	562,944	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	468,184	715,082
1929	17,347,344	6,847,050	589,340	878,094
	389,527,307	73,723,425	20,312,354	9,078,149

[a] Compiled from reports from Bureau of Foreign and Domestic Commerce.

Search for new oil fields in Alaska has not been vigorously carried on during the year, and at only two places was any drilling done. Hundreds of permits for prospecting for oil that have been issued by the Government and cover tracts in all parts of Alaska are out-

[a] Chilkat Oil Co. Twelfth Ann. Rept., Seattle, 1930.

standing in the hands of individuals and companies, but most of them were evidently taken up solely for speculative purposes and will lapse after a short time if no active work is done under them. The lack of success that followed the drilling of one or two deep test wells put a damper on further prospecting for oil, as it proved that the discovery of commercial pools would require much work, careful study, and the expenditure of large sums of money. The failure of these few wells, however, by no means indicates that the probability of finding other oil pools in the Territory is remote. From what has already been learned about the geology of the potential oil areas there is no reason to believe that the chances of finding oil in Alaska have been exhausted, and the experience with these first wildcat wells is not unlike the results of the early drilling in some of the fields in the States that subsequently have proved to be immensely productive. There are many tracts in Alaska that are believed to show favorable geologic structure that will warrant extensive tests 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 technical staff competent to interpret and utilize to the fullest the facts that are disclosed in the course of the work.

One of the two places where prospecting for oil by the use of the drill was in progress in 1929 was in the Katalla field not far from the tracts that were producing oil. This work was done by the Alaska Consolidated Oil Co., which is said to have taken over much of the ground formerly held by an old English company which was among the pioneers in this field. A drill rig was shipped in from the States in July and was taken to the ground soon afterward. So far as known, however, little more than the necessary construction and setting up of equipment to begin drilling was accomplished in 1929, but the company should be in a position to push the work forward vigorously in 1930. It is generally assumed that the oil that may be found in this tract does not lie at a depth of more than 2,000 feet or so, but the geologic conditions under which it occurs are not well understood, so that the result of the drilling will be watched with keen interest, not only for the information it will afford regarding the specific tract tested but also for its bearing on the general region perhaps even as far east as Yakataga. Rumors of other developments to be undertaken in prospecting for oil in the Katalla field have also been current, but none of them seem to have advanced to the stage of field work in 1929.

The only other place where drilling for oil was in progress in 1929 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 1928 the well had been put down to a depth of 1,300 feet. Early in 1929 the Star rig that had been used theretofore was dismantled, a Standard rig was put in its place, and various changes were made in the surface plant. After drilling began difficulties were encountered because of caves and open spaces in the formations penetrated, so that progress was slow. To cap the climax a bit broke off in the hole, and more than a month was lost in getting the necessary tools and fishing for it. The heavy rains that prevailed during most of the summer caused many washouts and slides on the railroad, which put the track out of commission and necessitated the expenditure of much extra time and effort in getting the needed supplies and equipment to the property. As a result the company finally stopped drilling at a depth of about 1,360 feet and closed down its camp early in the fall, though it expects to resume work in 1930. Apparently the showings are still regarded by the owners as sufficiently promising to warrant continuance of 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 locality. The finding of a commercial accumulation of oil would be of so much benefit to the region as a whole, as well as to the operators, 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 others which have at one time or another been produced in quantities large enough to have more than local significance, and some of which have been and still are the basis of profitable mining industries include, among metallic products, antimony, arsenic, bismuth, chromium, iron, manganese, mercury or quicksilver, molybdenum, nickel, tungsten, and zinc; and among nonmetallic products, asbestos, barite, building stone, clay, garnet, graphite, gypsum, jade, limestone, marble, and sulphur. Without doubt small quantities of practically all these materials were "produced" in 1929 in the broadest sense of that word, but with the exception of stone, marble, and quicksilver none of them were reported to have been produced and

sold in quantities that justified their inclusion as contributing 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, 1901–1929 [a]

Year	Value	Year	Value	Year	Value
1901	$500	1912	$165,342	1923	$229,486
1902	255	1913	286,277	1924	348,728
1903	389	1914	192,787	1925	454,207
1904	2,710	1915	205,061	1926	444,500
1905	710	1916	336,737	1927	162,000
1906	19,965	1917	203,971	1928	164,000
1907	54,512	1918	171,452	1929	194,000
1908	81,305	1919	214,040		
1909	86,027	1920	372,599		5,483,000
1910	96,408	1921	235,438		
1911	141,739	1922	266,296		

[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 of the Vermont Marble Co. For a number of years the principal quarries of this company were in the vicinity of Tokeen, off the west coast of Prince of Wales Island, in southeastern Alaska. Later the company opened quarries in the vicinity of Calder, also in southeastern Alaska, but the company reports that in 1929 it obtained no new stone from its Alaska quarries, its shipments during that year being blocks on hand that had been quarried in previous years. These rough blocks are shipped to the company's finishing plants in Tacoma, Wash., and San Francisco, Calif., and the product is used principally for interior decoration. In the past several marble quarries have been 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 [9] which shows, among other things, the distribution and extent of some of the large belts of limestone that traverse much of southeastern Alaska. According to Burchard,[10] many dif-

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

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

ferent types of marble occur in these deposits, some even approaching statuary grade.

The quarrying of large quantities of a high-grade limestone rock in southeastern Alaska to be used in the manufacture of cement at the plant of the Pacific Coast Cement Co. in Seattle was announced in the Alaska progress report for 1928. Since that time the work has been carried on and large shipments of limestone made. A comprehensive description of the whole operations and equipment of the company's plants has recently been published,[11] and the following abstract of the more significant facts relating to the development of the industry is based on that description:

The quarry site was selected after thorough examination, involving surveying, sampling, tunneling, and drilling on all known limestone deposits in western Oregon and many deposits in British Columbia and southeastern Alaska. The limestone is remarkably uniform in quality and with a considerable mixture of top soil averages 94.5 per cent calcium carbonate. The deposit is estimated to contain more than 20,000,000 cubic yards of rock, most of which runs over 97.5 per cent of calcium carbonate. The quarry is on Dall Island between Baldy Bay and Tlevak Strait, about 40 miles west of Ketchikan. During the winter of 1925–26 a thorough study of all literature relating to limestone on the west coast was made. In the summer of 1926 three parties of mining and consulting engineers and geologists prospected the territory and selected the Dall Island deposit. During the winter of 1926–27 parties spent a month surveying the deposit, examining possible worthy sites, and making soundings. In March and April, 1927, a topographic survey was made and drill holes were put down and further soundings made. In spring of 1927 the United States Coast and Geodetic Survey surveyed a tract and wire-dragged Baldy Bay. In February, 1928, the company sent the *Mazama*, with a construction crew of 65 men, supplies, and materials, to View Cove. The first cargo of crushed rock was delivered in Seattle October 31, 1928. During the development period drilling was done with pneumatic machines, but during the season of 1929 a Sanderson-Cyclone No. 14 standard well drill was used. Rock is loaded at the face with a 50-B Bucyrus electric shovel, with Ward-Leonard control, into 8-yard steel-pan standard-gage quarry cars. Two 8-ton Plymouth gasoline locomotives haul the cars over 56-pound rails to the crushing plant, which contains one Traylor 48-inch by 12-foot feeder, one Traylor steel-frame 42 by 48 inch Bulldog jaw crusher and one No. 5040 Dixie Mogul standard hammer mill, the crushers being driven by General Electric 125-horsepower and 150-horsepower motors, respectively. The plant is designed to handle over 100 to 125 tons of rock an hour. Crushed rock is delivered by an 18-inch belt conveyor from the hammer mill to the rock-storage pit cut into the solid rock of the hillside above the wharf. A 36-inch belt, running about 300 feet a minute on Rex Chainless Belt Co. rolls, receives the rock through shoots in the roof of a tunnel under the storage pit and delivers it through a loading tower on the edge of the wharf into the holds of the rock-carrying ship at the rate of 700 tons an hour. During dry seasons no fresh water is available, and consequently a Diesel electric-power plant was installed, consisting of

[11] Hutton, S. E., Outstanding Portland cement plant—the Pacific Coast Cement Co. plant at Seattle, Wash.: Rock Products, vol. 32, No. 25, pp. 33–51, Dec. 7, 1929.

two Fairbanks-Morse 6-cylinder 360-horsepower 240 kilovolt-ampere 2,300-volt 3-phase generating sets, pumps, Ingersoll-Rand air compressors, etc. The limestone is carried to Seattle in 6,200 to 6,400 ton cargoes. From 8 to 10 days is required for the round trip, and the average for the season of 1929 was approximately 8½ days. The ship is loaded in 8 to 12 hours, and its cargo is discharged in 30 to 36 hours.

Late in the fall of 1928 it was reported that arrangements were in progress for an English company to take over the development of a group of claims on Stampede Creek, in the Kantishna district, that were known to contain numerous showings of antimony ore. The promotion of the project was handled principally by George F. Lemon. Before development is undertaken here, however, very complete examinations will be required to determine the extent of the mineralization and the tenor of the ore. This is especially essential because there is small likelihood that the project will be undertaken unless it is worth carrying through 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.

Antimony minerals are widely distributed through Alaska, and the common antimony mineral, stibnite, is recognized in most of the mineralized areas in the interior. In the past antimony ore valued at more than a quarter of a million dollars has been mined in the Territory and sold. There has been little demand for this metal lately, and the market for it is said to be fairly closely controlled. As a consequence there has been little interest in the search for deposits of this metal or development of those properties already known which might prove profitable if the ore were readily marketable.

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 at the Parks property, lying north of the Kuskokwim River, between Georgetown and the mouth of the Holitna River, a small amount of quicksilver was mined and the metal recovered in a crudely built home-made furnace that was in operation for about two weeks. The owner reports that he expects to start up more extensive developments at this place early in the season of 1930. 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 some activity during the year in prospecting and development work on one of the old lodes on Swede Gulch 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 ore. At this property two men were employed in the underground developments. It is reported that work will be continued here on a small scale as long as the showings continue to be encouraging. A lode carrying quicksilver ore is reported to have been found in the Livengood or Tolovana district, on the ridge at the head of Olive and Lillian Creeks. A tunnel 300 feet long from which a shaft 100 feet deep has been sunk, was driven to prospect the deposit. The ore is said to carry considerable gold in addition to the quicksilver.

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, unless 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. However, it is reported that a shipment of nearly 1,000 pounds of the jade was made to dealers in New York and created considerable interest, the entire lot having been disposed of at a price satisfactory to the owner, though the jade was not considered to be of first quality. In southeastern Alaska on Bear Creek, near the north end of Admiralty Island and about 2½ miles from the shore, are several claims on which some asbestos has been found and considerable prospecting done. Attempts to develop the deposits to a producing stage have been made but have encountered various difficulties, some of which arose more through questions of management and finance than through the quality or extent of the material. Some of the samples of asbestos from this place have fibers more than a foot long, but they are rather weak and brittle. Possibly their physical character is due to the fact that the samples seen have been taken near the surface and are badly weathered, so that the strength of the material farther underground may be better. 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.

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 near this place is being continued, however, and a deposit of gypsum that appears to be worthy of more thorough exploitation has been discovered. Tunnels aggregating several hundred feet in length have been driven lately to explore the deposit. This region was recently visited by B. D. Stewart, and a short statement regarding the results of his examination is given as a separate section elsewhere in this volume.

Although the various mineral commodities here grouped under the heading "miscellaneous mineral products" yield small monetary returns—only $194,000 in 1929—yet their diversity, their wide distribution, and the interest that is being displayed in the search for them indicate that they already play an important part in the mineral economics of the Territory and that they are destined to become even more significant as the development of Alaska proceeds.

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 some of them 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 more than 100,000 square miles of country, such as the Yukon Delta and Yukon Flats, where, though there may be deposits of value, the services that can be rendered by geologists in a preliminary search would not be great enough 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 in Alaska 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 making a thorough inventory of 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 essentially a continuing project which has no clearly marked steps or interruption to serve as distinct breaks from which to report progress. Most of the work bears little relation to the calendar year. Many of the field projects start in May and may last a few months or several years, but some have been started in February and others in July or August. The fiscal year, which so clearly forms a basis for defining much of the other Government work, has little significance in reporting on the Geological Survey's work in Alaska, especially because most of the appropriations for the Alaska work are made immediately available on the passage of the act through which the money is appropriated. For example, the appropriations for the Alaska work in the act providing funds for the Interior Department covering the fiscal year 1929–30 became effective on March 4, 1929, and was available for expenditure at any time after that date until June 30, 1930. At the same time the similar appropriation contained in the act for 1928–29 was available until June 30, 1929, and the act for 1930–31, which was passed May 14, 1930, was available after that date until June 30, 1931. Under these conditions it is evident that except for the obvious limitations the determination as to which of these appropriations should be charged with a certain project is more likely to be based on administrative convenience than on any real difference in the character or object of the work. To describe as two jobs what was undertaken really as a single project, simply because parts of it were paid for from different appropriations, would obviously fail to give a correct perspective of the work in its entirety 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 1929 for many projects began early in the spring of 1929, when the field men began to assemble their supplies and equipment. It continued through the period of actual field operations and was followed in the fall and winter of 1929 and the spring of

1930 by the office and laboratory work of preparing the report of the results accomplished. The last stages of this work may have gone on more or less coincidentally with the beginning of preparations for the field season of 1930 and may have ceased only when the geologist or engineer left headquarters to undertake the new project; in fact, the final revision of this report and the reading of the proof may not have been completed even in the succeeding season.

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 1929 canvass went on throughout 1929, the bulk of the replies were not received until the end of the year, and the final compilations could not be made until well into the spring of 1930. Although the project of collecting these data relating to the calendar year 1929 might logically be counted as belonging to either or both years, the practice that has been followed in this report has been to consider that work as belonging to the season of 1929.

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 corresponding fiscal year. Thus, broadly speaking, the expenditures for starting parties in the field season of 1929 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 1930 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 available for the field expenses of 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 1929–30 the amount appropriated was $67,500. In the similar act for 1930–31 the amount appropriated was $75,000. 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 30, 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 1928–29 an allotment of $10,000 was made for work of this kind in Alaska, and for the fiscal year 1929–30 a similar amount was allotted.

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 21 such official reports have been issued or have been completed by their authors and approved for publication, as follows:

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

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

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

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

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

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

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

Mineral resources of Alaska: Report on progress of investigations in 1926, by Philip S. Smith and others (Bulletin 797).

Mineral resources of Alaska: Report on progress of investigations in 1927, by Philip S. Smith and others (Bulletin 810).

Geology and mineral deposits of southeastern Alaska, by A. F. Buddington and Theodore Chapin (Bulletin 800).

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

Geography and geology of northwestern Alaska, by Philip S. Smith and J. B. Mertie, jr. (Bulletin 815).

Mineral industry of Alaska in 1929, by Philip S. Smith (Bulletin 824–A).

Administrative report, 1929–30, by Philip S. Smith (Bulletin 824–A).

Phototopographic work in southeastern Alaska in 1929, by R. H. Sargent.

The occurrence of gypsum at Iyonkeen Cove, Chichagof Island, Alaska, by B. D. Stewart.

The Slana district, upper Copper River region, by F. H. Moffit.

The Lake Clark-Mulchatna region, by S. R. Capps.

Recent mining developments in the vicinity of Circle, by J. B. Mertie, jr.

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).

Glaciation in Alaska, by S. R. Capps.

Six short papers on the mineral production of Alaska and various phases of the work of the Alaskan branch were published as press bulletins.

A report entitled "A geologic reconnaissance of the Dennison Fork district," by J. B. Mertie, jr., prepared during the previous year, has not yet been sent to the printer.

The reports listed below are still in course of preparation by their authors 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 flora 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 Yukon-Tanana 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 have been published during the year:

Topographic map of Valdez and vicinity, by J. W. Bagley, C. E. Giffin, and R. H. Sargent; scale, 1:62,500. Published as a sale map.

Topographic map of Revillagigedo Island, by R. H. Sargent; scale, 1:250,000. Compiled principally from aerial photographs taken by the Alaska Aerial Survey Expedition of the Navy Department, 1926. Issued as preliminary photolithographic edition.

Map of Alaska; scale, 1:5,000,000. Containing index of Alaska maps and list of Alaska publications.

Topographic map of Goodnews Bay district, by R. H. Sargent and W. S. Post; scale, 1:250,000. Issued as preliminary photolithographic edition.

Progress was also made in the preparation of a map of the Mount Spurr region and a map of the Lake Clark-Mulchatna region, both on a scale of 1:250,000, compiled from surveys in recent years in the Skwentna, Mount Spurr, Chakachamna-Stony, and Lake Clark-Mulchatna districts. Considerable work has been done in compiling the results of recent surveys on a topographic map of the Yukon-Tanana region on a scale of 1:500,000, which has been in progress for several years, and in 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. The small general map of Alaska on a scale of about 80 miles to the inch is kept currently revised and reissued as frequently as required.

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 26 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:

Mountain building in Alaska, by J. B. Mertie, jr. (delivered before the Geological Society of Washington).

Alaska gold resources, by Philip S. Smith (published in Economic Geology).

Scientific work of the United States Geological Survey in Alaska in 1929, by Philip S. Smith (published in Journal of the Washington Academy of Science).

A new species of Tertiary cycads, by Arthur Hollick (for publication in Memoirs of the New York Botanical Garden).

Molybdenite deposit at Shakan, Alaska, by A. F. Buddington (for publication in Economic Geology).

Aerial photographing in southeastern Alaska, by R. H. Sargent (delivered at meeting of Association of American Geographers).

A study of the results of ice flow as shown in oblique and vertical photographs taken of glaciers in Alaska, by R. H. Sargent (delivered at meeting of Association of American Geographers).

Photographing Alaska from the air, by R. H. Sargent (published in Military Engineer).

Glaciation in Alaska, by S. R. Capps (presidential address delivered before Geological Society of Washington).

Albert Perry Brigham, geologist, by Philip S. Smith (published in Annals of Association of American Geographers).

PROJECTS IN PROGRESS DURING THE SEASON OF 1929

The work done by the Geological Survey in connection with the study of Alaska is so diverse that it can not be reduced to common terms capable of unified tabulation or coordinated description. Part of it embraces areal surveys readily definable in terms of square miles mapped, but other parts concern examinations in mining camps which areally cover only small tracts and yet require the outlay of much time and effort, and other parts may involve laboratory researches or office studies that exceed the scope of the original field investigations. The most comprehensive idea of the work of the Alaskan branch in 1929 may therefore be gained best from the following descriptions of the projects undertaken during that season.

In addition to the routine duties of supplying information in answer to hundreds of inquiries received from the public and from the various branches of the Government, as well as disposing of the

administrative details attendant on the general conduct of the work, the work of the Alaskan branch consisted of seven principal projects. These were topographic supervision of the aerial photographing of parts of southeastern Alaska, geologic reconnaissance in parts of the headwater region of the Copper River region, geologic and topographic reconnaissance surveys in the Lake Clark, Mulchatna, and Stony River region of the Alaska Range, geologic reconnaissance of parts of the Circle district and adjacent regions in the Yukon-Tanana Valley, general studies at some of the principal mining camps in southeastern and central Alaska, investigations carried on by the local field offices maintained by the Geological Survey in Alaska, and the statistical canvass and resulting compilations relating to the output of minerals from Alaska during the year.

The aerial photographic work in southeastern Alaska was a continuation of a project started in 1926, when the Navy Department, at the request of the Geological Survey, sent a detachment of aviators with the necessary equipment to photograph from the air parts of southeastern Alaska so that the resulting pictures might be used for preparing maps of the region. The work done was so successful and of such inestimable value, not only to the Geological Survey but also to other Government bureaus, notably the Forest Service, that in the winter of 1928–29 the Geological Survey joined with the Forest Service in urging the Navy Department to send another expedition to extend similar work into the tracts that had not been photographed. The Navy Department, recognizing the need of these bureaus and wishing to meet their desires as well as recognizing the splendid training that it afforded for its own members, assigned the necessary personnel and equipment to the task, under command of Lieut. Commander A. W. Radford. This unit performed its allotted task with speed, precision, and high technical competence, so that some 12,000 square miles of difficult country was photographed and the resulting films were turned over to the Geological Survey for cartographic use. In the course of this work many services were rendered to the other Government bureaus concerned with various phases of Alaskan development, and several hundred photographs were made with cameras other than the special phototopographic instruments. The successful accomplishment of this difficult piece of work without accident demonstrates the great value of the airplane as a means of transportation in a country that is almost untraversable by any other means and shows the economy that can be effected in many phases of the Geological Survey's work by this modern method of attack. In order that the naval officers might have knowledge of the requirements that must be met in the photographs if they were to be suitable for carto-

graphic purposes, a skilled topographic engineer of the Alaskan branch, R. H. Sargent, was attached to the expedition and served throughout its field work.

The completion of the field work and the turning over of the developed films ended the Navy Department's share of the work, though many subsequent steps must be taken before the data thus obtained are worked up into maps. One of the first things to be done was to print the films, and as both the Geological Survey and the Forest Service required a print of each picture this required the production of nearly 50,000 separate prints—a task that required the combined efforts of three men for about six months. This was a surprisingly good record, for two-thirds of the films required special manipulation to take out certain inclinations caused by the particular type of camera used, and all the work had to be done with close mathematical adjustments as well as photographic skill. This phase of the work was completed near the end of the fiscal year. The next step will be the mounting of these prints, most of which are assembled in groups of three on specially prepared cards. The prints must be accurately trimmed and mounted so that certain identifying marks on them will be brought into exact accord with other marks that were printed on the cards. This is a precise, time-consuming job that it is estimated will take the equivalent of one man's time for a full year. Then will come the taking off from these mounted prints of the desired cartographic data and their compilation on a working sheet, the inking of this sheet, and its completion by adding names and data from other sources to form a drainage map. It will then be sent into the field to serve a topographer as a base on which to determine the elevation of all the natural features and represent them by means of contours. It is estimated that at the current rate of progress more than 20 years will elapse before the photographs now on hand from the two Navy expeditions to southeastern Alaska will be worked up to this final stage. Obviously the rate should be greatly accelerated. A more complete account of the work on this project is given by R. H. Sargent elsewhere in this volume.

The geologic reconnaissance of parts of the area lying near the headwaters of the Copper River and extending over into the drainage basin of the Tok River, which flows into the Tanana River, north of the Alaska Range, was carried on by F. H. Moffit with a small pack train and the necessary camp gear and two camp helpers. This region was mapped topographically in 1902, on exploratory standards of that day, and some geologic exploration was carried on at the same time. The geologic results were never published in full, so that little information about the tract was available. Furthermore, the great

amount of geologic information that has been collected from near-by regions in the more than a quarter of a centry since that work was done raised many questions that could be answered only by a thorough field review and extension of the earlier field observations. The region is one of direct and indirect importance in the search for workable mineral deposits in Alaska. It is of direct importance because it lies adjacent to areas that have long been known to be mineralized and to have afforded evidence of the presence of gold and lead and some indications of the presence of copper. Placers that have long been worked and have yielded more than $2,700,000 in gold lie to the west, in the Chistochina district, and the mineralized areas of the Nabesna River Valley and the placers of the Chisana (Shushanna) district lie to the east. Indirectly the area is of great geologic significance, as it lies athwart the Alaska Range, and consequently the correct interpretation of its geologic history will throw light on the general history of the mountain-building and related processes which doubtless were more or less closely connected with the mineralization that was so significant in parts of Alaska. The tracing of the geologic sequence of events from the Copper River region, on the south side of the mountains, and their correlation with the features in the Tanana and Yukon Valleys, to the north, will greatly strengthen and supplement the information obtained from either district alone. The region is difficult of access and therefore has not been adequately examined or prospected, but the extension of the Abercrombie Trail from the Richardson Highway at Gulkana, a piece of road construction that is being carried on by the Alaska Road Commission, will help in opening up the country and make transportation less expensive, so that further exploration is likely to be undertaken in the near future. A more complete statement regarding the scope and results of this investigation has been prepared by Mr. Moffit and is given in a separate chapter of this volume.

The combined geologic and topographic reconnaissance surveys in the Lake Clark-Mulchatna region were conducted by S. R. Capps, geologist in charge, with Gerald FitzGerald, topographer. This party was landed at Iliamna Bay early in June and proceeded by the usual route along Iliamna Lake to the lower end of Lake Clark, where the new surveys were started from the hitherto surveyed tracts. The surveys were carried northward along the western flanks of the Alaska Range as rapidly and completely as conditions permitted until junction was made with areas surveyed in 1928 by the party that crossed the mountains from Trading Bay by way of Merrill Pass and traversed parts of the Stony River Valley. This party mapped more than 1,300 square miles of hitherto unsurveyed country and completed the general areal work of blocking out

the major features of an immense tract of the Alaska Range, though there still remain within that tract unsurveyed areas that were not reached, either because of lack of time or because they were in the most inaccessible part of the high mountain range. The geologic results obtained show that in this part of the Territory the Alaska Range consists primarily of a great granitic intrusive mass which is flanked on the west by sediments and extrusive igneous rocks of Mesozoic age. Little prospecting has been done in the region, and although placer gold has been recognized in a number of the stream valleys no deposits of commercial value have been found. Practically nothing has been done in prospecting for lode deposits of the metals, though the presence of the great intrusive mass cutting a variety of other rocks offers some hope that lodes of value may be found in the vicinity of the contacts. Much information was obtained as to the late glaciation of this part of Alaska that supplements and is correlative with that hitherto gathered from near-by and other parts of the Territory. Evidence was found at one place of a glacial stage, probably of early Pleistocene age, that much antedated the last great ice advance. A more complete statement of the results of this work will be found in a report by Mr. Capps that forms a separate section of this volume.

The geologic reconnaissance work in the Yukon-Tanana region was part of the general project which has been undertaken with a view to coordinating the many observations that have been made in that region in the last 30 years as well as to studying with more care certain tracts that had been passed by in the earlier survey or given only cursory examination. The particular part of this large tract that was examined for this purpose in 1929 lies north of Fairbanks and west of Circle. The field work consisted mainly in visiting a number of remote and hitherto unmapped areas in several ranges of hills that flank the Yukon Flats on the south, including the Crazy Mountains. This work was done by J. B. Mertie, jr., who with a small pack train and the necessary camp equipment and two camp assistants revised or completed the mapping of the geology of about 1,500 square miles of country and visited almost all the producing placer camps in the Circle district. No new geologic formations were distinguished, but the hard rocks, which range in age from lower Ordovician to Pennsylvanian, were mapped at a number of new localities. The completion of this season's work brings to an end the field work on the major project of revising the whole geology of the tract lying between the Yukon and Tanana Rivers, but the office studies and preparation of a report and the maps to accompany it will require much additional time and effort. The results of this critical study when finished should be of much

significance in explaining the general geologic history of the region and the conditions under which the mineralization that has taken place was effected. That information will be useful in suggesting the places where further prospecting for mineral deposits is most likely to be worth while. Some notes by Mr. Mertie regarding the recent mining developments in the Circle district, that were obtained during his work in 1929, are published as a separate chapter of this volume.

The collection of information regarding the output of minerals from Alaska each year is carried on mainly from the Washington office, but the wide acquaintance of the field men and their surveys in different parts of the Territory make them a source of much definite information. In addition many of the other Government organizations, such as the Bureau of Mines, the Bureau of the Mint, and the Customs Service, collect data within their respective fields which contribute to the general subject. Most of the banks, express companies, and other organizations conducting business in Alaska collect for their own use data regarding mineral commodities in their particular districts, some of which is freely placed at the disposal of the Geological Survey. 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, and from them many items regarding new developments are gleaned. In addition the Geological Survey sends out hundreds of schedules—one to each person or company that is known to be engaged in mining in Alaska—which call for information regarding the developments and production at each property during the year. From all these sources a large volume of most authoritative information is obtained. These annual production reports are conducted on the basis of the calendar year, but the work of canvassing the different producers and assembling the data is practically continuous. For example, the task of accumulating the facts regarding the production of minerals for 1929 commenced early in January, 1929, and was not completed until June, 1930, when the report was transmitted for publication. Necessarily during the period from January to June, 1930, data relating to two separate calendar years, 1929 and 1930, 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. The report on the mineral industry in 1929 is published as part of the volume accompanying this administrative report.

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, is 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 of 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 in detail, 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, at less expense. It was proposed that in 1929 the main task undertaken by Mr. Stewart should be the investigation of mineral properties that might yield tonnage to the Alaska Railroad. The plans for carrying out this project unfortunately miscarried, so that little was accomplished in getting it under way during the season of 1929.

One other piece of field work that was done during the season of 1929 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 Philip S. Smith, chief Alaskan geologist. Earlier in the year Mr. Smith had attended the Fourth Pacific Science Congress in Java, as one of the official delegates of the United States, and he did not get back to this country until late in July. He proceeded immediately to Juneau, where he visited the detachment engaged in the aerial photography of southeastern Alaska already described and had the opportunity of participating in some of the flights and seeing all the phases of the work in progress. In addition he visited the Juneau office and met and discussed problems with many of the men concerned with Alaskan developments. From Juneau he went

to Seward and Anchorage, where he conferred with Colonel Ohlson and other representatives of the Alaska Railroad and the members of the Geological Survey attached to the Anchorage office, and then visited the coal-producing camps in the Matanuska field and discussed mining conditions with operators. He then went to Fairbanks and spent some time visiting the recent lode developments in the vicinity of that town and going over the extensive placer-mining plant of the Fairbanks Exploration Co. The general familiarity with the mining industry such as may be gained by inspection trips of this sort is regarded as essential in keeping track of recent developments and laying out plans for future work of the Geological Survey in Alaska, so that they will fit the needs of the mining industry.

A field project that really does not fall within the jurisdiction of the branch, although it relates to Alaska, was carried on by the volcanologic section of the geologic branch. The representative of this section who was in Alaska in 1929 was Austin E. Jones, who reports that during the open season of July and August he installed specially designed and constructed seismographs at Dutch Harbor and Kodiak, Alaska, to obtain records of earth movements. These records will also be studied in connection with general volcanologic investigations relating to the whole northern Pacific Ocean basin and that are being carried on simultaneously at stations in Hawaii and California.

Each of the projects above described involves considerable office work in examining and testing the specimens collected, preparing the illustrations and maps, and writing the reports. In addition, considerable work of this sort was required on projects that had been started in 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 advancement of work that for some reason or other was not finished during the year in which the project was undertaken. Progress was also made during the year toward the completion of certain of the older reports listed on page 87 as still in the authors' hands.

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 should conform so far as practicable to the best Geological Survey standards. All the clerical work of the branch has been performed

under the direction of Miss Lucy M. Graves, who has been assisted in the Washington office by Miss L. H. Stone and Miss L. F. Nelson. During the year J. B. Torbert, who for nearly 30 years had done the greater part of the expert map drafting for the branch, died. No one appearing to have the drafting skill to fill his place satisfactorily, the position has remained vacant. The ordinary drafting requirements of the branch have been taken care of by J. I. Davidson.

Some of the results of the season's work described in the foregoing paragraphs, as well as that done in earlier years, may be expressed in terms of the area covered. The following tabular statement indicates the areas covered by the surveys of different types and 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, and therefore no account is taken of the work that was started during the field season of 1930 but remained uncompleted at the end of the fiscal year 1929–30. 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 1930 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, as already explained, the field season is regarded as a more practicable unit of measurement.

Areas surveyed by Geological Survey in Alaska, 1898–1929, 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)
1898–1928	75,150	[a]174,305	4,277	55,630	208,530	4,056
1929		3,675			1,875	
	75,150	176,330	4,277	55,630	209,905	4,056
Percentage surveyed of total area of Alaska	43.6			46.0		

[a] Includes 1,650 square miles revised extensively in 1929 and included also under 1929 and therefore counted only once in total given below.

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 at first are later resurveyed with more precision on the same or larger scale, 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 1,650 square miles which was reexamined geologically in 1929 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 geologists 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 features are of prime importance in their relation 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.

PROJECTS FOR THE SEASON OF 1930

Nine projects have been approved for the season of 1930. These projects had been under way for only a short time at the end of the fiscal year 1929-30, 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 practicable at this time to outline only the principal objects of these projects. Seven of these projects that involve field work are as follows: Reconnaissance topographic mapping in the Ketchikan district, southeastern Alaska; geologic and mining studies, principally in the Taku Valley near Juneau; geologic investigations in the vicinity of the Alaska Railroad in central Alaska; geologic reconnaissance mapping of part of the Chulitna Valley and adjacent parts of Broad Pass, in central Alaska; exploratory and reconnaissance topographic surveys in the Nushagak and adjacent areas of southwestern Alaska; geologic reconnaissance of the region lying north of the Yukon and adjacent to the international boundary; and a study of the general mining developments and conditions, with visits to such of the camps as time and other conditions permit. Two projects that do not directly involve field work are the annual canvass of the mineral production from Alaska in 1930 and the preparation of the photographs resulting from the airplane flights in southeastern Alaska by the Navy Department in 1929.

The topographic work in southeastern Alaska is a continuation of mapping parts of Revillagigedo Island, on which Ketchikan is situated, and of the adjacent mainland, a project that was started during the field season of 1928, during which about 1,000 square miles was mapped. The mapping of this region is needed by the Geological Survey in its studies of mineral resources, because the region contains several localities where strong indications of mineralization have been found and gold mines have from time to time been worked. The especial urgency for a map of this region at this time has been brought about by the need of the Forest Service and others who are concerned with the development of the power and pulpwood resources of the region. The work of this Geological Survey party, which is in charge of R. H. Sargent, topographic engineer, should be much facilitated by the fact that a drainage map of the entire area had been prepared before the party started its field

work. This drainage map was compiled from the aerial photographs taken by the detachment sent by the Navy Department in 1926, so that the work of Mr. Sargent's party will be mainly concerned with determining the elevation of the different natural features and sketching the contours so that they will show the appearance and height of all parts of this tract. Doubtless in the course of this work the more precise ground methods will disclose places where readjustment of the compilation from the photographs will be required. Such changes, however, will probably be more in the nature of refinements of position than the correction of any noteworthy discrepancies, and the availability of these compilations should obviate a large part of the difficult, costly, and time-consuming traverses through almost impenetrable thickets and over precipitous slopes that would otherwise be required. The transportation of the party in the field will be effected by a power boat which will also serve as a camp, a necessity in this region of heavy precipitation and few sites for suitable camps ashore. The topographer will be assisted by the necessary boatmen and field helpers. The work was started early in May and will be continued as late as weather conditions permit, which will probably be well into September.

Late in 1928 and early in the spring of 1929 finds of sulphide ore in the Taku region, mostly within British Columbia, were reported and created considerable interest in the region, not only locally but sufficiently far away to induce many outsiders to visit the field. In the course of the Navy's photographic work in southeastern Alaska in 1929 its planes were made available for certain members of the Geological Survey to view part of this region from the air. On these flights it became apparent that the former geologic map of part of this region was incorrect and that there was a strip about 10 to 15 miles wide adjacent to the international boundary but within Alaska that might be worth prospecting. In order to obtain more adequate information regarding this area, B. D. Stewart was assigned to the task of carrying on investigations in this region during the season of 1930. The finding of new deposits in this general region will have great influence in stimulating further search for ore deposits, and from what is known of the general geology of the region the chances of discovering deposits that may materially add to the mineral output of Alaska appears to be promising. In addition to his studies in the Taku region, Mr. Stewart has been directed to utilize such time as may be available in studies in some of the other mining camps in southeastern Alaska, in order to bring up to date the information regarding late developments.

The work in the vicinity of the Alaska Railroad was undertaken primarily in response to repeated requests from Col. O. F. Ohlson as

head of the railroad that the Geological Survey assist by advising him as to ore deposits that might contribute to the tonnage carried by the railroad and by considering some of the technical problems relating to mining that from time to time arose in connection with the railroad operation. The need for information of this sort and the advantage that would accrue from it not only to the railroad but to the whole mining development of central Alaska were so obvious that the Geological Survey welcomed the opportunity to assist. F. H. Moffit, who for more than 25 years has been engaged in the Alaska work, was assigned to the project. The precise services that can be rendered will have to be determined in the course of the work, but much of the time of the party will doubtless be devoted to the field examination of areas known to be more or less mineralized. One such area is that of the Kantishna district, where lodes of gold, silver, copper, lead, zinc, and antimony, as well as gold placers, have long been known and from which some shipments of ore have been made in the past, but whose development has been badly hampered by the lack of transportation facilities. The problem of building up a volume of freight for the railroad to handle is of course directly a matter for the railroad to face, but the larger problem of assisting the mining industry of the Territory to take full advantage of this opportunity is one that falls closely within the scope of the investigations that the Geological Survey has been carrying on for nearly a third of a century. In this connection it may not be amiss to point out that the building of the railroad was undertaken largely as a measure to help in the development of the mineral resources of the country adjacent to it and thereby to aid the development of the Territory as a whole.

Related to the general problem of determining the mineral resources of the country near the Alaska Railroad are the investigations that have been undertaken for the season of 1930 in the region adjacent to the head of the Chulitna River, near Broad Pass. This work involves the geologic reconnaissance of a tract of nearly 1,000 square miles that had been surveyed topographically in earlier years but had not been examined geologically. S. R. Capps, geologist, will be in charge of this survey and will work with a small pack train and the necessary camp equipment and camp hands. The region is known to be mineralized in part and lies on the southern flanks of the high mountains of the Alaska Range. It is rather difficult of access, in spite of its nearness to the railroad, because of its ruggedness and the large glacial streams that traverse it. Close cooperation will be maintained between the Moffit and Capps parties, so that if time is available they may supplement the work of each other and examine additional mining camps adjacent to the railroad,

knowledge of whose general conditions will have a bearing on the general problems of the region. Work in the Chulitna region commenced as early in June as forage for the horses was available and will be continued until terminated by frosts that kill the grass or snow that obscures the outcrops.

In southwestern Alaska, north of Bristol Bay, is one of the largest unsurveyed tracts in Alaska, about which almost nothing is known. Near-by regions that have been examined by Geological Survey parties have been found to be mineral bearing, and there is strong reason for believing that the mineralization may have extended into this region also. To determine these conditions, as well as the major features of the topography and other geographic facts, the Geological Survey has turned its attention to that area. One of the projects that was undertaken in the season of 1930 was to survey as much of the topography in the vicinity of Nushagak and the country to the north as time and field conditions permit. This work has been assigned to Gerald FitzGerald, who left the States in May and was landed in Nushagak by airplane from Anchorage early in June. His surveys will be carried on principally along the course of the larger streams, with such back-packing trips into the more remote tracts as opportunity allows, with the aim of obtaining general information regarding the larger aspects of the region. Although these surveys will doubtless be of general direct value, their principal purpose will be to serve as guides in formulating more comprehensive plans for the geologic and topographic reconnaissance of the whole tract between Bristol Bay and the Kuskokwim River, if the results obtained from this preliminary survey indicate the desirability of undertaking such a project. This larger project would necessarily involve several years' work and would require the sending in of a number of topographic and geologic parties equipped with transportation facilities that would best meet the conditions that would be encountered. The remoteness of this region from ordinary lines of travel makes it difficult and expensive to survey, so that every precaution will have to be taken in advance to adopt plans that will permit the greatest amount of work to be accomplished.

The large tract of country lying north of the Yukon River, adjacent to the international boundary and south of the Porcupine River, is another of the great areas of Alaska about which almost nothing is known and in which practically no surveys have been made. A preliminary reconnaissance geologic survey of the southern part of this area is one of the projects that has been undertaken in 1930. This work is in charge of J. B. Mertie, jr., who, with a pack train and the necessary equipment, started work near the mouth of the Tatonduk River early in June and will carry the work as far

north and west as conditions allow. So little is known about this region that no prediction as to whether or not it contains minerals of value can be made. Some lines of evidence suggest that conditions favorable for local mineralization may be found in the region, especially if intrusions of deep-seated igneous rocks are discovered. The area lies so close to the Yukon that if deposits of value occur in it the problem of transportation to and from them should be relatively easily solved. Even if search should not disclose mineral deposits of value, the area is likely to be of great geologic significance because observations made near its borders indicate that it probably contains one of the most complete Paleozoic sections to be found anywhere in Alaska and one that has undergone relatively little metamorphism. The general light that such a section would be able to shed on the whole Paleozoic geology of Alaska can hardly be overestimated. If the results obtained in this preliminary survey show satisfactory conditions, it will probably be the forerunner of more comprehensive surveys, both geologic and topographic, to be started next year and continued for several years until the entire triangle between the Yukon and the Porcupine has been mapped.

The general survey of Alaskan mining conditions to be conducted by the chief Alaskan geologist will resemble similar work in the past, though the individual points visited will necessarily differ, in order that the itinerary may include visits to as many of the field parties as are reasonably accessible and that some of the more productive mining camps, as well as others that have not recently been studied, may be visited. Detailed plans can not be stated in advance, as they will necessarily depend very largely on the conditions that are found in the field and the availability of transportation. It is hoped that opportunity may be found to visit the new placer developments south of Ruby and possibly parts of the Innoko, Tolstoi, and Takotna districts and some of the camps in the western part of the Kuskokwim Valley that have not recently been visited by members of the Geological Survey. Owing to duties in Washington this work will not be started until after the first of July.

The collection of statistics regarding the mineral output of Alaska in 1930 will in general be similar to the work done on the corresponding project in 1929 and described on page 93 of this report. The collection of material for this purpose should be completed about the middle of 1931.

The second of the office projects that was undertaken for the season of 1930 is the assembling and mounting of the thousands of photographs resulting from the printing of the films taken by the detachment of Navy aviators in southeastern Alaska in the season of 1929. There are approximately 25,000 views on hand to be pre-

pared for cartographic use, and this work, it is now estimated, will keep one man completely employed for a working year. This work is necessary not only to preserve the prints but so that they may be available for use in map compilations. If time and funds are available, a start will be made on the compilation of drainage maps of additional areas in southeastern Alaska, so that these maps may be available for the use of engineers engaged in topographic mapping in that region in the field season of 1931. In fact, the compilation of drainage maps from these photographs should be expedited as much as possible, even if it may not be practicable to follow up at once with complete topographic surveys of the areas thus compiled. The reason for this is that the drainage maps are of considerable use to other Government bureaus, especially the Forest Service, and to persons interested in the development of Alaska, as they furnish much general geographic information as well as data regarding possible power sites and sources of water supply. The Geological Survey has already received letters stating that the small drainage map of parts of the Ketchikan-Hyder region alone has saved thousands of dollars to persons developing the timber and power resources of that region. There is an equally urgent demand that a start on a similar mapping program be made in the vicinity of Juneau and on Admiralty Island, for which pictures are also available.

EXPENDITURES

The funds used for the work of the Geological Survey on Alaska's mineral resources during the field season of 1929 were made available through the Interior Department appropriation acts for 1928–29 and 1929–30. The amount appropriated by the act of 1928–29 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. The amount appropriated by the act for 1929–30 was $67,500. During the field season of 1930 the funds used were made available through the Interior Department appropriation act for 1929–30, already noted, and the act for 1930–31, which appropriated $75,000. From the foregoing statements 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 approximately 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 1929–30 were expended.

Expenditures from funds appropriated for investigation of mineral resources of Alaska for the fiscal year 1929–30

Projects for the season of 1929	$13,016
Projects for the season of 1930	12,700
Administrative salaries, July 1, 1929, to June 30, 1930	3,410
All other technical and professional salaries, July 1, 1929, to June 30, 1930	29,168
All other clerical and drafting salaries, July 1, 1929, to June 30, 1930	7,894
Office maintenance and expenses	1,312
	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 1929 from the appropriation for 1929–30 amounted to $13,016, which includes $9,062 for geologic and general investigations and $3,954 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 1930 shows that expenditures from funds for the fiscal year 1929–30 amounted to $12,700, of which $7,800 was for geologic work and $4,900 for topographic work. Of the $25,716 allotted to field projects for both seasons from the appropriation, $16,862, or about 65 per cent, was allotted to geologic or related general work and $8,854, or 35 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 1929–30 the chief Alaskan geologist was on leave without pay from July 1 to 19 and then was engaged in field work until September and later spent the equivalent of one and a half months on the preparation of the statistical report, as well as several months in

the preparation of other reports. During his absence in the field 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, to which is therefore charged a proportional part of their salaries. This makes for low cost of administration but lessens the amount of time spent in 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 covers part of the salary of the chief clerk and of two junior clerks and a draftsman in the Washington office and part of the salary of a clerk in the Anchorage office. Approximately three-fourths of the time of one of the junior clerks 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. The draftsman is engaged in all kinds of map preparation, involving the compilation of cartographic material and the preparation of fair copy therefrom for use in direct reproduction or for record purposes. 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 was 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 is really uneconomical.

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, the photographic and related work required in the course of the compilation and preparation of the maps, and the printing of field photographs other than those taken in the course of the airplane work. 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, and shipment of material not for use in designated projects. One of the largest single expenses charged to this item was the photolithographic reproduction of a topographic map of the Goodnews Bay region, which was issued as an advance edition subject to correction, at a cost of about $140. As will be seen, the total

charged against this item represents an amount equivalent to less than 2 per cent of the total appropriation.

In the following tables has been set down the cost of the work, including field expenses and the salaries paid from different appropriations, by geographic regions or by classes of work. The figures for the cost of the salaries charged against each project are 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 in 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 104 for a single fiscal year. Furthermore, the expenses from the appropriation for 1930–31 are necessarily all estimates, as actual expenditures will not be known until the end of the field work in the winter. The figures used therefore simply represent the allotments that have been made for the different projects.

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

Region and work	Appropriation for 1928–29		Appropriation for 1929–30		Total
	Expenses	Salaries	Expenses	Salaries	
Southeastern Alaska, Navy project	$2,350	$333	$600	$4,167	$7,950
Southeastern Alaska, printing films			1,000	960	2,960
Copper River region, geologic reconnaissance	1,800	833	2,080	5,375	9,688
Lake Clark-Iliamna, geology and topography	4,650	1,584	2,000	7,584	16,818
Yukon region, geologic reconnaissance	2,550	800	2,452	4,000	9,802
General mining developments			668	2,176	3,344
Alaska offices, field work			1,837	[a] 1,363	3,200
Mineral-resources statistics				[b] 2,015	2,015
	11,350	4,000	13,016	27,320	55,136

[a] Includes 3 months' salary of clerk in district office.
[b] Includes 1½ months' salary of geologist and 9 months' salary of clerk.

Approximate cost and distribution of work by geographic divisions for the season of 1930

Region and work	Appropriation for 1929–30		Appropriation for 1930–31		Total
	Expenses	Salaries	Expenses	Salaries	
Ketchikan district, topographic mapping	$2,400	$834	$5,250	$4,167	$12,651
Taku district and southeastern Alaska, mining geology			2,000	1,042	3,042
Alaska Railroad region, geology	2,500	625	2,200	4,167	9,492
Chilkitna district, geologic mapping	2,050	934	2,800	4,667	10,451
Nutzotin district, topographic mapping	2,500	632	2,300	3,167	8,599
Upper Yukon region, geologic mapping	3,250	800	3,500	4,000	10,550
General mining development investigations			1,000	2,133	3,133
Preparing airplane prints			3,550	1,140	4,690
Mineral-resources statistics				[a] 2,160	2,160
	12,700	3,825	21,600	26,643	64,768

[a] Includes 1½ months' salary of geologist and 9 months' salary of clerk.

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 or may be 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 1929–30 the allotment for Alaska leasing work was $10,000. This was the same amount as was allotted for the leasing work in the preceding fiscal year.

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 that conduct such mineral-resources work as is assigned to the Alaska local offices. B. D. Stewart, supervising engineer, who has headquarters at Juneau, is in immediate charge of the field work, assisted by 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 a clerk in the Anchorage office are 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 1929–30 the allotment for field expenses was approximately $1,500, 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 a 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 almost no active drilling for oil is being done in Alaska under Government permit, and consequently little of the time of the engineers is spent in the supervision of oil developments. There are, however, many tracts of public land 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. It would ordinarily be the practice for the Federal engineers to check up on these permits occasionally by field visits, but the field force available is altogether too small to attempt to make even a casual examination of most of the tracts under permit. Under present conditions it is therefore necessary to rely mostly on local unofficial reports, especially as these indicate no active oil prospecting in progress in any but two of the fields. 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 regular 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 to a mere gesture.

THE SLANA DISTRICT, UPPER COPPER RIVER REGION

By FRED H. MOFFIT

INTRODUCTION

This paper is a brief preliminary statement about the geology and mineral resources of an area north of the Wrangell Mountains which includes a small part of the drainage basins of the Copper and Tanana Rivers. The area comprises the valleys of Indian Creek and the Slana River and parts of the Chistochina and Tok Valleys. Mentasta Pass, which lies between the Slana River and the Little Tok and is an Alaskan landmark, is in the eastern part of it. (See pl. 1.)

Topographic maps on which most of this area appears were based on surveys made by T. G. Gerdine and D. C. Witherspoon in 1902. Hasty geologic reconnaissances of the area were made by W. C. Mendenhall and F. C. Schrader at the same time. The economic results of these surveys were printed shortly afterwards,[1] but only a part of the geologic observations appear on published maps.

The writer spent the summer of 1929 in this district in order to extend the earlier geologic observations and examine such mineral deposits as are known. An area of about 800 square miles was covered, and the principal results of the work are presented here, although it is expected that the field work will be continued and a more comprehensive report will be made at a later time.

DRAINAGE AND RELIEF

The area considered includes a small part of the east end of the Alaska Range. It is crossed in an east-southeasterly direction by the axis of the range, which extends across the northern portion, marking the divide that separates waters flowing to the Pacific Ocean from those flowing to Bering Sea. The highest point of the divide is Mount Kimball (9,680 feet) on the west side of the area, where the mountains are rugged, snow covered, and seamed by numerous glaciers. Toward the east the altitudes are less and in the vicinity of the Little Tok River average not far from 6,000 feet. Moreover, the mountains of this part of the range are less jagged and have no glaciers. The south-central part of the area, between the main range and the Copper River, includes a separate group of mountains, which

[1] Mendenhall, W. C., and Schrader, F. C., The mineral resources of the Mount Wrangell district, Alaska: U. S. Geol. Survey Prof. Paper 15, 1903. Mendenhall, W. C., Geology of the central Copper River region, Alaska: U. S. Geol. Survey Prof. Paper 41, 1905.

are somewhat less rugged than the Alaska Range on the north and are markedly lower and of smoother contour on the south and west.

The area is drained by several small tributaries of the Copper River, the chief of which are the Slana River, Ahtell Creek, and the Chistochina River, and by the headwater tributaries of the Big Tok River,[1] which flows into the Tanana. The Slana River rises in a glacial source near Mount Kimball and flows southeastward through the center of the area but finally swings to the southwest and joins the Copper River at the northernmost point of the big bend of that stream, where it turns to the west in its sweep around the Wrangell Mountains. For much of the distance between the east end of Mankomen Valley and Burnt Creek the Slana flows through a narrow, canyonlike valley, but below Burnt Creek it is less confined and in some places meanders widely. This is especially true near the mouth, where the current is sluggish, the course winding, and the banks soft, so that fording with horses is not always easy. The valley of the Slana River separates the main part of the Alaska Range from the isolated group of mountains on the south. This group is drained for the most part by Ahtell and Indian Creeks and the East Fork of the Chistochina River.

The head of the Big Tok River receives most of its water from glaciers on the north side of the Alaska Range, opposite the head of the Slana. Like the Slana, it flows southeastward at first, but after joining with the Little Tok, which comes in from the south or southeast, it turns northeastward and flows into the Tanana. The largest western tributary of the Big Tok River is known to the few who visit it as the Dry Tok. Its headwaters are easily reached from the head of the Slana River by Gillett Pass, a low pass slightly above timber line and only a few hundred feet higher than the Slana. The Dry Tok flows nearly due east and joins the Big Tok about 12 miles from the mouth of the Little Tok River. Gillett Pass, the Dry Tok, and the upper valley of the Big Tok provide the easiest route from the Copper River side of the range to the head of the Robertson River, one of the tributaries of the Tanana River which has received some attention from prospectors. Another route between the Slana and Big Tok Rivers is afforded by Sikonsina Pass, in which Burnt Lake lies. It is used by the Indians and white trappers in winter but has never been used much in summer by the whites, as it is not the most direct route to the Robertson and has a good deal of soft ground.

Mentasta Pass is the best-known pass through the Alaska Range west of the Richardson Highway and the Delta River. The broad,

[1] The name "Tok" is an abbreviation of the Indian name, which is said to mean timber. It was given as "Tokai" by Lieut. (now Gen.) Henry T. Allen, who crossed the Little Tok in 1885. The stream is sometimes called "Tokio" by the prospectors.

low summit of the pass is below timber line and little over a mile east of Mentasta Lake, at the west end of the east-west valley that leads from the Slana River to the Little Tok. Mentasta station of the old military telegraph line and mail trail between Valdez, on Prince William Sound, and Eagle, on the Yukon, was on this summit, and the creek that comes down out of the mountains on the north and formerly flowed eastward through the valley to the Little Tok was named Station Creek for this reason. This creek, however, is no longer tributary to the Little Tok, for immense quantities of gravel brought down by the high waters of 1929 dammed the stream at the point where it emerges from its narrow mountain valley and diverted the waters to Mentasta Lake. What was before this diversion the lower part of Station Creek still meanders eastward in its former course through a chain of swamps and small lakes to the Little Tok. The winter of 1928–29 in this district was marked by exceptionally heavy snows and a late spring and was followed by a summer of unusual rain, including a fall of snow on July 29 that was more than a foot deep at the head of the Slana River. It is probable that the changes in the landscape due to landslides and the movement of gravel deposits by high water in 1929 were greater than in many years previously.

Numerous ponds and small lakes are scattered over the area. The largest are Mankomen Lake, at the head of the East Fork of the Chistochina River; Mentasta Lake, between the Slana River and Mentasta Pass; and the Cobb Lakes, near the westward bend of the Copper River. Most of these bodies of standing water are due to the action of glaciers in this region. They belong to a topography in which the drainage lines are not yet thoroughly established.

TIMBER

Practically all of the district is covered with timber up to an altitude of about 3,000 feet. In sheltered valleys and on sunny slopes trees may grow at somewhat higher altitudes, but in such places they are usually scattered and small. Spruce is the most common tree, both in the valley bottoms and on the hill slopes. Along many of the stream courses it is intergrown with cottonwood. Excellent timber suited for many purposes grows in some parts of the area, but unfortunately for those who may need it in the future much of it has already been destroyed by fire. The heavy, wet snow of July, 1929, came at a time when the deciduous trees were in full leaf, and the damage from breaking and overturning was far greater than takes place in winter. Even the conifers suffered much injury. Traveling in the valley bottoms, where the alders and small trees were bent down by the snow, was for this reason even more difficult than is usual in this district.

TRAILS

The area has few trails and in recent years has had few travelers. The trails most in use at present are the trail up the west side of the Chistochina River to the gold placers of Slate Creek and that part of the old military trail between the Chistochina and the mouth of the Slana. This section of the military trail is part of the present trail to the Nabesna and Chisana Rivers and is used more than the Chistochina trail, chiefly because mail for the placer miners in the Chisana district passes over it twice a month. The military trail and telegraph line between Valdez and Eagle, often called the Eagle Trail, was established by the United States Army in the early days of Alaskan exploration, but the part of it in the upper Copper River Valley above Gulkana was abandoned after the Richardson Highway was established. From Chistochina station, on the Copper River a mile west of the mouth of the Chistochina River, it traversed the swampy lowland north of the Copper to the Cobb Lakes, then swung north across Ahtell Creek and through a high valley to the crossing of the Slana River near Mentasta Lake. Passing along the foot of the steep mountain east of this lake, it turned east, traversed the valley of Station Creek to the Little Tok, which it followed northward to the Big Tok and eventually reached the Tanana River at Tanana Crossing. The part of the military trail north of Ahtell Creek is now almost unused except by a few Indians and trappers who travel it occasionally on foot in summer or by dog sled in winter. Many miles of the old telegraph wire remain, although most of the poles are down. The horses used by the writer in 1929 were the only horses that have been over Mentasta Pass in several years.

This description of trails would not be complete without some mention of the work of the Alaska Road Commission. A branch of the Richardson Highway which has been named the Abercrombie Trail is being extended up the Copper River as rapidly as money is available for the work. This road is designed for automobile use and in 1929 was open for travel between Gakona and a point on the Copper River 8 miles below Chistochina. By using the bars of the Copper River it was possible to drive a truck with a moderate load as far as the Chistochina River during the middle and later part of the summer. A camp for a crew of men and a portable sawmill were erected on the Chistochina River in the fall of 1929 to get out timbers for a pile bridge over the river. It is expected that the road will be opened for use as far as the Chistochina by the end of 1930 and that eventually it will connect with an international highway by which automobile travel between the United States and points in Alaska will be possible.

POPULATION

In the summer of 1929 the population of the area, not including the Slate Creek district, was three white men and a few natives. There is a white trader at Chistochina, another at the mouth of the Slana River, and a trapper at Mentasta Lake. There are also small settlements of natives at each of these places. The natives gain their living almost wholly by fishing, hunting, and trapping, but may get work from the Alaska Road Commission during the open season if they wish it. Their numbers appear to be slowly diminishing.

GEOLOGY

Only a brief, imperfect account of the geology of this area can be given, for it is not possible in reconnaissance work to discover more than the most outstanding geologic features of a mountainous area like this part of the Alaska Range.

The accompanying sketch map (pl. 1) shows both sedimentary and igneous rocks, together with large areas of stream and lake gravel and morainal deposits. In general the mountains south of the Mankomen Valley, between the Chistochina and Slana Rivers, are made up of igneous rocks, which include coarse-grained granitic rocks, dark fine-grained lava flows, intrusive rocks, and tuffs. They also include beds of limestone in a few places and possibly some other sediments. The mountains north of the Slana River are composed dominantly of sedimentary rocks but include considerable amounts of dark fine-grained igneous rock and some granitic rocks. Near the axis of the range most of these rocks have been altered to schist.

The age of most of the formations has not been established, and consequently they will be described by groups and localities rather than strictly in the order of age.

BEDROCK FORMATIONS

The mountains of the group between the Chistochina and Slana Rivers, south of the Mankomen Valley, have a characteristic topography, but within the group itself they are higher and much more rugged on the east than in the area between the Chistochina River and Indian Creek, where they appear as isolated smoothly rounded masses. So far as they have been examined they are a complex of igneous rocks which Mendenhall [8] described as Tetelna volcanics and Kluti diorite. These rocks show wide variations in color and texture and possibly differ considerably in age. The dark fine-grained igneous rocks appear to include both lava flows and intrusive rocks. They are black or dark gray and show variations in texture that

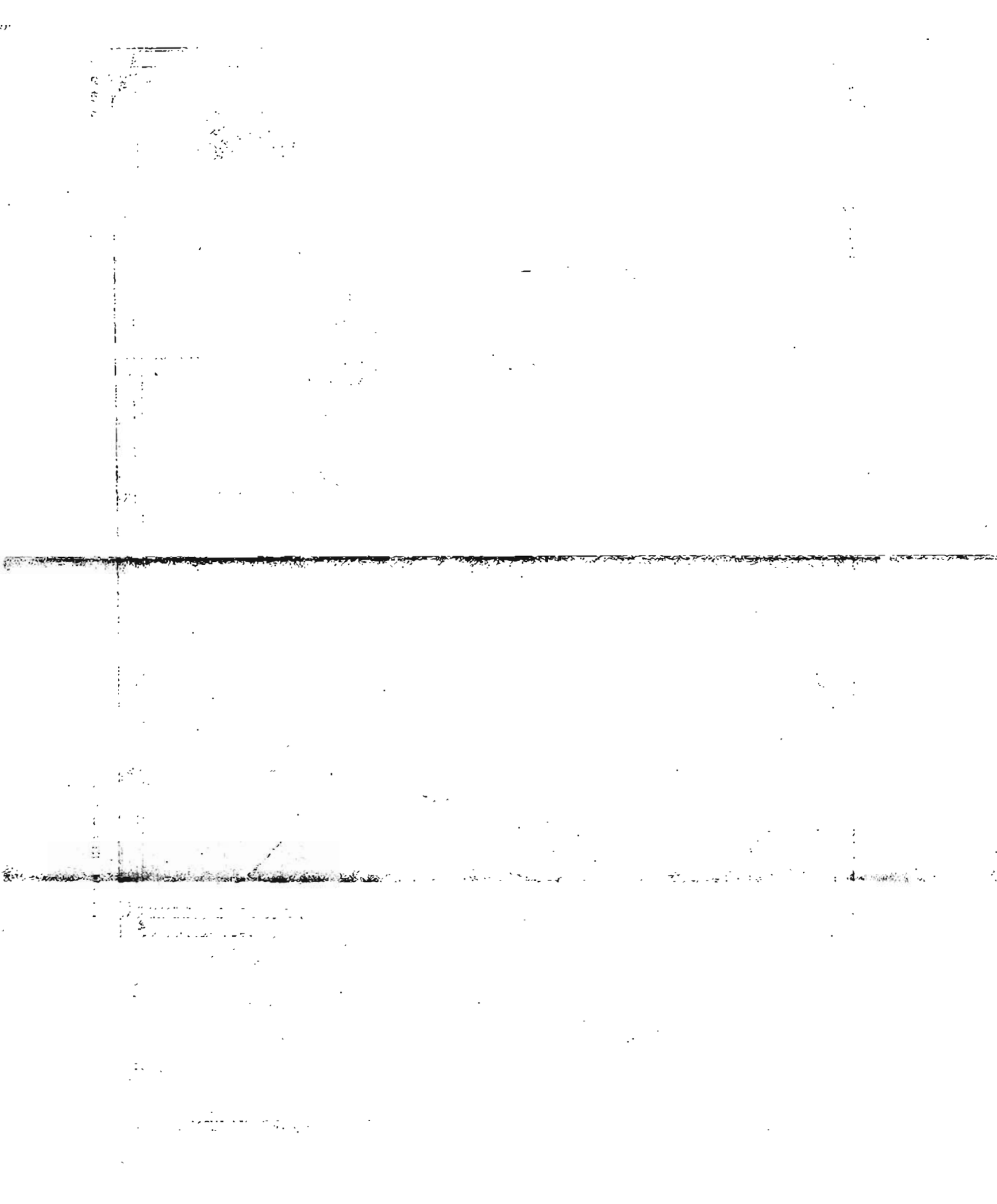
[8] Mendenhall, W. C., Geology of the central Copper River region, Alaska: U. S. Geol. Survey Prof. Paper 41, pp. 86, 88, 1905.

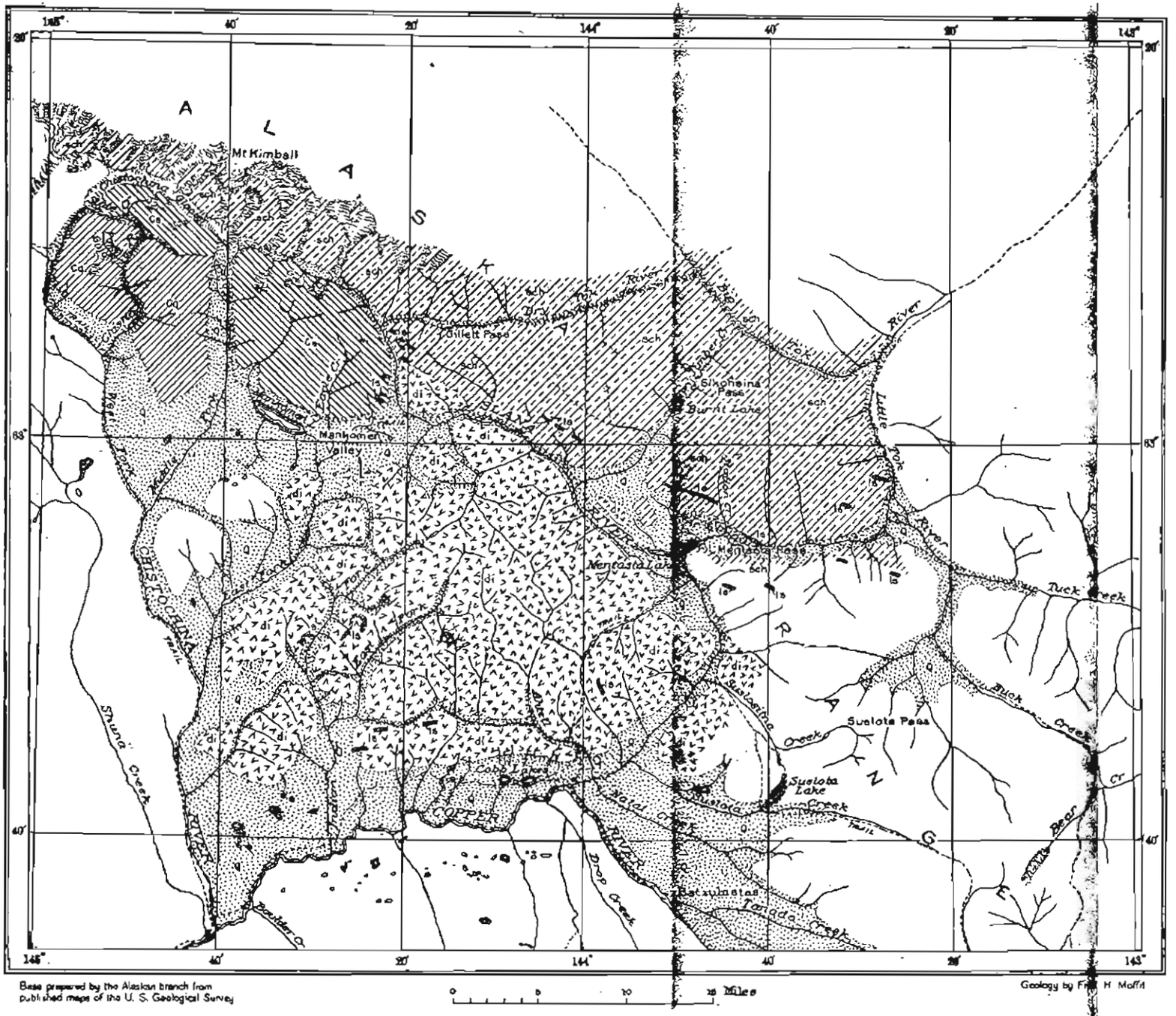
range from that of basalt so fine grained that individual minerals can not be determined to that of porphyritic rock with feldspar crystals an eighth of an inch across inclosed in a dense groundmass. Some of the porphyritic rocks were determined by Mendenhall as andesite. Coarse tuffs, which are calcareous in places and contain crinoid stems, are associated with some of the dark rocks. The dark rocks extend eastward across the lower Slana and appear also in a small area north of the upper Slana near the Mankomen Valley. In places they are pyritiferous and the weathered surfaces are brilliantly colored.

The coarse-grained light-colored granitic rocks have their greatest development in the northeastern part of the area south of the Slana but are present in all parts of it. They are prevailingly gray of varying shades but in places have a pinkish cast. They also vary in coarseness of texture. Some very coarse varieties are made up largely of pink feldspars. For the most part the granitic rocks are related to the diorites rather than to the granites and were described by Mendenhall as "chiefly quartz diorite or quartz diorite porphyry."

The relations of the light-colored granitic rocks and the dark fine-grained rocks are not everywhere clear. In some places dark rocks and light appear to grade into each other. Here and there dark rocks seem to intrude light rocks; elsewhere the reverse may be true. If the dark rocks are in part lava flows, as the writer believes, the relations are still more involved. It appears probable that the area has had a complicated history of igneous activity and that in addition to the extrusion of lavas and tuffs intrusion has occurred, perhaps in different geologic periods or epochs.

No sedimentary rocks were seen in the northern part of this mountain group, but the long low ridge north of the trail from Indian Creek to the mouth of the Slana is made up of igneous rocks, with which are associated beds of coarse white crystalline limestone and possibly some other sedimentary deposits, as observed by Mendenhall on Ahtell Creek. The limestone occurs in detached exposures but probably is several hundred feet thick. The recrystallization is thought to be due to the heat given off by hot intruded masses of melted rock rather than to dynamic metamorphism. The limestone appears to continue into the mountains west of Indian Creek but was not examined close at hand. Sedimentary rocks are known at two other localities within the area of igneous rocks. One locality is on the ridge between the forks of Indian Creek about 6 miles north of the junction. At this place a limy tuffaceous grit is overlain by about 100 feet of nearly horizontal light bluish-gray limestone weathering brown, which locally contains numerous fossils. The rocks that lie above the limestone and form the top of the hill are light-colored porphyritic granitic rocks of varying degrees of coarseness,





Base prepared by the Alaskan branch from published maps of the U. S. Geological Survey

0 5 10 15 Miles

Geology by Frank H. Moffit

EXPLANATION

BEDDED ROCKS

Q	Water-laid sand and gravel and morainal deposits	QUATERNARY
Ls	Sandstone, tuffaceous beds, shale, and limestone of Permian age	CARBONIFEROUS
Cg	Conglomerate, quartzite, and tuff, probably Carboniferous	
ls	Limestone, probably of different ages but in part Permian	AGE NOT DETERMINED
sch	Dark and light sericite and quartz-mica schist, phyllite, sheared conglomerate, altered limestone, and lava flows, dark fine-grained dikes, and light granitic masses	

IGNEOUS ROCKS

Gr	Granite	CARBONIFEROUS OR LATER
di	A complex of granitic rocks, chiefly quartz diorite and quartz porphyry and volcanic deposits (largely altered andesite) with which are associated limestone, in part of Permian age, and other sediments	
K	Galena prospect; contains copper	

GEOLOGIC MAP OF SLANA DISTRICT, ALASKA

containing feldspar, hornblende, and a little quartz. The second locality is about 4 miles from Ahtell Creek on the east side of the Eagle Trail. The exposures here were not examined, but the débris from the cliffs indicates the presence of rocks similar to those on Indian Creek.

The fossils collected on Indian Creek show that the limestone is of late Carboniferous (Permian) age and is to be correlated with the Mankomen formation of Mendenhall and with the Permian limestones at the heads of the White and Nizina Rivers. This is the only direct evidence of the age of any of the rocks so far described which has been obtained. On the other hand, Mendenhall pointed out the lithologic similarity of many of these rocks to the lava flows, tuffs, and interstratified sediments which he saw between the Middle and West Forks of the Chistochina River and regarded as older than the Mankomen formation.

Exclusive of the unconsolidated deposits, the rest of the area represented on the geologic map is occupied by rocks which are dominantly of a bedded character, in contrast to the complex of igneous rocks just described. They include slate, quartzite, and limestone, interstratified in places with large amounts of tuffaceous material and lava flows. All are folded and faulted, and part of them are altered to schist. In places they are intruded by igneous rocks of various kinds.

The mountains about the headwater tributaries of the Chistochina River, west of the Slana River, were not examined by the writer in 1929, but for a better understanding of the remaining part of the map a brief account of their geology is abstracted from Mendenhall's description.[4]

The block of mountains between the Middle and West Forks of the Chistochina River, south of the transverse valley in which Slate Creek lies, is made up of conglomerate, pyritiferous tuff, lava flows, quartzite, and arkosic beds cut by numerous diabasic and dioritic intrusive rocks. The bedded rocks have a nearly east-west strike corresponding with the direction of the Alaska Range in this vicinity and show various dips. Some of the calcareous members of this succession contain fragments of crinoid stems and other organic remains so imperfectly preserved that they have not yet yielded conclusive evidence for the age of the beds. Mendenhall named these rocks the Chisna formation and assigned them provisionally to the lower Carboniferous or Devonian.

The mountain mass between the Middle Fork of the Chistochina River and Slana River is described by Mendenhall[5] as

[4] Mendenhall, W. C., Geology of the central Copper River region, Alaska: U. S. Geol. Survey Prof. Paper 41, pp. 33–36, 1905.
[5] Idem, pp. 40, 41.

made up of a sedimentary series of sandstones, shales, and limestones with intrusive sheets whose total thickness, as determined from rough barometric measurements, is between 6,000 and 7,000 feet. * * *

This section falls naturally into two divisions, an upper prevailingly calcareous division, which includes somewhat more than half the total thickness, and a lower prevailingly arenaceous and tuffaceous division over 2,000 feet thick.

The sediments of the lower part, which are exposed near the Mankomen Valley, "are for the most part variegated feldspathic sandstones, often exhibiting decidedly tuffaceous phases." Near the head of Eagle Creek, in the upper part of the section, Mendenhall found a great bed of northward-dipping white limestone 500 feet thick overlying several hundred feet of beds which include dark thin-bedded limestone, sandy limestone, quartzite, sandstone, and thin beds of black shale. The big limestone is overlain by several hundred feet of black shale, which in turn is overlain by about 600 feet of very fossiliferous thin-bedded limestone lying beneath black shale of undetermined thickness. Mendenhall named this succession of beds the Mankomen formation and assigned to it a Carboniferous (Permian) age on the evidence of fossils. He recognized the fact that the Mankomen beds west of the Slana River are not structurally continuous with the rocks on the east side and attributed this to faulting. A narrow belt of the Mankomen formation extends from the Middle Fork of the Chistochina River to the West Fork. This belt is separated from the Chisna formation by a fault and from the schist north of it by another great fault, as is also the larger area of Mankomen rocks between the Middle Fork and the Slana River.

On both sides of Gillett Pass, between the head of the Slana and the Dry Tok, is southward-dipping black slate or phyllite filled with white quartz and cut by basaltic dikes. The black slate of this locality is evidently many hundred feet thick. It overlies silvery-gray schist on the north, and, although this condition may represent an original structural relation, faulting between the two formations has doubtless taken place. The mountain side east of the Slana River and south of Gillett Pass shows numerous exposures of silicified limestone representing a bed or succession of beds that crop out for a distance of more than a mile across the strike and appear to be several hundred feet thick. A few fragments of organic material were found in the limestone, but nothing from which the age could be determined. The black slate extends eastward from Gillett Pass, forming the lower slopes of the mountains north of the upper course of the Dry Tok and making up all the north slopes of the mountains south of it. Although the black slate beds were not followed through to Sikonsina Pass on the southeast, they are probably to be correlated with the black slate that is exposed there. The rocks north of the black slate on the upper Dry Tok comprise silvery

siliceous schist, black siliceous schist, sheared quartzite, and subordinate amounts of recrystallized limestone. They form the mountains on both sides of the lower part of the north end of the valley occupied by Burnt Creek and Timber Creek and extend eastward at least as far as the Little Tok. These rocks seem to be made up chiefly of altered sedimentary beds. South of Burnt Lake the schist beds are succeeded on the south by possibly 500 feet of black slate or phyllite overlain by several hundred feet of basalt flows. This section is repeated on upper Station Creek, and the volcanic member, which here includes a minor bed of black slate, is followed on the south by sheared conglomerate in which pebbles are sparingly scattered through a subschistose groundmass. In places the larger fragments consist wholly of limestone. This conglomeratic schist contains a bed of limestone which is conspicuous in the mountains north of Mentasta Lake, northeast of Mentasta Pass, and in the mountains south of Station Creek near the Little Tok. The rocks along the west side of the Little Tok are the eastward extension of those seen on upper Station Creek and Timber Creek. These rocks have been intruded by coarse granitic rocks whose outcrops may be seen in several places along the Eagle Trail. An example of such intrusive rocks is the light-gray granite north of the old telegraph station in Mentasta Pass. This granite is much altered chemically but is not schistose like the rocks which it intrudes. The difference, however, may indicate simply greater ability to withstand pressure rather than intrusion after the schistose structure was formed.

The geologic map immediately suggests that the limestone exposures south of Gillett Pass, north of the Slana River, and west of Burnt Creek, north of Mentasta Pass, and south of Station Creek between Mentasta Pass and the Little Tok belong to the same series of beds. Although this is probably true, the beds are much folded and faulted, and proof of their equivalence is lacking.

The two low hills about 2 miles northwest of Mentasta Lake are composed of dark basaltic rocks and tuffaceous conglomerate in which limestone pebbles are numerous. The mountain east of Mentasta Lake and south of Mentasta Pass shows a large thickness of hard conglomerate with many pebbles of limestone and limy argillite associated with beds of gray arkosic sandstone. Both the conglomerate and the arkosic sandstone appear in the hand specimen to be somewhat tuffaceous. These rocks contain one or more limestone beds, whose outcrops may be seen on the mountain slopes facing the Slana River several miles southeast of Mentasta Lake. The rocks between Mentasta Pass and the Slana River are distinctly less metamorphosed than those north of the pass. The significance of this difference was not learned. It may be that formations of different ages are present, or possibly the forces which produced the

schistose structure were less effective at this distance from the axis of the range.

UNCONSOLIDATED DEPOSITS

Deposits of unconsolidated material conceal much of the bedrock in this district. Aside from the thin mantle of vegetation and unsorted waste from rock disintegration that is now in progress, the unconsolidated deposits may be classified as stream gravel, lake gravel, and morainal deposits, the assignment depending on whether the effects of moving water or of glacial ice are most in evidence in their present condition, for these different deposits can not everywhere be distinguished from one another. The deposits of waterborne gravel and glacial deposits are not separated on Plate 1.

Practically all of the area under consideration, with the possible exception of some of the higher peaks, was once covered by glacial ice, which left a veneer of débris when it disappeared. This débris was most abundant at the lower levels, for the thickest accumulation of ice was there and remained there longer. As the glaciers melted the load of rock waste on and within them was gradually freed. Much of it was immediately subjected to sorting and transportation by running water, and the characteristic features of glacial deposits were modified or obliterated. In this way coarse and fine materials were sorted, and the sharp edges and angular forms of rock fragments typical of glacial deposits were largely destroyed.

Stream gravel is present along all the streams of the district and in their flood plains and terraces. Elevated bench gravel was not seen but is doubtless present in protected places. No preglacial deposits were recognized, and it is doubtful if they exist, for the ice moving down the narrow valleys swept away the loose material.

A feature that is not yet fully explained is the presence of well-rounded waterworn pebbles and cobbles of quartz, diorite, basalt, and other rocks on the hilltops up to an altitude of more than 4,000 feet, or 3,000 feet above the neighboring streams. The scattered pebbles are plainly rock fragments that have been rounded by running water and were probably brought to their present resting places by the glacier ice or by streams upon its surface, for many of them are foreign to the localities where they are found.

Glacial deposits are widespread and in places are so typical in form as to be recognized without difficulty. Such deposits are conspicuous in the Mankomen Valley, which is floored with sheets of morainal material crossed by numerous winding ridges of ice-borne débris and dotted with depressions, many of which are occupied by small lakes and ponds. Similar but less extensive deposits are present in the Mentasta Valley, where they are partly hidden by timber and are not so readily seen as in the Mankomen Valley. The south side of Men-

tasta Pass is covered with such deposits. Moreover, parts of the Mentasta Valley appear to be underlain by ice or by frozen silt, which thaws and allows the surface to sink, thus forming depressions that may be dry or may contain water and that are surrounded by nearly vertical banks with overhanging fringes of moss and vegetation. In some of these depressions the slumping of the banks has caused the trees to fall inward and has given the trunks a striking radial arrangement.

Although all the narrow mountain valleys were once occupied by ice, glacial moraines are not common in them, for the streams, confined to the narrow valley floors, eventually remove all traces of original morainal structure in the débris and redistribute the material in the stream gravel.

STRUCTURE

This area does not extend far enough north to furnish a complete section across the Alaska Range. Furthermore, not enough work has been done in it yet to give more than an imperfect idea of the structure of the part that was examined. In a general way the bedded rocks north of the Slana, which include volcanic as well as sedimentary material, dip southward away from the axis of the range wherever they were observed. Although steep dips are common, closely compressed folds are less so, especially in the less metamorphosed beds. In addition to being folded and in part altered to schist these rocks are much faulted, as is shown by discontinuous and offset beds of limestone and the disturbed condition of all the beds in many places. Faults of at least two kinds are present—those that trend with the strike of the beds and those that are transverse to it. Among the strike faults is the great southward-dipping fault between the black slate and silvery schist near Gillett Pass. This fault is believed to extend many miles to the west, but its eastward extension is not known. West of the head of the Slana River it separates relatively unaltered Permian deposits from schist. A parallel fault separates the Mankomen and Chisna formations on Slate Creek and the head of the Chisna. Doubtless much faulting of this kind has escaped notice.

Transverse faulting is suggested by Mendenhall as the explanation of the lack of structural continuity of the beds between the Middle Fork of the Chistochina and the Slana with the beds west of the Middle Fork and those east of the Slana. This mass of Permian beds appears to be a tilted fault block. Transverse faulting is also believed to account for offsetting of beds on Burnt and Station Creeks and in other localities.

A close relation probably exists between faulting and the intrusion of igneous masses like the granite at Mentasta Pass and the numerous dikes that cut the black slate at Gillett Pass and many other places.

MINERAL RESOURCES

The upper part of the Copper River Basin received considerable attention from prospectors in 1898 and the next few years. During this time the gold placers of Slate Creek, Miller Gulch, and neighboring streams were discovered and evidences of mineralization were found at several other localities, including Indian Creek and the vicinity of Mentasta Pass. Since that time and especially since the military telegraph line was abandoned comparatively little prospecting has been done.

The gold placers of Slate Creek and Miller Gulch are much the most valuable of the mineral deposits so far discovered and are the only deposits on which profitable mining operations have been conducted. This district was described first by Mendenhall[6] and later by Moffit.[7] Still later a short account of it was written by Chapin,[8] whose attention was given chiefly to the platinum that occurs with the gold. The Slate Creek placers have been in continuous production since their discovery. They were not visited by the writer in 1929 and will not be described here.

The brilliant coloring that results from the weathering of pyrite or other iron sulphides is particularly conspicuous in the mountains north of the Slana, and an examination of many specimens collected there shows that the content of pyrite is large. At one locality near the northward turn of the Eagle Trail into the Little Tok Valley large blocks of limestone mineralized with a variety of iron sulphides were seen in the debris from limestone cliffs high on the mountain. The outcrop of the sulphides was not sought out, but evidently the limestone contains one or more veins of such minerals.

Veins of galena were found by the early prospectors, and a little placer gold was discovered near Mentasta Lake, as well as in the Slate Creek district. A vein carrying tungsten is reported on the upper part of the Big Tok River, outside the area visited by the writer, not far from the pass to the Robertson River, a tributary of the Tanana, on which a little prospecting has been carried on for many years.

The only prospect known to the writer on which development work is being done at present is a vein of galena on Indian Creek held by Carl Whitham, who has prospected in the Copper and Tanana headwaters for many years. The claims are on a small tributary of Indian Creek 15 miles from its mouth. This tribu-

[6] Mendenhall, W. C., Geology of the central Copper River region, Alaska: U. S. Geol. Survey Prof. Paper 41, pp. 107–117, 1905.

[7] Moffit, F. H., Headwater regions of Gulkana and Susitna Rivers, Alaska: U. S. Geol. Survey Bull. 498, pp. 79–80, 1912.

[8] Chapin, Theodore, Platinum-bearing gravels of Chistochina River: U. S. Geol. Survey Bull. 692, pp. 137–142, 1919.

tary is little more than a mile long and flows northwestward, joining the east branch of Indian Creek a short distance above the point where Indian Creek forks. The vein is at the head of the tributary, near the top of the ridge dividing this tributary from the next small tributary on the east. The country rock is quartz diorite, which shows wide variations in texture but at the place where the vein was found is coarsely granular and contains large phenocrysts of feldspar. At this place the diorite is cut by a number of vertical fracture planes extending east and west and distributed over a distance of 100 or 200 feet from north to south. About 75 feet below the top of the ridge, which is 1,800 feet above Indian Creek, a quartz vein stands more than 6 feet above the ground and is at least 10 feet wide, although its boundaries are not exposed. Broken-down ledges and float show that this vein extends down the hill several hundred feet, but it does not hold the same width and where it crosses the ridge is reduced to about 18 inches. The quartz is cavernous and iron stained and evidently contained iron sulphides, which have been leached out, leaving the more resistant galena.

Between 100 and 200 feet south of this vein are two open cuts on similar quartz veins, but they were caved, so that the veins could not be seen. Almost directly west of these open cuts and 300 feet lower on the mountain slope are two other open cuts on the east side of a small gulch. The southern one is about 15 feet higher than the other. The diorite between them is crossed by numerous parallel fracture planes, which are vertical, trend east, and contain mineralized quartz in veins from a fraction of an inch to several feet thick. The largest of the quartz veins exposed in the gulch is about 7 feet thick but was not wholly in view, for the gulch was still partly filled with snow at the time of visit. Moreover, the character of the vein varies within a short distance, for a few feet above in the gulch half of the thickness of solid quartz is replaced by smaller parallel veins. The quartz is mineralized with galena, chalcopyrite, and probably pyrite. It is cavernous and iron stained from the weathering of iron sulphide and in places is stained with copper. A small vein about an inch thick in the lower open cut shows a large proportion of galena distributed with considerable regularity throughout a gangue of quartz, but the larger vein of the cut to the south contains galena and a little chalcopyrite somewhat more unevenly distributed. Between the outcrop and the open cuts near the top of the ridge several exposures of quartz vein matter were seen, but because of loose material on the surface it was not possible to tell whether they are part of a continuous vein or fracture zone. The development work on the claims consists of open cuts, mostly on the west side of the ridge, and a trail

which climbs the mountain side from the rock slide at the head of the valley to the upper open cuts, a vertical distance of 400 feet. There is also an open cut on the east side of the ridge which was not examined because of a snow comber on that side.

At 3 miles below the forks of Indian Creek is a pass leading to the west branch of that stream. About 2 miles northeast of the summit of this pass, near the head of the stream that flows westward from the pass, is a vein of galena-bearing quartz in diorite showing great similarity to the occurrence just described. Several open cuts have been made to uncover the vein, but they were so badly caved at the time they were visited that none of the vein material could be seen in place. The hill slope below the open cuts is strewn with loose blocks of float, but the writer was unable to tell whether they came from a vein uncovered by the pits or are float from a more distant source. The valley is a cirque valley and contains many erratic boulders.

At present no productive mining is being done within the district about the Slana River, but the evidences of mineralization appear in widely separated localities and are the basis of a hope for the development of profitable mining in the future. The district has features which commend it to the attention of prospectors, yet its distance from a source of supplies and the lack of inexpensive transportation have so far prevented thorough prospecting. Among the geologic features that may be looked on as favorable are the presence of sedimentary rocks, including limestone, and interstratified volcanic beds cut by numerous intrusive masses of diorite, granite, and other igneous rocks. These rocks show different degrees of metamorphism, ranging from slight alteration to well-developed schistose structure, and in numerous places they contain iron sulphides widely distributed, as is shown vividly by the brilliant color of the weathered surfaces. Although the presence of such granitic rocks is not an assurance of the presence of valuable minerals, the close genetic relationship of a great number of well-known mineral deposits with such rocks is a firmly established fact.

The physical features of the district are no more unfavorable than those of much of the rest of Alaska. The summer season is short and the winter is cold, but the snowfall is usually not great. Feed for stock is not everywhere plentiful but in places is abundant for a few weeks in summer. Much of the district is favorably situated with reference to a supply of timber, which is always in demand in mining operations. Lastly, the completion of a highway suitable for automobile transportation will assist greatly in reducing the cost of supplies and should stimulate prospecting.

THE LAKE CLARK-MULCHATNA REGION, ALASKA

By Stephen R. Capps

INTRODUCTION

LOCATION AND GENERAL CHARACTER OF THE REGION

The region here considered lies in south-central Alaska, on the west flank of the Alaska Range between latitude 60° 15′ and 61° 5′ north and longitude 153° 40′ and 155° 10′ west, and includes the western face of the range and a part of the foothills in a belt that ranges from 15 to 25 miles in width and extends from Lake Clark northeastward to the basin of the Stony River. It is therefore an intermediate belt, bordered on the east by the high, rugged, snow-capped mountains of the Alaska Range, which reach altitudes of 8,000 to 9,000 feet or more, and on the west by the headwater basins of the Mulchatna River, a tributary of the southward-flowing Nushagak River, and the Hoholitna and Stony Rivers, tributaries of the Kuskokwim. These basins are characterized by wide, level lowlands broken by more or less isolated hills and ridges of mature slopes that rise 1,000 to 3,000 feet or more above the adjacent valleys. The existence of a large lake at approximately the position of Lake Clark, at the south edge of the region here described, has been fairly well known since the early days of the Russian occupancy. The area north of Lake Clark, although it has been visited by a considerable number of white prospectors and trappers during the last 30 years, has remained one of the little-known parts of Alaska. Only crude sketch maps have been available to show the courses of the main rivers, and these maps differed so much among themselves that little reliance could be placed upon them.

PREVIOUS EXPLORATIONS AND SURVEYS

From the time of Bering's discovery of Alaska, in 1741, many navigators sailed along the coast of southern and southwestern Alaska, and its shore lines were fairly well known by the end of the eighteenth century, when Cook, Dixon and Portlock, and Vancouver had made rather complete charts of the shores of Cook Inlet and the Russians had explored the shores of southwestern and western Alaska. Inland

explorations into the region between Cook Inlet, Bristol Bay, and the headwaters of the Kuskokwim River came more slowly. An unpublished manuscript by Alfred H. Brooks outlines many details of the early explorations in this region, and a condensed statement of Brooks's findings has been given by P. S. Smith,[1] so that only a brief summary will be given here.

The first inland exploration of importance was made in 1818 by Korsakorsky, who traveled from Cook Inlet to Bristol Bay by way of Iliamna Lake. In 1829 Vasilief and Lukeen journeyed from Bristol Bay up the Nushagak and thence to the Kuskokwim at the mouth of the Holitna, and in 1832 Kolmakof and Lukeen followed the same route and established Lukeen's Fort, on the Kuskokwim a hundred miles below the Holitna. This settlement was partly burned by the natives in 1841 but was soon replaced by a new one named Kolmakof's Redoubt, a few miles below. This is the site of the present village of Kolmakof. Other explorations of the Russians in this region that are worthy of mention are Glazanof's trip some 50 miles up into the basin of the Stony River, in 1834, and Zagoskin's journey in 1844 from Lukeen's Fort up the Kuskokwim to the Takotna.

Martin and Katz[2] report that some of the early Russian maps indicated a large lake in the general region of Lake Clark, and the presence of such a lake had long been vaguely known, but the first definite account of its existence resulted from an exploration of A. B. Schanz and J. W. Clark, who in 1891 ascended the Nushagak and Mulchatna and possibly traversed a part of the area considered in this report.

In 1898 J. E. Spurr and W. S. Post, of the Geological Survey, made a notable expedition from Cook Inlet across the Alaska Range by way of the Skwentna River, descended the Kuskokwim to its mouth, and thence made their way partly overland and partly along the coast to the head of Bristol Bay and across the Alaska Peninsula to Katmai Bay. They thus made a complete circuit around the Lake Clark-Mulchatna region, though they did not set foot within 100 miles of it.

Osgood[3] and Maddren, of the Biological Survey of the United States Department of Agriculture, in 1902 roughly mapped the route from Cook Inlet to Lake Clark and thence by the Chulitna, Mulchatna, and Nushagak Rivers to Bristol Bay. In 1901 and for several succeeding years an exploration for a railroad line from Iliamna

[1] Smith, P. S., The Lake Clark-central Kuskokwim region, Alaska: U. S. Geol. Survey Bull. 655, pp. 12–16, 1917.

[2] Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region, Alaska: U. S. Geol. Survey Bull. 485, p. 24, 1912.

[3] Osgood, W. H., A biological reconnaissance of the base of the Alaska Peninsula: U. S. Dept. Agr. Biol. Survey North American Fauna, No. 24, 86 pp., 1904.

Bay to Anvik, on the Yukon, was carried on intermittently, and a route was selected; but so far as is known only a crude exploration survey was made, and that only as far as the Mulchatna River. Apparently this route ran westward from Lake Clark up the valley of the Chulitna River. No construction work was done.

About 1912 reports of important discoveries of placer gold brought about a small stampede to the upper basin of the Mulchatna River. The focus of activity was in the neighborhood of the canyon of Bonanza Creek, a tributary that rises in the foothills west of the area directly concerned in this report. A large number of claims were staked and a little gold was recovered, but no ground was found that could be worked at a profit under the conditions then prevailing, and no serious mining has since been done there. As a result of this stampede a good many men prospected the headwaters of the Mulchatna, but they left no record of their explorations.

The first accurate survey in this region, of which a published record was made, was that of the United States Geological Survey in 1909, when D. C. Witherspoon, topographic engineer, and G. C. Martin,[4] geologist, with 10 other technical and camp men, surveyed an area between Iliamna Bay and Lake Clark. Their published report included topographic and geologic maps of the area covered, and their observations and conclusions in respect to the geology of that area, which is directly south of the region here under discussion, has been of great help in preparing this report.

In 1914 another expedition from the Geological Survey, in charge of R. H. Sargent, topographer, with P. S. Smith as geologist, landed at Iliamna Bay with pack horses and proceeded to the foot of Six-mile Lake, a southwestward continuation of Lake Clark, where the field work began. From that point they traveled in a northwestward direction, eventually making their way to the Kuskokwim and thence to Iditarod. This expedition also resulted in the publication of a valuable report, including geologic and topographic maps of the route traversed.[5] As the area included in that survey directly adjoins on the southwest and west the region treated in this report and as several rock groups are present in both areas, Smith's report has been freely drawn upon by the present writer, who here gives rather brief descriptions of formations that have already been adequately described elsewhere.

It will thus be seen that as a result of the exploratory expeditions of Spurr in 1898 and Brooks in 1902 and of the reconnaissance surveys of Martin, Witherspoon, and their associates in 1909 and Sargent and Smith in 1914 a great area in the southern part of the Alaska

[4] Martin, G. C., and Katz, F. J., op. cit.

[5] Smith, P. S., The Lake Clark-central Kuskokwim region, Alaska: U. S. Geol. Survey Bull. 655, 162 pp., 1917.

Range has been surrounded by surveys, but there remained a rather compact block of rough, mountainous country bordered by the Skwentna River on the north, the Iliamna-Lake Clark region on the south, Cook Inlet on the east, and the Mulchatna-Kuskokwim lowland on the west, which had been visited by few white men and about which little was known. Plans for exploring and mapping this region had been under consideration by the Geological Survey for many years, and in 1926 a series of expeditions in charge of the writer was begun. The first of these expeditions, in which K. W. Trimble was topographer, in 1926 ascended the Skwentna River and mapped its headward basin, together with some contiguous country on the Kuskokwim slope of the Alaska Range. In 1927 the writer, with R. H. Sargent as topographer, penetrated into the basin of the Chakachatna River from the east and connected with the preceding year's work in the Skwentna Basin. In 1928 the writer, with Gerald FitzGerald as topographer, took up the work in the head of the Chakachatna Basin and carried it westward across the range to include the headward basin of the Stony River.

PRESENT EXPEDITION

The expedition of which this report is an account, the fourth in the series carried out in this general region, had as one of its main purposes the connecting of the earlier surveys carried west and northwest from Iliamna Bay with those carried into the region in preceding years by way of the Skwentna River and from Trading Bay on Cook Inlet. This purpose was successfully accomplished. The party, in charge of the writer as geologist, with Gerald FitzGerald as topographer, included four other men—Fred M. Bullard as recorder, G. W. Pearson and L. W. Oules as packers, and Thomas Owens as cook. To all these men the writer wishes to express his appreciation for able and faithful services. With 15 pack horses and the necessary equipment and provisions for the summer, the party was landed from the steamship at the mouth of Iliamna Bay upon an open barge in tow of a launch, supplied through previous arrangement by the Alaska Railroad. There are no regular landing facilities at Iliamna Bay. On landing the party proceeded over the trail and road to Iliamna Village, on the Iliamna River some 4 miles above the point where that stream flows into Iliamna Lake. From the village most of the supplies and three of the men traveled by boat to Severson's trading post, at the foot of the portage to the Newhalen River, while the pack horses were taken around the north shore of Iliamna Lake to the same point. From Severson's post the party went to the foot of Sixmile Lake, where the horses were swum across the head of the Newhalen River. At that point a

man was hired to take several hundred pounds of provisions, the supplies for the last half of the season, up Lake Clark to be stored at Carlson's cabin, a few miles above the mouth of the Kijik River. The pack train proceeded northwestward to the Chulitna River along an old Indian trail, and field work was begun in the hills just north of Long Lake, connecting with the 1914 surveys of Sargent and Smith. From Long Lake the party followed a northeasterly course through the foothills and along the face of the range to Telaquana Lake, at which the work was tied in to the 1928 surveys by Capps and FitzGerald, in the basin of the Stony River. The return trip was made from Telaquana Lake to Lake Clark over the Indian trail known to the natives as the Telaquana trail, and from Carlson's cabin, a few miles northeast of the mouth of the Kijik River, the pack train and three men followed the northwest shore of Lake Clark and Sixmile Lake to the head of the Newhalen River, while the other three members of the party traveled down the lakes by boat. The writer wishes to express his thanks to Mr. Brown Carlson for sheltering and caring for provisions left with him during the summer and for conveying personnel and supplies from his camp to the Newhalen portage in the fall.

From the head of the Newhalen portage the party followed the same route back to Iliamna Bay as that taken in the spring. Arrangements having already been made through the courtesy of the Alaska Railroad for a launch to meet the party at Iliamna Bay in the fall, the party proceeded to Anchorage, where it was disbanded.

As a result of this expedition an area of some 1,400 square miles of previously unmapped and little-known country was mapped, both topographically and geologically, the position and headward courses of the eastern tributaries of the Mulchatna River were determined, and a connecting link was obtained between the surveys of 1909 and 1914 and those of 1926 to 1928 that were carried westward to the west slope of the Alaska Range by way of the Skwentna, Chakachatna, and Stony Rivers.

The microscopic examination of the thin section of rocks described in this report was made by J. B. Mertie, jr.

GEOGRAPHY

RELIEF

The area here referred to as the Lake Clark-Mulchatna region includes a strip from 20 to 30 miles in width that stretches northward from Lake Clark to the Stony River. This strip includes the basin of the Koksetna River and crosses several of the headward tributaries of the Mulchatna River. At the time the field work was done

it was hoped that the mapping could be carried to the heads of these streams and so include a considerable area in the high, rugged portion of the Alaska Range, but bad weather so retarded the work that this was impossible. The Chilikadrotna, Mulchatna, and Telaquana Rivers all head in the high snowy peaks of the range and have considerable glaciers at their heads. These glaciers were formerly much larger than they are to-day, and glacial ice from the higher mountains pushed westward into the foothill region, surmounted and smoothed off all the lower groups of hills, and deposited great quantities of morainal material. By both erosion and deposition, these former glaciers had a profound effect upon the topography, and glaciated mountain forms, moraines, and outwash gravel are still conspicuous features of the landscape.

The long mountain spurs that extend southwestward from the main range between Lake Clark and the Little Mulchatna River have rather high relief, and summit altitudes of 4,000 feet or more are common, yet these spurs are cut at intervals by broad, open passes, so that travel from one stream valley to another is not difficult, and when the time comes that road and trail construction is necessary fairly direct routes with moderate gradients can be found.

West, northwest, and southwest of the area here described is a great lowland that includes on the north the lower basins of the Stony and Hoholitna Rivers, and on the west and southwest the Mulchatna-Nushagak lowland. These lowlands are characterized by more or less isolated groups of hills and ridges of moderate height, separated by broad alluvium-filled valleys that are occupied by lakes and rather sluggish streams. Through this great lowland, which stretches from Bristol Bay northward to the Kuskokwim River, travel in the winter by dog team is fairly easy, for the broad valleys can be followed and the hills avoided. In the summer, however, travel on foot or with horses is difficult, for the valley floors are in many places swampy, lakes are numerous, and many streams are too large to ford easily.

The high portion of the Alaska Range, bordered on the west by the region here under discussion, on the east by Cook Inlet, on the north by the Chakachatna Basin, and on the south by Lake Clark, is unexplored, although the eastern face of the range is visible from Cook Inlet and something is known of its geography. Probably the largest valley within that unmapped area is that of the Tlikakila River, or Big River, as it is locally called, a stream that enters the head of Lake Clark from the northeast. This valley is said to extend some 60 miles to the northeast, and a glacier-filled pass at its head is reported to lead to the valley of the Kustatan River and afford a possible winter route from Lake Clark to Cook Inlet. With the exception of the Tlikakila Basin and its tributary valleys it

seems certain that the remainder of this mountainous region is drained by the tributaries of the Kijik, Mulchatna, and Stony Rivers on the south and west and by a number of rivers of moderate size that flow eastward to Cook Inlet.

DRAINAGE

The drainage systems of the region here described include streams that flow to Lake Clark, thence by the Newhalen River to Iliamna Lake, which in turn drains through the Kvichak River to Bristol Bay; several of the eastern headwaters of the Mulchatna River, which joins the Nushagak about 100 miles above the point where that stream flows into Bristol Bay; and the Telaquana River, which flows into the Stony River, a tributary of the Kuskokwim. Of the Lake Clark tributaries, the largest within this region are the Chulitna River and its main northern tributary, the Koksetna. The Chulitna drains a great lake-dotted lowland between the Mulchatna and Lake Clark and for most of its length is sluggish and too deep to ford with horses. It is said that the only feasible ford is that used by the Geological Survey party, just south of the center of Long Lake. At that point a riffle was found with water only 3 feet deep in late June. The Chulitna is easily navigable for shallow-draft power boats for many miles above Lake Clark, and there would probably be no serious difficulty in ascending it at least as far as the Nikabuna Lakes. The Koksetna follows a peculiar course, flowing first north, then making an irregular curve to the southwest, south, and east, and finally reversing its direction to a southwest trend where it joins the Chulitna. This unusual drainage pattern is the result of the former severe glaciation of the area and the succeeding deposition of heavy accumulations of outwash gravel in all the valleys near the ice margin. This scour and fill brought about many changes in the courses of the streams, and the present Koksetna River has no doubt a quite different pattern from that of the streams that drained this area in preglacial time. The present basin contains many small lakes, some of which are of glacial origin and some formed behind beaver dams.

The only other important tributary to Lake Clark in this area is the Kijik River, which enters the lake from the northwest 17 miles below the head of the lake. The Kijik heads in rugged mountains, and although the extreme head of its basin was not mapped, its cloudy waters show that there are active glaciers at its head. The low pass northeast of Ingersoll Lake that gives access to the valley of the Tlikakila (Big) River indicates that the upper part of the Kijik Basin once drained to that stream but was diverted to the southwest by a great glacier that filled the Tlikakila Valley.

The headward tributaries of the Mulchatna River, including an unnamed stream just north of the Kijik River, the Little Mulchatna, the Chilikadrotna, and the main head of the Mulchatna, with the Telaquana River, a tributary of the Stony, drain the remainder of this area. All head at the face of or within the high mountains of the Alaska Range and flow southwestward through broad gravel-filled valleys. The Chilikadrotna, the Mulchatna, and the Telaquana head in glaciers and have large glacial lakes at the points where they emerge from the range into the foothill belt. All these lakes are impounded behind glacial moraines, and their waters are slightly cloudy with glacial silt. These streams vary greatly in volume from time to time. All of them are ordinarily fordable on foot, but after heavy rains they become so swollen that crossing even on horseback is hazardous.

CLIMATE

No reliable records of temperature or rainfall are available for this part of Alaska. The nearest points at which accurate weather observations are kept are on the coast of Cook Inlet and of Bristol Bay, and at these points the climate is obviously affected by the influence of the ocean waters and is unlike that of the interior region here under discussion. In general, it may be said that the winters are cold, with moderate snowfall, and the summers cool and rainy. Between June 13 and September 11, 1929, there were 45 days during which rain fell in the places where the Geological Survey party happened to be, and on many other days there was low-lying fog or a heavily overcast sky. A wide range in the number of rainy days may occur within short distances, however, and the year 1929 was said to be unusually clear and fine on Iliamna Lake. It appears that there is much more rain in the areas of high mountains than in the lowlands to the west. Late spring and early summer weather is likely to be clearer than that of middle and late summer. Frost may be expected in the mountains in any month during the summer, though along the shores of Lakes Iliamna and Clark vegetables do well and summer frosts are infrequent.

VEGETATION

The distribution of timber within the region here described is largely determined by the altitude. In general, the upper limit to which trees grow is about 2,000 feet, although in a few places scattered trees may be found above this altitude, and there are large areas below 2,000 feet that have little or no timber. Figure 5 shows the areas in this region in which timber occurs. The gradually decreasing altitude of timber line southward along the Alaska Range

is an anomaly for which no entirely satisfactory explanation has yet been advanced. Timber would naturally be expected to grow at successively higher altitudes on these mountains southward from the northern part of the range, near Mount Hayes, but this is not the case. Along the range from the international boundary past Mount McKinley and as far southwestward as the basin of the Stony River

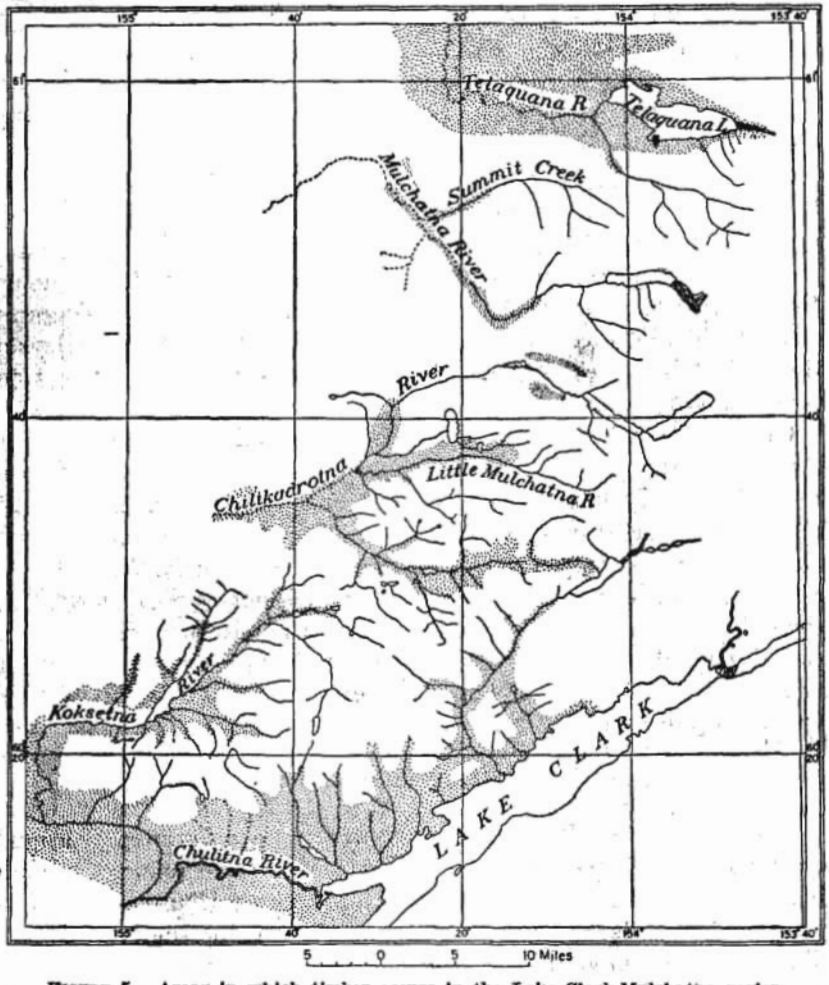


FIGURE 5.—Areas in which timber occurs in the Lake Clark-Mulchatna region

timber line lies at 2,500 to 3,000 feet above sea level, with scattered trees and patches of timber at altitudes of 3,500 to almost 4,000 feet From the Stony River southward, however, the conditions for the growth of trees become rapidly less favorable. The lowlands bordering the lower part of Iliamna Lake have only scattered, small trees, although they stand only 200 to 1,000 feet above sea level. Still

farther south groves of trees become more scattered, and the Alaska Peninsula from Becharof Lake southward is timberless.

In the Lake Clark-Mulchatna region trees of sufficient size to yield saw logs occur only along the shores of Lake Clark and in the lower valley of the Chulitna River. The commonest tree is the spruce, which in places reaches a diameter of 18 inches to 2 feet, but there are only small areas of spruce of that size. Cottonwood trees as much as 2 feet in diameter were seen in the lowlands bordering Lake Clark and the Chulitna River. In the same areas birch trees as much as a foot in diameter are to be found on well-drained slopes. Elsewhere in the region the timber consists mainly of small spruce trees that are of value only for local uses.

The usual assemblage of brushy plants occurs throughout the timbered areas, including alders, willows, cranberry and currant bushes, and various other shrubs, but in most places pack horses can be taken with only a moderate amount of trail cutting. Willows large enough for tent poles and for the camp fire can be found in many places for considerable distances above the last timber, but the upper valleys of the main tributaries of the Mulchatna lack even brush sufficient for camping purposes.

Grass sufficient for forage for horses 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 where grass is scanty or lacking. The most abundant grass is a variety known as redtop, which in places grows luxuriantly. There is also some bunch grass and some vetch, which horses eat eagerly. All these kinds of forage plants will maintain horses in working condition during about four summer months, but after heavy frosts in the fall most of them lose their nourishing qualities, and horses will lose weight rapidly unless fed hay and grain.

WILD ANIMALS

The Lake Clark-Mulchatna region was the natural range of a moderate number of caribou, but the natives keep them reduced in numbers for some distance back from the shores of Iliamna and Clark Lakes. A few dozen caribou were seen during the summer of 1929. There are a few mountain sheep in the high country around the upper end of Lake Clark, and probably also in the rough country at the heads of the tributaries of the Mulchatna River. One band of sheep was seen near the head of Telaquana Lake.

Both black and grizzly bears are present, and some of the grizzlies are large. From the experience of the Geological Survey parties during the years 1926 to 1929 in this general part of Alaska, bears are less common in the upper basins of the Mulchatna and Stony Rivers

than farther north in the range. Moose may be found throughout this region, but are more abundant in the valleys of the northern tributaries of the Mulchatna and in the Stony Basin than farther south.

The fur-bearing animals that are most abundant in this area are beaver, fox, otter, lynx, mink, and muskrat. From time to time restrictions are placed upon the trapping of beaver, and in the 1929–30 season no trapping for them was permitted. As beaver are the most abundant and easily taken fur bearers of the region, restrictions on beaver trapping have an important influence on the value of the annual catch of furs, and as most prospectors depend upon trapping as their main source of income restrictions on trapping are reflected in the decreased number of prospectors in the country.

Small game animals and birds were notably scarce in the Lake Clark-Mulchatna region in 1929. It is a well-recognized fact that in any part of Alaska the abundance of rabbits and of ptarmigan varies greatly from year to year, and the rabbits in particular seem to have a cycle of six to eight years, during which from a small number they increase to astonishing numbers and then decline rapidly. The ptarmigan similarly may be present in tremendous numbers in one year and almost completely absent the next. As many of the carnivorous fur-bearing animals depend largely upon rabbits and ptarmigan for their food supply, the abundance of the fur bearers depends closely upon the presence or absence of these small animals. In 1929 rabbits were almost completely absent in this region, not one being seen by any member of the Geological Survey party. Ptarmigan and spruce grouse also were scarce.

This region as a whole is exceptionally well supplied with fish. Lakes Iliamna and Clark and their larger tributaries being notable spawning grounds for red salmon, which come up in the early summer in large numbers. This fish furnishes the main item of food for the natives. These two lakes, as well as the many other lakes of the region, contain lake, rainbow, and dolly varden trout, whitefish, and pickerel, all in sufficient abundance to form a reliable food supply and to make a paradise for the angler. The smaller streams of the region are also stocked with trout and grayling, except in those upper reaches of the creeks that are obstructed by beaver dams.

ROUTES OF TRAVEL

So few white men have visited the region between Lake Clark and the Stony River that there are no established routes of travel in it. The Geological Survey party in 1929 approached the region from Iliamna Bay, between which and Iliamna Village, on the Iliamna River 4 miles above the mouth of that stream, an old native trail

has long existed. This trail has been improved during recent years by the Alaska Road Commission, and parts of it have been widened and graded to form a passable wagon road. Plans are under way to continue this improvement, and it was expected that by the end of 1930 a light wagon could be taken across the entire 12 miles of this route from Cook Inlet to the navigable waters of the Iliamna Lake-Kvichak River drainage basin. During 1929 a gasoline launch made calls at intervals of about two weeks at Iliamna Bay, landing mail, perishable goods, and light freight, and a small pack train was operated between Iliamna Bay and Iliamna Village. From Iliamna Village westward practically all summer travel goes by boat and winter travel by dog sled, so that only faint trails or none lead overland. Pack horses, however, can be taken along the north shore of Iliamna Lake at least as far west as the foot of the Newhalen portage, at Severson's trading post, though the trail is poor and travel slow. In summer power launches are able to ply between Iliamna Lake and Bristol Bay by way of the Kvichak River, and most of the supplies for this region come in by that route. A trading post with a small stock of goods is operated at Iliamna Village, and a larger trading post, at which supplies of all kinds can be purchased, is maintained on the north shore of Iliamna Lake about 4 miles northeast of the mouth of the Newhalen River. From that point an old portage trail leads northwestward to a point above the upper rapids of the Newhalen. This portage trail is soft for a mile or so from Iliamna Lake but is hard and well worn beyond. From the head of this portage the Newhalen River is navigable to Sixmile Lake and Lake Clark, and the Chulitna River, tributary to Lake Clark from the west, is also navigable by small boats for many miles above its mouth. There were in 1929 no work animals other than dogs in the region except the three or four horses used between Iliamna Bay and Iliamna Village. As a consequence all materials that pass back and forth between Iliamna Lake and Lake Clark are taken across the Newhalen portage mostly on men's backs, though in lesser part by dog sled in winter. In this way are carried all the supplies for the Indian village of Nondalton and for the white trappers and prospectors on Lake Clark, including such heavy materials as gasoline and dried salmon.

North of Lake Clark the region is almost devoid of well-marked trails. A faint Indian trail leads from Nondalton in a northwesterly direction to a ford across the Chulitna River, and another dim trail leads northeastward from that village along the shore of Lake Clark. This trail follows the lake beach much of the way but is plain across most of those places where rock cliffs along the lake shore make beach travel impossible.

An old Indian trail, known as the Telaquana trail, leaves the shore of Lake Clark at the site of an abandoned native village at the mouth of the Kijik River and leads northward across several stream valleys to Telaquana Lake, where there was formerly a native settlement. This was a well-traveled native trail and can be followed without difficulty for the first 20 miles or so, but in the basin of the Mulchatna River it is indistinct in many places. Although very steep where it ascends from the valley of the Kijik River to the divide leading into the Mulchatna Basin and somewhat marshy in a few places, throughout most of its length it is entirely feasible and affords good footing for horses.

With the exception of the primitive native trails described above, there are no established routes of travel in this little-visited region. Nevertheless the country is open and fairly free from brush and thick timber, and except in certain marshy areas in the stream valleys and the more rugged mountains of the main range a pack train can be taken almost anywhere without more difficulty than is to be expected in any unsettled part of Alaska.

POPULATION

Except for one white man on the north shore of Lake Clark, about 5 miles above the mouth of the Kijik River, there are no permanent inhabitants in the region described in this report. There were formerly native villages at the foot of Telaquana Lake and at the mouth of the Kijik River, and a few native houses along the north shore of Lake Clark, but all of these are now abandoned. The nearest settlement of any size is Nondalton, on the west shore of Sixmile Lake, where some 60 or 80 natives and one white man live. There are perhaps half a dozen white men prospecting or trapping on Lake Clark. Although most of the natives of this region have their homes at Nondalton, many of them visit different parts of this region to trap during the midwinter months and move to temporary fishing camps in the summer, so that the inhabitants of the village are rarely all present there at the same time.

On Iliamna Lake and on the lower Iliamna River there are about a dozen white men and two native villages. Iliamna Village, on Iliamna River, 4 miles above its mouth, is inhabited by 60 or 70 natives of the Kenai tribe. Another village a few miles below the mouth of the Newhalen River is occupied by Aleuts. A herd of about 500 reindeer has been maintained by the natives for many years near the south end of the Newhalen portage.

It will thus be seen that although the Iliamna-Lake Clark region has been known to white men for many years and is fairly easy of access both from Cook Inlet and from Bristol Bay, its development

has been very slow, and the few white men in it live by trading, trapping, and prospecting.

GEOLOGY

GENERAL OUTLINE

The areal distribution of the rocks of the Lake Clark-Mulchatna region is shown on Plate 2 in so far as the formations have been differentiated. Prior to the expedition upon which this report is based this region was unmapped and only partly explored, and except for a few scattered observations along the northwest shore of Lake Clark nothing was known of its geology. The expedition of 1929 attempted only reconnaissance mapping. Of the 91 days spent between the arrival at Iliamna Bay in June and the return to that place in September 40 days was required in getting to and from the field of work, so that only 51 days was available for actual mapping in a new area, and during even that short field season rainy weather greatly interfered with the work. A further handicap to the close mapping of geologic boundaries arose from the fact that the topographic mapping was carried on concurrently with the geologic field work, and a completed topographic map as a base for the geology was not available until several months after the end of the field season. As a consequence of these difficulties the geologic boundaries as shown on the map are only approximate, but they represent the best information obtainable during the short season.

The geologic units shown on Plate 2 include four rock groups and a fifth comprising all the relatively young unconsolidated materials. All these units have been described in reports on adjoining areas, and only brief descriptions of their salient characteristics will be given here, with references to the more complete descriptions already published.

The oldest rocks in this area comprise a group of volcanic materials with which are associated large quantities of sediments, all more or less metamorphosed. These rocks occupy the foothills northwest of Lake Clark and are present near the face of the Alaska Range as far north as the basin of the Stony River. The volcanic rocks include andesite and basalt flows and large volumes of water-laid fragmental volcanic materials that may be included under the general term "tuff." Interbedded with the tuff there is locally much sedimentary material that was originally mud and impure sand but is now indurated and metamorphosed to form shale, argillite, and graywacke. It is believed that the lower part of this group is composed dominantly of medium basic to basic lava flows, with fragmental volcanic material and sediments increasing in abundance toward the upper limit of the group. The age of this undifferentiated group of

rocks is somewhat uncertain, but it is here tentatively assigned mainly to the Lower Jurassic, though it may include materials as young as Upper Jurassic or even Cretaceous.

The next younger rocks in this region consist of a series of argillites and graywackes, cut by numerous dikes and sills, but containing only minor amounts of lava and tuff, that occurs west of the Koksetna River and in the vicinity of Telaquana Lake. These rocks lie along the strike of a similar series of rocks in the Stony Basin, from which a fossil has been determined as probably of Upper Cretaceous age. A third group, composed almost exclusively of lava flows and tuff of andesitic, rhyolitic, and basaltic composition covers a considerable area of the foothill region in the upper basin of the Chilikadrotna River. These rocks are locally faulted and mildly folded but in general are not greatly deformed and are obviously younger than the Upper Cretaceous sediments. They are no doubt of Tertiary age, though it is as yet impossible to determine to what part of the Tertiary system they belong.

Granitic rocks form a prominent element in the Alaska Range from Iliamna Lake northward to and beyond Mount McKinley, being present in bodies of large area and also in smaller outliers. In the Lake Clark-Mulchatna region granitic rocks occur both as small outliers and as part of the larger masses that are present in the main range, though it happens that the region here covered lies a little too far west to include extensive areas of granite. Such an area occurs, however, not far east of this region, and studies in the Iliamna-Lake Clark area and in the Chakachatna Basin, farther north, indicate that much of the main range is composed of granitic rock. Still farther north, in the Stony and Skwentna Basins, these granites are found to cut Upper Cretaceous sediments, though they are nowhere known to intrude Eocene sediments, and they are therefore thought to be of late Mesozoic age.

Unconsolidated materials of Pleistocene and Recent age are abundantly present in this region and include conspicuous glacial moraine deposits, glacial outwash gravel, and the deposits of the present streams. Almost the entire foothill belt was formerly buried by glaciers that moved out from the high range and spread over the lowlands. This area is characterized by wide gravel-floored valleys, whose filling, in part at least, has been derived from the outwash left behind by the Pleistocene glaciers during their retreat. In many places the gravel has been partly removed by the streams, and the remnants now occupy terraces at various heights above the present flood plains. Active glaciers still exist in the rugged, unsurveyed portion of the range, and the draining streams carry much glacial débris. Most of the present glacial outwash, however, is trapped

in the lakes that occur in all the main valleys, and the waters of these lakes and of the streams that drain them, while slightly opaque, nevertheless are much clearer than glacial streams usually are.

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

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

Tertiary.—Andesite, rhyolite, and basaltic lavas and tuffs.

Mesozoic.—Granitic intrusive rocks, probably of late Upper Cretaceous age; black shale, argillite, slate, and graywacke cut by dikes and sills, probably in part of Upper Cretaceous age; slate, argillite, graywacke, medium basic to basic lavas, and fragmental volcanic material, in part water-laid, all more or less metamorphosed, probably of Lower Jurassic and later age.

STRATIGRAPHY

Of the four rock groups in this region shown on Plate 2 one is in part sedimentary but contains much lava and fragmental material, one is dominantly sedimentary, and one is composed entirely of lava and fragmental volcanic material. All three of these groups, however, are stratified and presumably in part water-laid, and therefore they occupy definite positions in the stratigraphic column. In this discussion groups containing bedded lavas and tuffs as well as the ordinary sediments will be discussed in order of their age. The fourth group consists of deep-seated intrusive rocks.

MESOZOIC ROCKS

Three of the groups of hard rocks are believed to be of Mesozoic age. Beginning with the oldest, these are (1) an undifferentiated complex consisting mainly of medium basic to basic lava and tuff but containing locally considerable amounts of sedimentary materials and some intrusive rocks; (2) a group consisting mainly of black argillite, slate, and graywacke, with minor amounts of intrusive material; and (3) granitic intrusive rocks, which are present in this region only in small areas but which farther east form a conspicuous element in the Alaska Range. All these rocks are cut by dikes and sills, some of which are probably of Mesozoic age, but some no doubt are to be correlated with the Tertiary lavas. None of these rocks have yielded fossils in the region here described, and in adjacent regions fossils are so rare as to be of little aid in stratigraphic work. It is only by correlation with similar rocks in other regions that the

age of these rock groups can be even tentatively determined. From such unsatisfactory evidence it is believed that the lower complex is in part, at least, of Lower Jurassic age; that the argillite, shale, slate, and graywacke group is of Upper Cretaceous age; and that the granites cut Upper Cretaceous rocks but do not cut the Tertiary volcanic rocks.

COMPLEX OF LAVAS, TUFFS, AND METAMORPHOSED SEDIMENTS

Character and distribution.—The oldest group of rocks in the region here considered includes an undifferentiated complex of basic to medium basic lava, tuff, and associated argillite, slate, and graywacke, all more or less metamorphosed. These rocks dominate in the foothills immediately northwest of Lake Clark and extend northwestward to the Koksetna River and the southernmost tributary of the Chilikadrotna River. In the main range they occur near the western face of the mountains from Lake Clark northward to the Mulchatna, north of which they are interrupted by granitic intrusive rocks. As only the front face of the main range has been surveyed in this region, the areal distribution of the rocks of this group within the range is not known. Martin and Katz [6] found the porphyry and tuff of this group to give way toward the east to greenstone, slate, chert, crystalline limestone, gneiss, and quartzite schist of probable Paleozoic age, which are cut off on the east by granitic rocks. In the present investigation the Paleozoic rocks described by Martin and Katz were not seen, though they may be present farther back in the range. Apparently the western boundary of the main granitic core of the range, which at the head of Lake Clark has a northeasterly trend, swings westward in the region here described and comes to the face of the mountains near Telaquana Lake. It is thought likely that the greater part of the region east of the area here discussed and west of the granitic core of the range is composed of rocks of this group of lava, tuff, and metamorphosed sediments.

In composition this rock group is composed of a lower portion that consists almost exclusively of porphyritic lava and tuff and an upper portion that consists mainly of argillite, slate, graywacke, and tuff, with minor amounts of lava. The lower lava and tuff portion has been described rather fully by Martin and Katz [7] and by Smith,[8] and a brief review of its salient characteristics will suffice here. South of Lake Clark the igneous portion of this group includes rocks, commonly of porphyritic texture, that range in composition from rocks containing quartz and alkali feldspar to augite andesites and tuffs of similar composition. All are more or less

[6] Martin, G. C., and Katz,, F. J., op. cit., pl. 11.
[7] Idem, pp. 50–56.
[8] Smith, P. S., op. cit., pp. 104–112.

metamorphosed, and such alteration products as calcite, chlorite, secondary quartz, epidote, and iron oxides are common. Little opportunity was afforded for the study of these rocks immediately northwest of the upper end of Lake Clark, but in the headward tributaries of the Chilikadrotna River rocks that are thought to belong to this group include olivine basalt porphyry, now much chloritized and serpentinized; andesite greenstone, also much altered; and basaltic greenstone.

Farther southwest, in the area drained by the eastern tributaries of the Koksetna River, the porphyry and lava are less abundant, and the rocks consist mainly of clastic materials that range from argillite and slate to tuff in which most of the fragments are of volcanic origin but which also contain some fragments of sedimentary rock and to graywacke containing mainly normal sedimentary material. In composition the graywacke and tuff grade into one another in such a way that it is impossible to draw a sharp line of distinction between them, and in the field it is impracticable to make such a distinction. Apparently during the deposition of these beds there were times of little volcanic activity during which normal sedimentation took place, but at other times volcanic activity yielded considerable fragmental material that was intermingled and deposited with the clastic detritus and so built water-laid beds containing variable proportions of fragments of igneous origin. The eastern basin of the Koksetna River was apparently so far removed from the areas of volcanic activity that relatively little volcanic material fell there, but farther east and northeast volcanic materials greatly preponderate.

The beds of this group have suffered considerably from regional metamorphism. The lava and tuff are much altered and full of secondary minerals. The sediments are faulted, folded, and metamorphosed, the mudstone having become hard argillite and in places even slate and the graywacke and tuff having been cemented with secondary silica to form hard, impure quartzitic beds. Locally the group contains some black or gray chert. In general the bedding stands at rather high angles, and locally care must be exercised to avoid confusing the slaty cleavage with the true bedding, which is obscure.

On Plate 2 only a few granitic bodies are mapped as cutting the rocks of this group, but dikes and sills intruding them are common, and no doubt more detailed work will outline other granitic areas of sufficient size to be shown on a map of this scale.

No reliable estimate can be made of the thickness of this group. Northwest of Lake Clark mountains 4,000 feet or more in height are composed entirely of these rocks, and although it is recognized that faulting and folding have been active and in places may have made

the section appear thicker than it normally is, nevertheless it is difficult to imagine that less than 4,000 to 5,000 feet of beds are involved in the group. The thickness certainly varies greatly from place to place, however, for it depends to a considerable degree upon the amount of igneous material present, and individual lava flows vary greatly in thickness from place to place.

Age and correlation.—No information was obtained in the region that warrants a precise definition of the age of this rock group. No fossils have been found in it, and its approximate age can be determined only by correlation with similar rocks in neighboring areas, where the age relations are more definite. Thus Martin [9] suggests that the volcanic rocks of this group near Iliamna and Clark Lakes may possibly be correlated with beds at Seldovia that have similar lithology and sequence and that have been assigned to the Lower Jurassic. Similarly the writer [10] considers the lava and tuff to be correlative with similar rocks observed in the Stony, Chakachatna, and Skwentna Basins that he tentatively assigned to the Lower Jurassic. Certainly the volcanic rocks in those regions underlie Upper Cretaceous shale, and the evidence given for their assignment to the Lower Jurassic seems fairly conclusive. The slate-argillite-graywacke-tuff portion of this group appears to overlie the dominantly volcanic portion and therefore to be younger. It also appears to underlie the shale-argillite-graywacke group west of the Koksetna, and, as will be shown, that group is probably, in part at least, of Upper Cretaceous age. This entire group of sedimentary and volcanic rocks therefore appears to occupy the interval between the Triassic and the Upper Cretaceous and to be in part Lower Jurassic. Some of the upper sedimentary beds may be as young as Upper Jurassic or possibly even Lower Cretaceous.

ARGILLITE, SHALE, SLATE, AND GRAYWACKE GROUP

Distribution and character.—West of the Koksetna River and in the vicinity of Telaquana Lake there are areas in which the prevailing bedrock is composed mainly of metamorphosed sediments that were originally laid down as mud and impure sand but have now been consolidated to form argillite, shale, and graywacke, and these rocks have locally been further altered through faulting and folding to form slate. The areas of this formation, as shown on Plate 2, are widely separated, but it is likely that the sediments are fairly continuous from those localities through the region to the west of

[9] Martin, G. C., and Katz, F. J., op. cit., pp. 58–59.

[10] Capps, S. R., The Chakachamna-Stony region, Alaska: U. S. Geol. Survey Bull. 813, pp. 111–113, 1930; The Mount Spurr region, Alaska: U. S. Geol. Survey Bull. 810, pp. 156–160, 1929; The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 82–86, 1929.

that in which geologic observations have been made. Smith,[11] in a traverse from Lake Clark to the Kuskokwim, found shale and sandstone of this group to be the dominant rocks from the Chulitna River northward to and beyond the Hoholitna and eastward nearly to Whitefish Lake, and there is reason to believe that these rocks predominate from Smith's route eastward to the area here under discussion. Still farther north, in the basin of the Stony River, a continuation of this rock group has been traced to the head of the Stony.

The isolated mountain mass lying west of the Koksetna River and between it and the Mulchatna and the Chilikadrotna is composed entirely of sediments of this group, cut by minor amounts of intrusive rocks of various sorts. The eastern flank of these mountains was traversed by P. S. Smith, who describes the rocks rather fully under the designation "Mesozoic shales south of the Kuskokwim," so that only a brief description will be given here. The rocks consist of a monotonous succession of dark shale or argillite and impure sandstone or graywacke, the relative amounts of these two types of sediment varying from place to place. Locally the shale and argillite predominate, and little graywacke is present. Elsewhere the graywacke is much more abundant than the mudstones.

Both argillite and graywacke locally show the effects of contact metamorphism in the neighborhood of bodies of intrusive rocks, with the formation of secondary mica and other contact minerals such as chiastolite, cordierite, and andalusite. Locally, too, the sediments have suffered from dynamic metamorphism also, and pronounced schistosity and slaty cleavage have been developed. In general, however, the sediments are moderately altered shale, argillite, and graywacke.

The sediments exhibit a wide variation in structure. West of the Koksetna River the prevailing strike of the bedding is east-northeast, with generally steep dips both northwest and southeast. Near Telaquana Lake the sediments have been much sheared, faulted, and crumpled; the folds trend nearly east, and the prevailing dips are about 50° S. Still farther north, in the upper part of the Stony Basin, the beds strike nearly north, dip steeply, and are highly schistose. In many places both coarse and fine sediments of this group contain scattered cubes of secondary pyrite and on weathering take on a conspicuous rusty color.

Age and correlation.—No fossils have been found in this group of sediments in the region here described, nor did Smith find fossils in his traverse over these sediments between Lake Clark and the Hoholitna River. By correlation and by inference Smith con-

[11] Smith, P. S., op. cit., pp. 63–72.

cluded that these rocks were of Mesozoic age and that in part they were to be assigned to the Middle Jurassic, though he suggested that some beds might be younger and some older than that. In 1928 the writer found a fossil invertebrate in the basin of the Stony River, in beds that are lithologically like those here described and that lie directly along the strike of this group and only 10 or 15 miles northeast of the area of these rocks at Telaquana Lake. That fossil was determined to be an *Inoceramus* of Cretaceous, probably Upper Cretaceous age. Still farther north, in the basin of the Skwentna River, the writer had earlier found in similar beds a fossil leaf that was identified as of Upper Cretaceous or Tertiary age. As the containing rocks were much older in appearance than any known Tertiary beds in this part of Alaska the plant was assumed to be Upper Cretaceous. That determination, supported by the fossil from the Stony Basin, seems sufficiently definite to warrant the conclusion that at least a large part of the argillite-shale-slate-graywacke group on the west side of the Alaska Range, between Lake Clark and the South Fork of the Kuskokwim River, is of Upper Cretaceous age. Neither of the fossils upon which this determination is based was found at the top or at the bottom of this group of beds, and as the group is several thousand feet thick it is entirely possible that some beds older and some younger than Upper Cretaceous may be included. The known Tertiary rocks of this part of Alaska, however, are different in lithology and are younger in general appearance than the rocks of this group, and the writer considers it doubtful that any of this group is younger than Upper Cretaceous. On the other hand, it appears quite likely that some Jurassic beds are included in it.

TERTIARY VOLCANIC ROCKS

Distribution and character.—A considerable area in the upper basin of the Chilikadrotna River is occupied by lava and tuff that are younger than any of the Mesozoic rocks described above. These rocks occur mainly in the foothills and in general form rounded hills or mountains that rise 1,000 to 2,500 feet above the bordering valleys, though just south of the large lakes in the upper reaches of the Chilikadrotna, where the foothills merge into the main range, mountains of these lavas rise 3,000 feet above the lakes. Rocks of this formation have been noted by Martin and Katz [12] on the southeast shore of Lake Clark and on Chulitna Bay, and by Smith [13] on the mountains immediately west of Sixmile Lake. In none of those places does this lava occupy continuous areas of more than a few

[12] Martin, G. C., and Katz, F. J., op. cit., p. 76.
[13] Smith, P. S., op. cit., pp. 122–127.

square miles. In the upper basin of the Chilikadrotna, however, there is an area of over 200 square miles that is occupied almost exclusively by these rocks, though they are overlain and concealed in places by unconsolidated surface deposits.

This volcanic group is composed of lava and tuff of sharply contrasting appearance and composition. The predominant rocks range in color from white through cream-colored to pink, red, and brown and consist of rhyolite and andesite flows and tuffs. Especially conspicuous are certain areas of nearly white rocks that in the field appear to be well-laminated volcanic glass but under the microscope prove to be very fine grained rhyolite tuff, probably derived from the consolidation of beds of volcanic ash. Elsewhere black obsidian occurs. Associated with these acidic volcanic materials are almost equally conspicuous black diabase and basalt flows, some showing columnar structure. In general the basaltic flows appear to occur near the upper part of the series, though in places basalt flows were seen overlain by several hundred feet of the more acidic lavas.

Structure and thickness.—As a rule the Tertiary lavas lie more nearly horizontal and are less deformed than any of the other hard rocks of the region. In the outlying foothills they show little folding or tilting, though nearer the main range mild folding and both normal and thrust faults of considerable displacement were observed. Their freedom from metamorphism is also apparent in the thin sections, which show the rocks to be fairly fresh and unaltered. In areas where these rocks lie nearly horizontal and there is no evidence of duplication by folding or faulting the series is certainly 2,000 to 2,500 feet in thickness, with a possible maximum of 3,000 feet.

Age and correlation.—No close age assignment for this group of volcanic rocks is possible at present. They carry no fossils, overlie unconformably the older Lower Jurassic (?) group of volcanic and sedimentary rocks, and are themselves overlain only by Pleistocene and Recent unconsolidated materials. Martin[14] assigns the basalt flows and tuff of Iliamna Lake and east of Lake Clark to the late Tertiary, his conclusion being based in part on some poorly preserved fossils of probable Tertiary age that he found in sandstone underlying the basalt on Iliamna Bay. Martin, however, separated the basalt of this group from the more acidic associated lava and tuff, considering that the andesite and rhyolite belonged to the group of Lower Jurassic volcanic rocks and the basalt to be Tertiary. Smith[15] later found rhyolite, overlain by basalt, lying unconformably on older, much decomposed andesite, and recognized the fact

[14] Martin, G. C., and Katz, F. J., op. cit., p. 82.
[15] Smith, P. S., op. cit., pp. 125–126.

that the younger group of lavas comprises both acidic and basic flows and tuffs. Observations in the Lake Clark-Mulchatna region support the view taken by Smith, for these basaltic lavas were found interbedded with more acidic flows, though in general the basaltic phases were near the top of the series. Smith accepted the assignment of these lavas to the Tertiary. This age determination is strengthened by the later evidence as to the Upper Cretaceous age of at least a part of the argillite-shale-slate-graywacke group west of the Koksetna River, for those sediments are certainly older than this group of lavas. As the lavas are younger than part of the Upper Cretaceous rocks and older than Pleistocene, they fall somewhere in the late part of Upper Cretaceous time or in the Tertiary, but no more accurate assignment is possible from the evidence now at hand. It is suggested that they may be the surface, effusive phase of the granite intrusions, but that seems hardly likely, for the lavas are little deformed, whereas the granites and the sediments they intrude are much deformed and appear to be older than the lavas.

INTRUSIVE ROCKS

Granitic rocks form an abundant element in the Alaska Range from its south end, south of Iliamna Lake, northward to and beyond Mount McKinley, and in those areas that have been mapped much of the higher and more rugged portion of the range is carved from granitic materials.[16] Within the area here described, however, granitic rocks occur in less abundance. In the basin of the Koksetna River a few granitic outliers occur, but in the upper Mulchatna and Telaquana Basins the main granitic mass of the range projects farther west and actually reaches the face of the range. On Plate 2 granitic rocks are shown as having no very broad distribution, but it should be remembered that not far east of the area mapped the range is predominantly granitic, the contact between the granitic rocks and the Mesozoic lavas and sediments stretching through unsurveyed country from the head of Lake Clark to the face of the range at Telaquana Lake. No doubt the proportion of granular intrusive rocks to lavas and sediments would have been found to be much larger if the mapping had been extended to the extreme headwaters of the Mulchatna and Telaquana Rivers.

The rocks here described under the inclusive term "granitic rocks" include a considerable variety of coarsely crystalline, deep-seated

[16] Capps, S. R., The Chakachamna-Stony region, Alaska: U. S. Geol. Survey Bull. 813, pp. 109–110, 1930; The Mount Spurr region, Alaska: U. S. Geol. Survey Bull. 810, pp. 140–172, 1929; The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 67–98, 1929; The Yentna district, Alaska: U. S. Geol. Survey Bull. 534, p. 75, 1913. Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, p. 234, 1911.

intrusive materials, of varying color, texture, and composition. Gray colors predominate, though pink granite is present, and the range is complete from nearly white rocks with almost no ferromagnesian minerals to black hornblende rocks that have little quartz and feldspar. In some localities true granite prevails; elsewhere quartz diorite and diorite predominate. The outlying masses in the basin of the Koksetna River are less coarsely crystallized than the typical granite of the main range and might properly be termed granite porphyry.

The age of at least part of the granitic intrusive rocks of this region can be assigned within certain limits, though the evidence is not so conclusive as could be desired. Martin and Katz[17] placed some of the granites on the shores of Cook Inlet rather definitely as later than Triassic and earlier than Upper Jurassic and considered them as, in part at least, of Lower Jurassic age. In the region north of Lake Clark the granitic rocks in the Koksetna Basin certainly cut tuffs and sediments that are believed to be in part of Lower Jurassic age and possibly in part younger. So far as known they do not cut the lavas and tuffs that are thought to be of Tertiary age. In the Chakachamna-Stony region, adjoining this area on the north, and in the upper Skwentna Basin, still farther northeast, the writer found granite cutting argillite and shale that carry Upper Cretaceous fossils. The granite has nowhere in the range been found to intrude the Eocene coal-bearing formation. From these facts it may be stated that at least part of the granitic rocks of the Alaska Range are as young as Upper Cretaceous and are probably older than the part of the Eocene represented by the coal-bearing beds of that age.

QUATERNARY DEPOSITS AND HISTORY

Preglacial conditions.—The youngest hard rocks in the Lake Clark-Mulchatna region are the Tertiary volcanic materials in the Mulchatna Basin. The part of Tertiary time represented by these volcanic rocks is not known, but the lavas and tuffs were probably laid down as terrestrial deposits, and so far as the sedimentary record shows this region finally emerged from the sea at the end of Upper Cretaceous time and has remained a land area ever since. The end of the Mesozoic era was here marked by pronounced folding, faulting, and warping of the preexisting rocks, and after the Tertiary volcanic rocks were laid down there was still some regional metamorphism, which also involved folding and faulting, though these movements were less severe than those at the end of the Mesozoic.

During all of Tertiary time, therefore, this region was exposed to erosion by streams and by all the agencies that are at work upon

[17] Martin, G. C., and Katz, F. J., op. cit., pp. 76–77.

exposed land surfaces. Mature drainage patterns were developed upon it, and mature stream valleys were carved. It is believed that at the end of the Tertiary period the mountains had approximately their present relief and the rivers followed much the same courses that they do to-day. The general aspect of the country, however, must have been quite different from that we now see. The mountain forms, developed mainly by stream erosion, were less rugged than at present, the valley walls in the high mountains were less steep, and the stream gradients from the valley heads to the great lowlands on the west were more uniform than they now are. The widespread mantle of unconsolidated gravel and of glacial deposits, now so conspicuous in the foothills, was absent, as were the many lakes that form so striking a feature of the present landscape.

Glacial epoch.—Neither the beginning nor the end of the glacial epoch is so sharply defined in Alaska as it is in the lower latitudes in the United States. The high mountains of Alaska to-day nourish vigorous glaciers, and it is likely that this was true also in Tertiary time. Thus the higher valleys in this part of the Alaska Range have probably been continuously glaciated for a very long period, perhaps since some time in the Tertiary. At the beginning of Pleistocene time, however, there came a gradual change in climate, with a decreasing mean annual temperature, so that the existing glaciers grew in size, and in many valley heads that had been previously free of glaciers snow and ice accumulated year by year to form ice tongues. These separate valley-head glaciers slowly grew larger and longer, pushed down their separate troughs to join in the main stream valleys, and ultimately stretched down to the westward beyond the mountain front and far out onto the lowland, there to coalesce with ice streams from adjoining mountain basins. In this way all the mountain valleys became filled with ice, so that at the times of maximum glaciation only the higher ridges and peaks projected above the surface of the glaciers. Each mountain valley sent its ice flood out onto the lowland, and these streams, coalescing in the lowlands, formed a piedmont glacier that filled the valleys in the foothill belt and surmounted most of the isolated groups of hills there. On the shale-graywacke hill west of the Koksetna River the glacial ice stood up to an altitude well over 3,000 feet. In the upper Mulchatna Basin practically all the lava ridges below 4,000 feet were surmounted by ice, and the surfaces of the ice streams in the Telaquana, Mulchatna, and Chilikadrotna Valleys stood at a height of about 4,000 feet at the points where they emerged from the main range into the more open valleys of the foothill belt.

The western margins of these glaciers, at the time of their last great development, lay west of the region here described. Smith[18] has outlined approximately the outer margins of the glaciers that moved westward from the Alaska Range into the Mulchatna, Hoholitna, and Stony Basins during the last great ice advance and shows that they moved well down into the Mulchatna Valley and that a lobe pushed down some 15 or 20 miles beyond Whitefish Lake into the Hoholitna Valley and down the Stony to a point within about 40 miles of the mouth of that stream. This distribution corresponds closely with what could have been predicted from observations made on the height reached by the ice along the flanks of the main range. At the south border of this region the ice that moved southwestward along the great valley now occupied by Lake Clark was moving into an open lowland country that included the broad flat basin of the Chulitna River and the great lowland of lower Iliamna Lake. In these lowlands the mountain glaciers could expand laterally, and the surface of the ice became correspondingly lower, so that at the mouth of the Nondalton River the glacier was only 1,200 to 1,400 feet thick.[19]

Glacial erosion and deposits.—The influence of the Pleistocene glaciers upon the topography of this region was tremendous. By the abrading action of enormous masses of moving ice, shod with innumerable rock fragments, the loose materials upon the surface were rapidly removed, and later the bedrock itself was worn down in places to great depths. Within the narrow valleys in the mountains the ice was deepest, its movement was most rapid, and its power to deepen and widen its troughs was greatest. As a result, each mountain valley now carries conspicuous evidences of the former presence of great glaciers, such as steep headward cirques, clifflike side walls, broad, troughlike valleys free from projecting spurs and ridges, and glacial lakes. The processes of glacial erosion are still active in those valleys which harbor glaciers to-day.

Beyond the face of the mountains, in the piedmont area, the results of past glaciation are equally striking, though different. There the ice could expand laterally as the valleys widened, its thickness and its rapidity of movement decreased, and although projecting ridges and hills over which it passed were attacked by ice erosion, the glaciers could deposit in this area of more sluggish movement much of the material picked up above. Thus in the high mountains the action of the glaciers was mainly erosive, but within the foothills and in the lowlands to the west the glaciers modified the appearance of the country mainly by deposition. The most conspicuous of the accumulations of ice-deposited débris are the great lateral moraines

[18] Smith, P. S., op. cit., pp. 85–94.
[19] Martin, G. C., and Katz, F. J., op. cit., pp. 82–88.

that border the north side of the valley of the Chilikadrotna and both sides of the Mulchatna and Telaquana Valleys at the places where those streams emerge from the mountains. The surface of the moraine north of the Chilikadrotna, at the point where it abuts against the mountain face, stands 2,000 feet above the valley floor, reaching an altitude of 4,000 feet, but descends rapidly toward the west, so that 7 miles west of the mountain face it has an altitude of only about 2,100 feet and is only 300 feet above the valley floor. Similarly, on both sides of the large lake in the upper Mulchatna Basin lateral moraine ridges rise to altitudes of 4,000 feet at the mountain face some 1,500 feet above the surface of the lake. Telaquana Lake is likewise flanked on the north and south by great lateral moraine ridges that at their highest points stand 3,600 to 3,800 feet above sea level, or 2,400 to 2,600 feet above the lake surface. Some of these moraine ridges certainly consist of a thick veneer of glacial débris over a preexisting rock spur, and possibly all of them are so constituted. Nevertheless, postglacial gulches cutin some of these lateral moraines show that in places the morainal material is at least several hundred feet thick.

Between the north lateral moraine on the Mulchatna and the south lateral moraine on the Telaquana there is an area some 6 or 7 miles wide and 10 miles or more long that has mild relief and comprises a high rolling plain. It appears to be composed entirely of gravel deposits and is probably an outwash plain which, during the early stages of retreat of the last great glaciers, formed a basin between two large glaciers, from each of which heavily loaded streams discharged gravel into this basin.

A characteristic feature of the foothill belt in this region and of the hill-dotted lowland to the west consists of the wide gravel-floored valleys with their many lakes and generally low gradients. All these valleys were occupied by ice during the last great ice advance, and during the retreat of the glaciers they were aggraded by great quantities of glacial outwash gravel, sand, and silt. In places the present streams have cut through this filling to the underlying bedrock, but in general they flow over a gravel fill and are flanked by gravel terraces. In all likelihood the outwash gravel extends westward down the Mulchatna, Hoholitna, and Stony Valleys beyond the border reached by the ice during its farthest westward stand.

As a result of the extensive aggradation of the lowland valleys of this region and of glacial erosion in the more mountainous areas, many changes in drainage have resulted during and since glacial time. Thus the upper Koksetna probably once drained into the Chilikadrotna. Quite possibly the present Lake Clark Basin had its preglacial outlet to the Mulchatna by way of the Chulitna Valley. The present head of the Mulchatna might well have flowed into the

Chilikadrotna at the low pass 8 miles southwest of the lake. Without much doubt College Creek and Ingersoll Lake formerly drained eastward through a low pass to the Tlikakila (Big) River, and many other drainage changes, small and large, resulted from the occupancy of this region by glacial ice. Most of the lakes owe their origin either to glacial erosion or to damming by glacial deposits, or both, though many small lakes and ponds have been formed behind beaver dams.

Older glaciation.—It has long been known that throughout the northern United States there were repeated advances and withdrawals of glacial ice during the Pleistocene epoch, each advance being separated from the others by a long interval during which the ice melted back and a milder climate prevailed. Information is gradually accumulating to show that Alaska also has been the scene of repeated glaciations during Pleistocene time. At several places glacial deposits have been observed which either underlie the débris left by the last great glaciers or which in stage of oxidation, weathering, or induration indicate plainly that they are much older than the materials left during the last great glacial stage. A deposit of this type was observed in the upper basin of the Chilikadrotna River, about 2 miles north of the outlet of the lower of the two large lakes, where there is an exposure of rounded and subangular boulders and pebbles and of fragments of a wide variety of rocks, embedded in a clayey matrix. Boulders, pebbles, and rock fragments are somewhat decayed, and their original surfaces are lost. No striae were found, but few pebbles were sound enough to have retained striae, even if they had once been present. The matrix and the included rocks are oxidized to a conspicuous reddish color, in contrast to the blue color and unoxidized and undecayed character of the more recent till by which this deposit is overlain. The fresh overlying till is a part of the lateral moraine left by the ice during the last great ice advance, in Wisconsin time. The oxidized and decomposed till beneath is believed to be morainal material left by the ice during a pre-Wisconsin stage of the Pleistocene. There is too little information at hand to justify the correlation of this older glacial deposit with any particular stage of Pleistocene glaciation.

Present stream gravel.—The deposits of the present streams, which on Plate 2 are included in a single pattern with the other unconsolidated deposits of the region, are of rather scanty development in the area here described. In most parts of the Alaska Range the streams that head in the high mountains, especially those that rise in glaciers, have broad flats built up of the detritus received from the glaciers or eroded from the steeply sloping mountain basins. The region here discussed includes only the outer face of the main range. Farther

east many of the streams have extensive gravel flats and wide flood plains. As it happens, most of these streams have large lakes in their basins at the points where the valleys pass from high mountains to the foothill belt. This is true of the Telaquana, Mulchatna, and Chilikadrotna Rivers, and Ingersoll Lake lies in the mountain valley of the Kijik River. Above these lakes the rivers are characterized by broad outwash trains of gravel through which the streams flow in many branching channels. The lakes, however, act as traps in which the streams drop all of their heavy débris, and the rivers that drain the lakes, while somewhat cloudy with fine glacial silt, nevertheless carry little gravel and sand. As a consequence they have developed only narrow flood plains and flow in single, well-defined channels through the lowlands. They are only moderately swift, and on most of them places at which horses can ford can be found in normal stages of water. It is not known whether or not the Telaquana River is fordable below the lake. In fairly high stages the Kijik River is said to be a dangerous stream to cross, even with horses, but in July and August, 1929, an easy ford was found a short distance below the point where the Telaquana trail meets the river.

Volcanic ash.—At several places within this area, as throughout the region from Lake Clark northward to the Skwentna River, there is a layer of volcanic ash just beneath the turf. The ash ranges from a few inches to several feet in thickness, and apparently was scattered by an eruption from some volcanic vent that cast ashes over an area of many thousands of square miles in the southern portion of the Alaska Range. In the Mount Spurr region [20] ash, apparently from this same fall, attained 6 feet in thickness, and in the Skwentna region [21] the deposit was from an inch or so to more than 3 feet thick. In general the ash is thickest in the region around Mount Spurr, a volcanic mountain that still shows signs of mild activity. It therefore seems probable that this mountain was the vent from which the ash was ejected. Mature spruce trees growing on top of the ash indicate that it fell at least 100 or 200 years ago.

MINERAL RESOURCES

The Lake Clark-Mulchatna region has been so little visited by white men and is still so incompletely prospected that no fair judgment as to its mineral resources can yet be made. Mining has been limited to small gold placer-mining operations on some of the

[20] Capps, S. R., The Mount Spurr region, Alaska: U. S. Geol. Survey Bull. 810, pp. 167–168, 1929.

[21] Capps, S. R., The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 95–96, 1929.

tributaries of Lake Clark. The most ambitious attempt to develop the gold placer deposits on any one stream took place in 1910 to 1912 on a creek locally known as Portage Creek, which flows into Lake Clark from the northwest some 10 miles northeast of the mouth of the Kijik River. A number of men worked for three summers on the lower four claims on that stream, and it is reported that the total value of the gold recovered was about $2,000. Desultory mining has been done at a few other localities near Lake Clark, but the results were discouraging, and in 1929 no placer mining was in progress in this region.

It is reported that a small gold-placer stampede took place about 1912 to what was then known as "the Stony River country." The focus of interest was at the canyon of Bonanza Creek, a tributary of the Mulchatna that flows westward from the foothills that lie west of the part of the Chilikadrotna Basin shown on the plate, some distance west of the region here under discussion. Some gold placer prospects were found, but only a few dollars' worth of gold was recovered. It is said that there is some ground on Bonanza Creek that might be profitably worked if the region were less remote and the cost of hauling in supplies and equipment not prohibitive.

In the region between Lake Clark and Iliamna Lake there are reported to be several gold and copper prospects that show considerable mineralization. These prospects occur in rocks similar to those that have been mapped in the present investigation. This occurrence and the fact that many areas near the contacts of granitic rocks with sediments, especially those of the smaller granite masses, are sites of mineral deposits give some hope that further prospecting will result in the discovery of valuable lode deposits in this region. The outlook for the finding of profitable gold placer deposits in this region is less promising, though possibly small areas of workable ground occur there. The severe glacial erosion within the high mountains is likely to have removed any extensive preglacial accumulations of placer gold that may have existed, and the thick deposits of gravel in the valleys in the foothill belt make it difficult to sink to bedrock and so determine whether or not paying ground is present.

As for nonmetallic mineral deposits of value, little can be said. No coal-bearing beds are known in this region and there is probably no coal here. There is also no likelihood that the rock formations here represented are oil bearing. Certainly the granite and other igneous rocks offer no hope, and the Mesozoic sediments are so highly metamorphosed and so lacking in organic material that the chance that they contain oil pools is remote.

MINING IN THE CIRCLE DISTRICT

By J. B. Mertie, Jr.

INTRODUCTION

The term "Circle district," as now used, includes not only the headwater tributaries of Crooked, Birch, and Preacher Creeks but also Coal, Woodchopper, and other near-by gold-bearing streams that drain directly into the Yukon River. The latter creeks, however, have not been visited by the writer since 1925, and the present report deals entirely with the tributaries of Crooked and Birch Creeks, or what was formerly known as the Birch Creek district.

During the summer of 1929 the writer was engaged in geologic investigations in the region north and northwest of the Circle district and terminated his field work at Circle. As no report on this district had been issued by the Geological Survey for a number of years, the opportunity was utilized for making an examination of the mining properties then in operation. This report is therefore intended as an outline of the progress of mining in the Circle district in 1929.

Circle, which is on the Yukon River at the east end of the Yukon Flats, is the nearest supply point for the Circle mining district. Circle has recently been connected with Fairbanks by an automobile road, and the district is therefore served in summer by automobiles and trucks operating on this road from Fairbanks and by the fortnightly steamboat of the American Yukon Navigation Co. on the Yukon River. In winter the mail comes to Circle by horse sleds from Fairbanks and is distributed thence both up and down the Yukon. Quick communication is supplied by a radio station operated by the United States Signal Corps and also by a local telephone system which connects Circle with the outlying mining properties. An airplane landing field assures rapid transit to Fairbanks or elsewhere in the Territory when occasion demands it.

Mining in the Circle district centers in two general localities. One of these is about Deadwood Creek and its tributaries. This area is approached by a wagon road from Central House, a roadhouse on the main automobile road about 35 miles from Circle. A branch automobile road, built in 1929, also leaves the main road at Central

House, to go to Circle Hot Springs, which is now well known in Alaska as a health resort.

The second locality centers about Mammoth Creek and its tributaries, Miller, Mastodon, and Independence Creeks. It also includes Bonanza Creek, which is a tributary of Porcupine Creek, and several headwater tributaries of Birch Creek, principally Eagle Creek. The Circle-Fairbanks automobile road runs directly through this area, following up Mammoth and Miller Creeks, passing close to Eagle Creek and down the northwest side of Birch Creek. Another roadhouse, known as the Miller House, on the automobile road about 50 miles from Circle, serves as a stopping point for this area as Central House does for Deadwood Creek and the Circle Hot Springs. Fourth-class post offices are maintained at Central House and Miller House, and both these roadhouses carry a small stock of general merchandise.

Gold was discovered on Birch Creek in 1893. Placer mining was begun in the summer of 1894 and has continued without interruption to the present day. This is therefore one of the old mining camps of interior Alaska. Mastodon, Miller, and Independence were the first creeks to be worked commercially, and after 36 years they are still producing gold. During 1929 Deadwood Creek and its tributaries, Boulder, Bonanza, and Eagle Creeks, were also worked, and prospecting was done on the North Fork of Harrison Creek and possibly also on other creeks. The summer of 1929 in the Circle district was characterized by more than the usual rainfall, so that ample water was available and placer-mining operations were unusually successful.

GEOGRAPHY AND GEOLOGY

The geography and geology of the Circle quadrangle, which includes the Circle mining district, have been described by Prindle[1] in earlier publications; in this report, which deals primarily with the progress of mining, a concise summary of the geographic and geologic features seems adequate.

The Circle mining district lies in the northwestern part of the Circle quadrangle, between parallels 65° 20′ and 65° 40′ and meridians 144° 40′ and 146°, and embraces an area of about 200 square miles. The index map (fig. 6) shows its location with respect to Alaska as a whole. The area in which mining is now being done is drained entirely by Birch Creek and its tributaries, although a contiguous zone to the northwest, which has been considerably prospected and is regarded as a part of this district, is drained by headwater

[1] Prindle, L. M., The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska: U. S. Geol. Survey Bull. 251, 1905; The Yukon-Tanana region, Alaska: U. S. Geol. Survey Bull. 295, 1906; A geologic reconnaissance of the Circle quadrangle, Alaska: U. S. Geol. Survey Bull. 538, 1913.

tributaries of Preacher Creek. (See pl. 3.) One of the principal lower tributaries of Birch Creek, entering from the west, is Crooked Creek. The four largest tributaries of Crooked Creek are Deadwood, Boulder, Mammoth, and Porcupine Creeks. Deadwood and Boulder Creeks enter Crooked Creek from the south; Mammoth Creek, entering from the southwest, and Porcupine Creek from the west, unite to form the upper part of Crooked Creek. Above the mouth of Crooked Creek Birch Creek cuts back into the hills to the south and drains a large fan-shaped basin. The northwest end of this basin adjoins the Crooked Creek Basin, so that a continuous ridge

FIGURE 6.—Index map showing location of Circle district

of considerable height trending southeast is drained on the northeast by tributaries of Crooked Creek and on the southwest by headwater tributaries of Birch Creek.

The three tributaries of Mammoth Creek, named from east to west, are Independence, Mastodon, and Miller Creeks. Bonanza Creek, to the northwest of Miller Creek, flows parallel with it, but drains into Porcupine Creek. Ptarmigan, Eagle, and Golddust Creeks, headwater tributaries of Birch Creek, and Harrison Creek, which enters Birch Creek farther downstream, are the principal streams within the Circle mining district draining the southwest slope of the ridge previously noted.

Central House is situated at an altitude of somewhat less than 1,000 feet. Mastodon and Porcupine Domes, two prominent points on the main ridge southwest of Crooked Creek, have altitudes of 4,400 and 4,810 feet, respectively, so that the maximum relief in this district is close to 3,000 feet. North of the Circle mining district is an isolated group of hills known as the Crazy Mountains, the highest point of which is 3,690 feet above sea level, and between this point and Circle, on the Yukon, there is likewise a difference in altitude of nearly 3,000 feet. These upland areas represent a maturely dissected land surface drained by streams which at the end of the Pliocene epoch had been adjusted in their lower courses to a base-level 600 to 800 feet above the present level of the Yukon. The subsequent lowering of this base-level of erosion to the present one has caused rejuvenation of all the tributaries of the Yukon. In the longer tributaries fall lines far upstream show that the process of adjustment has not yet been completed. Another of the evidences of this post-Pliocene lowering of the base-level of erosion is the presence of rock-cut terraces, as may be seen along the Yukon above Circle.

Another interesting physiographic feature of this district is a wide alluvium-filled depression that separates the Circle mining district from the Crazy Mountains. This depression is now drained by two sluggish, incompetent streams, one flowing southeastward to Crooked Creek and the other flowing northwestward to Preacher Creek. It is believed that this wide valley represents the site of an ancient river channel through which the Yukon flowed, perhaps during a part of the Pleistocene epoch.

Six hard-rock geologic formations have been distinguished and mapped in this district, including the Crazy Mountains. These are:

Granitic rocks. Mesozoic.
Chert formation. Mississippian.
Rampart group. Lower Mississippian.
Limestone. Devonian or Silurian.
Noncalcareous sedimentary rocks and greenstone. Devonian to Ordovician.
Birch Creek schist. Pre-Cambrian.

The oldest of these formations, the Birch Creek schist, includes a group of metamorphosed sedimentary rocks, which consist mainly of quartzite schist, quartz-mica schist, quartzite, and mica schist. By definition, metamorphic rocks of igneous origin are excluded from the Birch Creek schist, but in reconnaissance areal mapping such rocks are not actually distinguished as separate cartographic units. One of the most distinctive of such units is a group of granitic gneisses, known in Yukon Territory as the Pelly gneiss, which will eventually be separately mapped. Other rocks sometimes included with the Birch Creek schist are phyllite, chlorite and sericite schists,

amphibolite, hornblende schist, and various types of greenstones. Some of these are certainly younger than pre-Cambrian, but in areal mapping they are often included because time does not permit their separate delineation. The Circle district is considered the type locality of the Birch Creek schist.

The next younger rocks, often called the lower Paleozoic metamorphic rocks, are a group composed of sheared arkose and graywacke, quartzite, purple and green phyllite, and green, red, and black slate, together with some limestone and chert. This group includes rocks which are the equivalent of the Tatalina group, described by Prindle[2] as probably of Ordovician age, and also other pre-Carboniferous metamorphic sedimentary rocks. Where possible the Silurian and Devonian rocks of this complex have been mapped separately.

Bands of crystalline and semicrystalline limestone trending east are found in the Crazy Mountains. These appear to be different from the Silurian limestone that is found to the west, in the White Mountains, and they are certainly not to be correlated with the siliceous limestones of the Carboniferous. They resemble more than anything else the Middle Devonian limestones of the Woodchopper volcanics, which are exposed along the Yukon River about 50 miles above Circle. But as the limestones of the Crazy Mountains have yielded no determinable fossils, they are designated Silurian or Devonian.

The Rampart group is an assemblage of basic igneous rocks, mainly lava flows, with some interbedded sediments. The type locality is along the Yukon River between Fort Hamlin and Rampart. A similar formation, believed to be equivalent to the Rampart group, is exposed along the Yukon River just above Circle. Because the exact equivalence of these two formations had not been proved, the latter was called by the writer[3] the Circle volcanics. The Rampart group has now been traced intermittently eastward from Fort Hamlin to the Crazy Mountains, within 30 miles of Circle, and the belief in the equivalence of the two formations, which was based originally on lithologic and petrographic similarities, is now further strengthened by areal distribution. The sediments interbedded with these volcanic rocks are mainly chert, but in the Rampart district one small lens of limestone and several beds of calcareous tuff have yielded Mississippian fossils. The next two overlying formations along the Yukon are also of Mississippian age, so that the Rampart group and the Circle volcanics are referred by the writer to the basal Mississippian.

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[2] Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U. S. Geol. Survey Bull. 525, pp. 37–39, 1913.

[3] Mertie, J. B., jr., Geology of the Eagle-Circle district, Alaska: U. S. Geol. Survey Bull. 816, pp. 85–88, 1930.

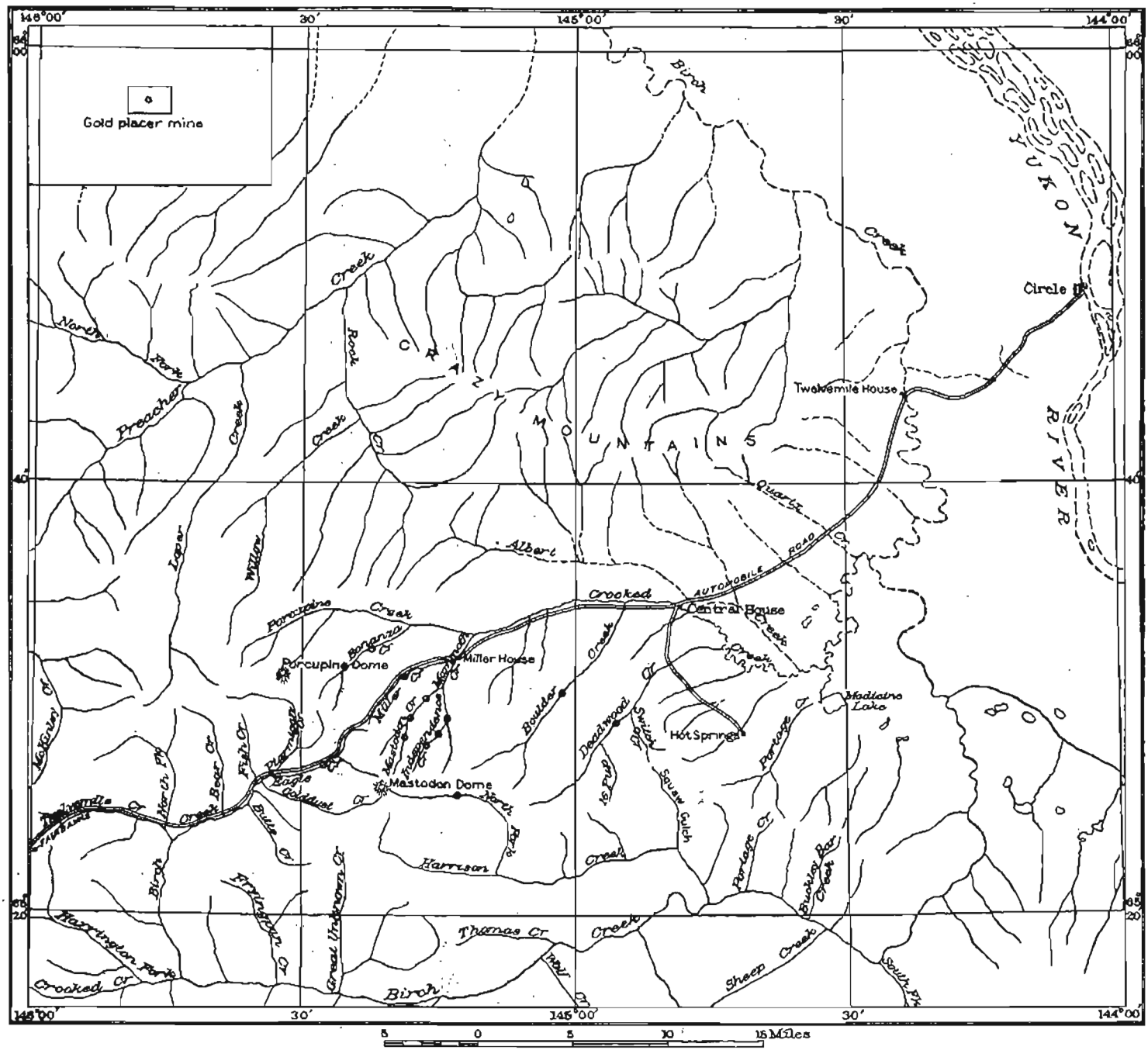
Above the Rampart group lies a chert formation, of which the type locality is in the valley of Livengood Creek and vicinity, about 60 miles west of the Circle district. This formation has been traced intermittently eastward into the Crazy Mountains, and it has also been found on Woodchopper and Coal Creeks, southeast of the Circle district. The chert formation, to which a formal name has not yet been applied, is a distinctive lithologic unit, composed essentially of thin beds of chert, with a massive basal chert conglomerate. Interbedded with the chert are also some beds of slate and limestone, in minor proportion, as well as some basic igneous rocks, partly extrusive and partly intrusive. The interbedded limestones are particularly easy to distinguish, in that they are rather cherty, resembling in this respect the Lisburne formation of northern Alaska. The basal chert conglomerate is the most distinctive part of the formation; it is composed of rounded to angular pebbles of chert set in a chert matrix and so firmly cemented together that the rock commonly fractures across the pebbles. At some localities the fragmental character of the rocks is apparent only by the weathering. The chert formation was described by the writer[4] in 1916, and the genesis of the chert conglomerate has been considered at greater length in a subsequent publication.[5] Fossils found in this formation by R. M. Overbeck in 1918 have been determined to be of Mississippian age.

The youngest mappable unit, except the alluvial deposits, consists of a variety of granitic rocks, of which the most common are biotite and hornblende granites. Other varieties of granite, however, are found, as well as quartz monzonite, quartz diorite, diorite, gabbro, and ultrabasic igneous rocks. Several small intrusive bodies of granitic rocks are found in the Circle district, particularly in the area where gold placer mining is in progress. The hot waters of the Circle Hot Springs issue from rocks of this type. The granitic rocks originated later than the youngest of the Paleozoic sedimentary formations of this district, but as no Mesozoic rocks are present in the near vicinity, their age can not be stated with assurance. Similar granitic rocks of Jurassic, Cretaceous, and Tertiary age are known elsewhere in Alaska, and as the granitic rocks are believed to have had an important influence in the processes of mineralization, the position, size, and shape of their outcrops are considered to be matters of economic interest.

Unconsolidated deposits ranging in age from Pleistocene to Recent are found in nearly all the stream valleys of this district. As this part of Alaska has not been glaciated, the older alluvial deposits, as

[4] Mertie, J. B., jr., The gold placers of the Tolovana district, Alaska: U. S. Geol. Survey Bull. 662, pp. 239–244, 1918.

[5] Mertie, J. B., jr., Geology of the Eagle-Circle district, Alaska: U. S. Geol. Survey Bull. 816, pp. 88–95, 1930.



SKETCH MAP OF CIRCLE DISTRICT, ALASKA, SHOWING LOCATION OF GOLD PLACER MINING OPERATIONS

well as the later deposits, are mainly of fluviatile origin, though at some localities lacustrine deposits also are known. The older gravel deposits, usually found in ancient bench channels, are for the most part covered with black muck composed of silt and peaty material, with a few beds of sand or gravel. The later gravel deposits conform more closely with the general run of fluviatile deposits found elsewhere. Commonly the older deposits are frozen, but the later deposits, particularly close to running streams, are thawed. Some of the fluviatile deposits were formed by ancient or present streams that drained areas mineralized with gold; these deposits also contain gold, and where the auriferous content is sufficiently high they constitute commercial gold placers.

GOLD PLACERS

DEADWOOD CREEK

Deadwood Creek is about 20 miles in length. It heads in the high ridge that forms the divide between the Birch Creek and Crooked Creek drainage areas and flows in a northeasterly direction to Crooked Creek. In the upper 12 miles the valley is narrow, but in the lower 8 miles it widens gradually as it merges into the flats of Crooked Creek. A bench follows down the west side of the lower valley. The stream gradient is about 150 feet to the mile in the upper part of the valley, but becomes appreciably less in the lower part.

Deadwood Creek has a number of small tributaries, of which the two largest ones enter from the southeast side. The lower of these is known as Switch Creek and the upper as "16 Pup." About halfway between Switch Creek and 16 Pup, on the opposite side of the valley, a small gulch known as Discovery Gulch enters Deadwood Creek. Switch Creek is about 3 miles long and enters Deadwood Creek in a narrow gorge.

The bedrock of Deadwood Creek, including also Switch Creek, is composed mainly of massive quartzite schist and quartz-mica schist, but small intrusive bodies of granitic rocks constitute a considerable part of the bedrock at several localities, particularly on lower Deadwood Creek, where such rocks crop out on both sides of the valley for several miles below the mouth of Switch Creek. Some carbonaceous and chloritic schists are also present, and dikes of basic igneous rocks occur at intervals. In places, particularly near the granitic rocks, the schists are garnetiferous. Where seen by the writer on upper Deadwood and Switch Creeks, the cleavage of the schists dips at a moderate angle northeastward. The stream gravel is derived from the bedrock of the various types exposed in Deadwood Creek and therefore embraces a considerable number of types of schist and intrusive rocks. As a rule the stream boulders do not exceed a foot in

diameter, and the deposit includes much fine material, but at the site of present mining operations on Switch Creek boulders as much as 2 feet in diameter were noted. The depth of the stream gravel on Deadwood Creek ranges from 3 to 14 feet, but a somewhat greater thickness is reported on the west bench. At some places gold has been found rather evenly distributed throughout the gravel, but as a rule most of the gold is found close to and in the bedrock. Where the bedrock is massive and much jointed the gold penetrates deeply into the joint crevices, and the recovery of this gold involves much labor in removing and cleaning by hand large slabs of bedrock. The pay streak on Deadwood Creek is said by Prindle [6] to range from 25 to 800 feet, and the average tenor of the developed pay streak is stated to have been 25 cents to the square foot of bedrock, although ground with a gold content as high as $1 to the square foot has been mined. The gold of the creek placers is inclined to be flat in shape, and at the lower end of the creek it is flaky. The largest nugget so far reported was worth $122. It was formerly thought that the gold of Deadwood Creek was of lower grade than that of the other creeks in the Circle district, but the average from the two plants operated in 1929 was $15.96 an ounce, as compared with $15.58 an ounce from the three plants operated on Mastodon Creek.

The concentrates recovered with the gold on Deadwood Creek and its tributaries are particularly interesting. According to Johnson,[7] they include wolframite, cassiterite, magnetite, ilmenite, arsenopyrite, pyrite, galena, limonite, garnet, tourmaline, and quartz. In the concentrates from Switch Creek wolframite was not detected, and magnetite was scarce, but the arsenopyrite, pyrite, and galena were found principally on this stream. Cassiterite was found in all the concentrates from Deadwood Creek and its tributaries. Wolframite was not found above Discovery Gulch, but it occurs in all the stream placers for at least 4 miles below Discovery Gulch. Both wolframite and cassiterite occur most abundantly in the zone between Discovery Gulch and Switch Creek, and Johnson states that they were coarsest and most plentiful on Deadwood Creek a short distance below Discovery claim. The largest piece of wolframite there seen measured 1.7 by 1.8 by 1.8 inches, and the largest piece of cassiterite was 1 by ¾ by ½ inch; pieces even larger have been reported. A light-colored porphyritic granite that was observed by Johnson in the vicinity of the heaviest tungsten concentrates is believed by him to be related genetically to the wolframite. During 1916, when the price of tungsten was high, some of the wolframite concentrates from Deadwood Creek were saved and shipped.

[6] Prindle, L. M., A geologic reconnaissance of the Circle district, Alaska: U. S. Geol. Survey Bull. 538, pp. 60–62, 1913.

[7] Johnson, B. L., Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, Alaska: U. S. Geol. Survey Bull. 442, pp. 246–250, 1910.

Deadwood Creek and Switch Creek have been worked for many years by shallow drifting operations in winter and by open cuts in summer, but of late years only summer mining has been done. Nearly all this work has been done by small-scale mining methods, including shallow drifting, shoveling-in operations, or small hydraulic plants. Brooks[8] stated in an early report that many of those who worked ground on Deadwood Creek in the early days never attempted to gain more than a living wage and that the creek might well be called a stronghold of conservatism. He suggested the desirability of consolidation of some or all of the 106 claims on Deadwood Creek, so that large-scale operations might be undertaken. He also predicted the presence of shallow-thawed ground in the lower valley. These predictions and recommendations now seem about to bear fruit. Two men have acquired possession or control of the creek claims from 22 below to 59 below Discovery and are attempting to interest capitalists in placing a dredge upon this ground. These claims, like most of the other claims on Deadwood Creek, were staked 500 feet in length under the old mining law. Drill holes and shafts indicate that the ground between claims 22 below and 36 below Discovery is largely unfrozen and that the pay streak on claim 30 below Discovery is 250 feet wide. At the lower end of this group of claims the ground is said to be but 14 feet deep to bedrock.

Claim 3 above Discovery was worked by a hydraulic plant during the summer of 1929. Four persons, including the cook, were engaged in this work, and the plant was operated about 95 days. The gravel in this property is about 10 feet thick, with little or no overburden, and consists mainly of schist with a little granite. No boulders larger than 2 feet in diameter were noticed in the gravel. The bedrock is schist and dips downstream. Contrary to what might be expected, little or no gold is here found on bedrock, but instead the gold is distributed rather evenly in the lower 4 feet of gravel. A cut about 370 by 130 feet, or about 48,000 square feet in all, was worked; with an average depth of 10 feet this amounts to 18,000 cubic yards handled. The hydraulic plant consists of two nozzles, one being used for moving gravel into the sluice boxes and one for stacking tailings. Water is supplied by a ditch with an intake 1 mile upstream from the plant and is delivered to the nozzles under a head of 125 feet. A line of 12 sluice boxes is used, with a vertically placed sheet-iron shear board, which is mounted on the sluice boxes on the side opposite to that from which the gravel is being piped in. The gold recovered at this plant has a fineness of $16.22 an ounce but passes commercially at about $15.50 an ounce.

Another hydraulic plant was worked on Switch Creek, on claim 6 above Discovery, about a mile above its mouth. Two men were

[8] Brooks, A. H., The Circle district, Alaska: U. S. Geol. Survey Bull. 314, p. 192, 1907.

engaged in this work. The gravel here is about 5 feet thick, and the bedrock is a greenish quartzite that weathers brown. The gold penetrates deeply into the joints of this bedrock, and about 5 feet of rock has to be removed and hand cleaned in order to recover all the gold. Two cuts were worked, one 170 by 45 feet and another 70 by 30 feet, or about 9,750 square feet in all. With an average depth of 5 feet of gravel, this amounts to about 1,800 cubic yards. The largest nugget recovered in these operations was worth about $7. The gold was said by the operators to assay $15.71 an ounce.

In addition to these two hydraulic plants prospecting and small-scale open-cut operations were in progress on upper Deadwood Creek during 1929, but no mining was being done at the time of the writer's visit in late August.

BOULDER CREEK

Boulder Creek is a stream of about the same length as Deadwood Creek and flows parallel to it to join Crooked Creek. The bedrock is schist, and in all probability it is intruded by granitic rocks, as on Deadwood Creek. As Boulder Creek drains part of a mineralized area, it might be expected to yield commercial placers, but so far little mining has been done. Years ago workable placer ground was located on a small tributary of Boulder Creek known as Greenhorn Creek. This ground was shallow and easily worked, but lack of water was the principal handicap to mining.

During the season of 1929 one man was engaged in hydraulic mining on a bench on the southeast side of Boulder Creek. The depth to bedrock here is 8 feet, of which the lower 3½ feet of gravel is considered to carry gold in paying quantity. About 1,500 square feet of ground was worked, and this at an average depth of 8 feet gives a total of about 450 cubic yards. The gold is said to assay $18.15 an ounce. This plant was operated about 95 days.

INDEPENDENCE CREEK

Independence and Mastodon Creeks unite to form Mammoth Creek. Independence Creek is about 6 miles long and is markedly asymmetric, as it receives a number of small tributaries from the east and southeast but none from the west. At its mouth the valley floor is 100 yards or more in width, but the valley becomes rather narrow upstream. At its head the valley opens out somewhat into a steep basin that lies on the north flank of Mastodon Dome.

Independence is one of the earliest-producing creeks of the Circle district. Apparently it has not been the site of any large-scale mining operations but has produced steadily on a small scale for many years. Some well-defined benches occur in the valley, but so far as can be learned mining has been done only in the creek placers. The

gravel is from 3 to 9 feet thick, and the pay streak extends as a narrow strip, cutting first to one side and then to the other side of the present creek valley. This ground, which is being worked by open-cut methods, ranges in gold content from 30 to 90 cents a square foot of bedrock.

Three small open cuts were worked during 1929. The farthest downstream, on Discovery claim, about a mile above the mouth of the creek, was worked for 85 days, and 960 square feet of bedrock was cleaned. The cubic yardage given by the owner indicates a depth of 8 feet of material mined, but some of this thickness is probably bedrock that had to be removed. The gold assays $16.83 an ounce. This plant was not in operation at the time of the writer's visit.

The next plant upstream is on claim 10 above Discovery, although the operator owns other claims above and below the plant. Here mining was continued over a period of 112 days, and 1,100 square feet of bedrock was shoveled in. The bedrock at this place is a greatly jointed, blocky quartzite schist, into which the gold penetrates deeply. The gravel is about 5 feet thick, but the character of the bedrock makes it necessary at places to take up 5 feet of bedrock also.

The third plant, which is being operated on claim 14 above Discovery, was worked for 126 days and opened up 1,800 square feet of bedrock. Here 5 to 8 feet of gravel is present, and usually 3 feet and sometimes 5 feet of bedrock also must be removed in order to recover a high percentage of the gold.

MASTODON CREEK

Mastodon Creek, like Independence Creek, is about 6 miles long, heads in the north flank of Mastodon Dome, and runs about north-northeast. The valley is bounded on both sides by even-topped spurs that rise to a height of 1,200 feet or more above the creek and slope gradually at their northeast ends to the valley floor. Like that of Independence Creek, the valley is asymmetric in outline, but the steeper wall is on the southeast instead of the northwest side. At its mouth the valley floor is about 400 yards wide, but within 2 miles upstream it narrows to half that width, and about 3 miles above its mouth it becomes still narrower, but still farther upstream it widens out again. The gradient of the stream ranges from 100 to 150 feet to the mile.

The bedrock consists essentially of quartzite schist and mica schist, which are cut at many places by quartz veins. The cleavage of these rocks strikes about N. 60° W. and has been observed by the writer dipping both upstream and downstream, although the usual direction of dip has been considered to be upstream. Other varieties

of bedrock also occur in minor proportions, as, for example, certain greenish feldspathic schists mentioned by Prindle[9] and some thin-bedded impure closely folded limestone that crops out near the mouth of the creek. Dikes and small intrusive bodies of granitic rock are also found in the valley of Mastodon Creek.

The stream detritus is similar to that found on Deadwood Creek and consists of subangular to rounded material, ranging from sand and clay up to cobbles and boulders 2 feet in diameter and in the upper valley still larger. The gravel deposit ranges in thickness from 6 to 20 feet and averages perhaps 10 to 12 feet. Usually several feet of muck overlies the gravel. As on Deadwood Creek, the gold is not localized at any one horizon in the gravel but is found at some places on or near bedrock and at others rather evenly distributed through the lower half of the gravel. The pay streak is variable in width, ranging from 85 feet in the upper valley to 200 feet in the lower valley. The ground first worked on Mastodon Creek yielded as high as $2 to $3 a cubic yard, but the ground now being worked on lower Mastodon Creek yields about 75 cents a cubic yard.

The gold in the upper valley is fairly coarse and light in color, but farther downstream the usual run of the gold is fine and flaky. According to Prindle,[10] the gold recovered 20 years ago from Mastodon Creek assayed about $17.35 an ounce and passed commercially at $17 an ounce; but the gold from the plants operated on Mastodon Creek in 1929 ranged from $15.25 to $16.15 an ounce, with an average value of $15.58. The gold appears to become progressively higher in grade downstream.

Mastodon Creek was from the beginning and still is the largest producer of placer gold in the Circle district and in the aggregate has probably produced between $2,000,000 and $3,000,000. During the season of 1929 three plants were operated on this creek. The largest was the hydraulic plant of the C. J. Berry Dredging Co., on claim 3 below Discovery, just above the mouth of Independence Creek. The gravel, which is composed almost entirely of schist, is about 7 feet thick, but several feet of overlying muck is ground-sluiced off prior to hydraulicking. The bedrock is a blocky quartzite, the cleavage of which dips upstream. Into the joints of this schist the gold penetrates deeply, so that from 5 to 7 feet of bedrock must be removed. Large slabs of the bedrock are pried loose with crowbars, but inasmuch as the boulders in the gravel do not exceed 1 foot in diameter, these slabs are the only heavy material to be handled. The gold is fine and flaky and assays $16.15 an ounce after melting. The largest piece so far found on this property

[9] Prindle, L. M., The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska: U. S. Geol. Survey Bull. 251, p. 62, 1905.

[10] Prindle, L. M., The Circle district, Alaska: U. S. Geol. Survey Bull. 535, p. 63, 1913.

weighed 1 ounce, but three-quarters of this by volume was vein quartz. In late August, 1929, a cut measuring about 165 by 700 feet, or about 115,500 square feet, had been opened up at this property. Just below this cut, on the west side of the valley, a slight elevation of the bedrock gives rise to a well-defined low bench, covered by gravel. This has been prospected for 125 feet from the rim and showed a good tenor, and it was expected that this ground would be mined in 1930. The present hydraulic plant utilizes three nozzles—4 inches in diameter when water is plentiful and smaller when water is scarce. Two of these nozzles are used for hydraulicking the gravel, and one is used for stacking tailings. Water is supplied through hydraulic pipe, with a penstock about three-quarters of a mile upstream, and the water is delivered to the hydraulicking nozzles under a head of 80 feet. A line of 10 sluice boxes is used, with overhead sheet-iron shear boards, pivoted to swing to either side of the boxes. Six men, including the cook, were engaged in these operations.

The next plant upstream is on claim 24 above Discovery. This likewise is a hydraulic plant, and the mining methods and local conditions are very similar to the plant on claim 3, above described. The gravel here is said by the owner to be 10 feet thick, but along the east side of the cut the gravel and overlying muck together appeared to be nearly 20 feet thick. This plant was operated 143 days during the season of 1929, and a cut about 300 by 175 feet was opened up.

The third hydraulic plant on Mastodon Creek is on claim 36 above Discovery. At this point the valley is narrow and the pay streak is about 85 feet wide. The bedrock consists of quartzite and quartzite schist, which dip downstream. The overburden consists of 12 feet of heavy gravel, of which the upper 7 feet is particularly coarse, containing boulders as much as 4 feet in diameter. Above this gravel lies 7 to 8 feet of muck and gravel, which has to be groundsluiced off in advance of hydraulicking operations. The gold lies mostly in the lower 5 feet of gravel and the upper 2 or 3 feet of bedrock. The gold is fairly coarse, not well worn, and light yellow. It is of rather low grade and is said to assay on the average about $15.25 an ounce after melting. The largest piece of gold so far found on this property was worth $20. Heavy sand concentrates are said to be scarce. For hydraulicking, a ditch 1 mile long has been built along the west side of the valley, which supplies water at a head of 100 feet. Another ditch on the east side has just been completed to supply water under a head of 300 feet, but as the intake is much farther upstream the supply of water may be inadequate. A small dam a short distance above the cut is used for sluice water. Six sluice boxes are used in washing the gravel. In late August, 1929, a cut measuring

about 140 by 85 feet, or nearly 12,000 square feet, had been mined out, and the plant probably continued in operation for another two or three weeks.

MILLER CREEK

Miller Creek is about 7 miles long and flows into Mammoth Creek about 2 miles below the junction of Independence and Mastodon Creeks. It heads against Eagle Creek and flows in a general northeasterly direction. Like Mastodon Creek, it has an asymmetric valley, with a much steeper southeast than northwest wall. The northwest side of the valley is benched, and the new automobile road follows up this side from Miller House over the ridge to Eagle Creek. This divide, known as Eagle Summit, is the highest point along the automobile road, and the depth of snow on it determines how early in the spring and how late in the fall the road may be traversed by automobiles. The grade of Miller Creek is said to be from 150 to 200 feet to the mile.

The bedrock on Miller Creek consists of quartzite and quartzite schist veined with quartz. Granitic dikes occur along the ridge between Miller and Eagle Creeks, but no intrusive bodies of granite of any size have been noticed in the valley of Miller Creek. The gravel is therefore composed mainly of different varieties of schist, with a little granite, and is similar in size and arrangement to that of Mastodon Creek. The thickness of the gravel in the lower valley of Miller Creek ranges from 8 to 16 feet, averaging perhaps 12 feet, of which about 4 feet is an overburden of muck and gravel that can be removed by groundsluicing. In the upper valley the gravel is but 4 or 5 feet thick. At some places, according to Prindle,[11] clay as much as 3 feet thick lies between the gravel and bedrock and contains most of the gold. At most places, however, the gold is said to be found in the lower few feet of gravel, which occurs as a pay streak with a maximum width of 50 feet. This gold is reported to be about the same in character and grade as that obtained on Mastodon Creek, but in view of the lower-grade gold now being produced from Mastodon Creek and the high-grade gold in Eagle Creek, just across the divide, the writer would expect that the gold of Miller Creek should be of higher grade than that of Mastodon Creek, though not so high as that of Eagle Creek. As no recent assays from Miller Creek are available, this question can not be decided. As a rule, the gold is rather fine, but pieces weighing as much as an ounce have been found.

Miller Creek has never been a large producer of gold but has been worked intermittently since 1895. No mining was in progress here

[11] Prindle, L. M., The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska: U. S. Geol. Survey Bull. 251, p. 64, 1905.

at the time of the writer's visit, but two men were engaged in constructing a ditch along the northwest side of the valley about 3 miles above Miller House with the expectation that they would begin hydraulic mining on claim 8 above Discovery in 1930.

BONANZA CREEK

Bonanza Creek heads in the ridge just southeast of Porcupine Dome, is about 8 miles in length, and empties into Porcupine Creek. The lower valley of the creek is sharply incised, but the upper valley opens out into several tributary valleys. A long nearly horizontal spur separates Bonanza Creek from Miller Creek.

Little is known of the general condition of bedrock, gravel, and pay streak on Bonanza Creek, for although some prospecting was done on both Bonanza and Porcupine Creeks in the early days of the camp, commercial mining was not begun until a few years ago. The site of present mining operations on Bonanza Creek is about 4 miles above its mouth, on a group of five 40-acre claims known as the Bonanza Association. The bedrock here is schist 6 feet thick, with about 2 feet of overlying vegetation and muck. The pay streak is from 60 to 80 feet wide. Some fine gold is found in the lower part of the gravel, but the coarse gold, which constitutes most of the output, is found on and in bedrock. At places 5 feet of bedrock must be taken up to obtain this gold. During the summer of 1929 a nugget worth $160 was found. One sample of gold weighing 2.5 ounces, taken from a prospect hole, was assayed and found to have a fineness of 0.811 in gold and 0.178 in silver; this, at the current price for silver, shows a value of $16.88 an ounce after melting. A sample of the heavy sands recovered with the gold was found to contain zircon, garnet, ilmenite, limonite, magnetite, pyrolusite, pyrite, pyrrhotite, and galena.

Three men operate this hydraulic plant on Bonanza Creek. Some work was done five or six years ago, but owing to illness and ditch trouble active mining was not begun until 1927. Water is obtained from the upper end of a long ditch, which was originally built by the Mammoth Dredging Co. to deliver Porcupine and Bonanza water on Mastodon and Mammoth Creeks. By means of the upper 2 miles of this ditch, water under a head of 200 feet is delivered to the nozzles in the cut. A 16-inch hydraulic pipe at the intake is reduced to 8 inches at the cut, and the water is fed to a 3¼-inch nozzle. A cut measuring 60 by 350 feet, or about 21,000 square feet, was mined out during the 118 days of operation in 1929.

EAGLE CREEK

Eagle Creek is formed by the junction of two creeks known as Miller and Mastodon Forks, so called because they head, respectively,

against Miller and Mastodon Creeks. Eagle Creek, from the junction of these forks, is 4 miles long and flows southwestward to Birch Creek. Mastodon Fork heads to the east in Mastodon Dome and flows for 3 miles through a narrow valley to its junction with Miller Fork. Miller Fork has a somewhat more open valley.

The pay streak on Eagle Creek continues on up Mastodon Fork. Miller Fork is barren. The bedrock on Mastodon Fork is mainly quartzite schist, and the gravel is composed mainly of the same material. According to Prindle,[12] the depth to bedrock ranges from 8 to 10 feet, and the pay streak is said to be irregular and spotted. Some very good ground has been found and worked on Mastodon Fork, and much of the gold is coarse. No mining was in progress on Mastodon Fork in 1929.

The valley of Eagle Creek proper widens rapidly below the forks and opens gradually downstream into the valley of Birch Creek. Beginning in 1901 the pay streak on Mastodon Fork and Eagle Creek was worked by open cuts and drifts for 2 miles below the forks, but much of this ground is now being worked by hydraulic methods. The bedrock and gravel on Eagle Creek are the same as those on Mastodon Fork, but the depth to bedrock is greater, ranging from 14 to 20 feet. The lower 6 feet was said to carry most of the gold, and the pay streak was considered to be from 30 to 80 feet in width. Much coarse gold was found, and one piece worth $74 was recovered. This gold was of high grade.

The present hydraulic operations on Eagle Creek are being carried on by the Berry Holding Co. Work was begun a number of years ago on claim 8 above Discovery and has progressed upstream to claim 15 above Discovery, the site of mining in 1929. The bedrock at this place is a slabby schist striking N. 60° E. and dipping 30°–40° NW., and several feet of this rock must be pried up with crowbars after the gravel is removed in order to recover a high percentage of the gold. It contains some very irregular stringers and kidneys of quartz. The gravel is about 20 feet thick and ranges in size from very fine material up to subangular slabs 3 feet in diameter. Overlying the gravel is from 2 to 5 feet of muck, which is groundsluiced off before hydraulic operations are begun. The best pay is a streak about 60 feet wide which was worked years ago, but in the present type of mining the pay streak is considered to be 200 feet in width. The gold is rather coarse, the largest pieces so far found in these hydraulic operations being worth $58. This gold is worth $18.46 an ounce after melting and is therefore the highest-grade gold recovered in the Circle district.

[12] Prindle, L. M., The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska: U. S. Geol. Survey Bull. 251, pp. 64–65, 1905.

This hydraulic plant gets its water from a ditch that taps Mastodon and Miller Forks and also a small stream known as Cripple Pup on the southeast side of the valley below the forks. This ditch supplies water at a head of 70 feet at the top of the gravel and at 90 feet in the bottom of the cut for stacking tailings. Five sluice boxes are used for washing the gravel. The present ditch does not permit the work to be continued much farther up Eagle Creek, and the owners feel doubtful whether a higher ditch would supply sufficient water. Seven men were employed at this plant, and two cuts aggregating about 50,000 square feet were worked during the season of 1920.

NORTH FORK OF HARRISON CREEK

Harrison Creek is fed from two forks, of which only one, the North Fork, has been proved to contain gold placers. The North Fork of Harrison Creek heads in the south side of Mastodon Dome, against Mastodon Fork of Eagle Creek, and flows east for about 7 miles and thence south for 4 miles to join the main Harrison Creek. In the upper 7-mile stretch most of the tributaries enter from the south side of the valley.

According to Spurr,[13] the first discovery of gold in the Birch Creek district was made in 1893 on Pitkas Bar, at the junction of the North Fork with the main Harrison Creek; but the first gold found on the North Fork is said to have been discovered a mile below Mastodon Dome in 1895. No very high-grade placers were found on Harrison Creek, and until lately its lower-grade placers have been neglected. A number of people, however, have retained their interest in the North Fork, and prospecting and assessment work continue to be done.

According to Brooks,[14] the valley floor in the upper North Fork is from 300 to 400 yards wide, with a steep south valley wall. Farther downstream the valley becomes constricted, and the creek passes through a steep-walled canyon before joining the main Harrison Creek. The bedrock is said to be mainly quartz-mica schist, but some granite pebbles in the gravel show the presence of granitic rocks farther upstream, probably around Mastodon Dome. Much vein quartz is found cutting the schist, and Spurr states that one such specimen of vein quartz was observed to contain gold.

At Discovery claim, 6 or 7 miles above the canyon, the depth to bedrock is said by Brooks to be from 8 to 9 feet on the north side of the valley but only 3 to 4 feet on the south side. Here the bedrock grade is 75 to 100 feet to the mile. The valley floor at Discovery

[13] Spurr, J. E., Geology of the Yukon gold district, Alaska: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 351–354, 1898.

[14] Brooks, A. H., The Circle precinct, Alaska: U. S. Geol. Survey Bull. 314, pp. 195–197, 1907.

claim is about 300 feet wide. The gold is found mainly in the lower part of the gravel and in the decayed schist bedrock to a depth of 1 or 2 feet. The gold is fine, flaky, and bright colored. A recent assay of some gold recovered by one operator somewhere above Discovery claim shows 807 parts gold and 183 parts silver per 1,000, worth, at the current price for silver, $16.77 an ounce after melting. No very coarse gold has been found, the largest nugget so far reported being worth but $4. Garnet and pyrite occur among the heavy sands.

One small hydraulic plant was operated for a short time during 1929 at the head of the North Fork of Harrison Creek, probably several claims above Discovery. No information is available about the results of this work. Prospecting and assessment work on the North Fork were also continued on the Clayworth Association and other claims.

PRODUCTION

The following table gives the value of gold bullion produced in the Circle district, by years, from 1894 to 1929. As will be seen from these figures, the total production is about $7,500,000.

At the conventional value of 1 per cent of dross in the bullion, the fineness of the gold from the Circle district is 804 parts per thousand, with 186 parts of silver. As this production, however, includes gold from other districts during 10 years, these values can only be regarded as approximations.

Gold production of Circle district, 1894–1929

1894	$10,000	1913	$176,000
1895	151,000	1914	216,000
1896	[a] 706,000	1915	231,000
1897	[b] 464,000	1916	301,000
1898	[b] 403,000	1917	201,000
1899	[a] 252,000	1918	177,000
1900	[a] 253,000	1919	136,000
1901	[a] 202,000	1920	56,000
1902	[a] 201,000	1921	61,000
1903	[a] 202,000	1922	122,000
1904	[c] 202,000	1923	115,000
1905	[c] 202,000	1924	91,000
1906	303,000	1925	151,000
1907	202,000	1926	163,000
1908	176,000	1927	72,000
1909	226,000	1928	81,000
1910	227,000	1929	110,000
1911	352,000		
1912	326,000		7,520,000

[a] Includes production from Eagle and Rampart districts.
[b] Includes production from Fortymile, Eagle, and Rampart districts.
[c] Includes production from Rampart district.

THE OCCURRENCE OF GYPSUM AT IYOUKEEN COVE, CHICHAGOF ISLAND, ALASKA

By B. D. Stewart

EARLIER MINING OPERATIONS

LOCATION AND EXTENT OF THE DEPOSIT

The occurrence on Chichagof Island of gypsum deposits of commercial grade and size was known prior to 1905. Active mining of the largest known deposit was commenced in 1906 and continued thereafter with but brief interruptions for a period of nearly 20 years, until the deposit was exhausted.[1]

This deposit was situated on Gypsum Creek, which enters deep water on Chatham Strait near the head of Iyoukeen Cove, on the east side of Chichagof Island, and was owned by the Pacific Coast Gypsum Co.

The lowest horizon from which gypsum was mined was at the 300-foot level. The workings on that level are said to have been about 600 by 800 feet in extent, and the quality of the product mined was excellent. On the 160-foot level the deposit is reported to have had a length of more than 1,000 feet and a width of about 500 feet, measured on a horizontal plane.[2] The gypsum produced throughout the life of the mine was of exceptional purity. The color ranged from white to light bluish gray. The gray gypsum was translucent, and some of it approached alabaster in texture and appearance. The crude gypsum was shipped to Puget Sound, where a mill was built that for many years supplied the market with a large percentage of the plaster products consumed on the Pacific coast. The productive capacity of the mine was over 100 tons of gypsum a day, and the total output was probably in the neighborhood of 500,000 tons.

[1] Brief references to the occurrence of gypsum at Iyoukeen Cove are given in the following Geological Survey publications: Mineral resources of Alaska, 1905: U. S. Geol. Survey Bull. 284, pp. 58–59, 1906. Mineral resources of Alaska, 1906: U. S. Geol. Survey Bull. 314, pp. 79–80, 1907. Mineral resources of Alaska, 1907: U. S. Geol. Survey Bull. 345, pp. 124–125, 1908. Mineral resources of Alaska, 1912: U. S. Geol. Survey Bull. 542, pp. 50–51, 1913. Gypsum deposits of the United States: U. S. Geol. Survey Bull. 697, pp. 47–48, 1920 (out of print but may be consulted at principal public libraries).

[2] These approximate measurements were furnished by Mr. M. S. Hudson, formerly mine foreman at Gypsum.

DIFFICULTIES OF OPERATION

As this deposit was about a mile from the mouth of Gypsum Creek, shipping of the product mined involved the building of a railroad 1 mile in length, on which a steam-driven "dinky" engine was used, and the construction of a wharf 2,000 feet in length with storage bunkers on the seaward end. The mine workings below the level of Gypsum Creek were so situated with reference to the stream that twice during the life of the property the mine was flooded. An underground watercourse was also encountered following a channel in the conglomerate formation that overlay the gypsum deposit. To keep the water from entering the workings entailed heavy expense for pumping. The fact that profitable operations were possible at this locality in spite of the heavy costs involved in pumping water and in maintaining the railroad line and long wharf attests the high quality of the gypsum produced.

RECENT DEVELOPMENTS

LOCATION AND GENERAL GEOLOGY

As the deposit at Gypsum Creek underlies the creek valley the surface is so thickly covered by modern stream gravel that bedrock outcrops are scarce. For this reason and because the old mine workings were confined almost wholly to the gypsum beds, the geology in the immediate vicinity of that deposit is somewhat obscure. It is known, however, that the underlying bedrock is cherty limestone and that a chert conglomerate overlies the gypsum beds.

Eastward from Gypsum Creek along the shore of Iyoukeen Cove evidences of additional gypsum deposits have been discovered, and at one locality development work has recently revealed the possibility of the occurrence of an extensive body. The deposit is about 1½ miles due east of the mine on Gypsum Creek and underlies an elevated bench land adjacent to the shore of Iyoukeen Cove. The property on which this deposit is found comprises eight claims, known as the Gypsum-Camel group, which is owned by Larson & Anderson, of Juneau, Alaska, and associates. The underlying bedrock formation at this locality is exposed at numerous places along the shore line of the property and comprises tilted beds of lime-chert breccia and yellowish and bluish-gray cherty limestone. The trend of the marine terrace that skirts the shore is slightly east of north.

EXPLORATORY WORK

Three tunnels have been driven in a westerly direction into the terrace at an altitude of about 15 feet above high-tide line. Tunnel 1, which is the southernmost tunnel, is about 130 feet in length. It

enters the terrace at the outcrop of a prominent bluff of yellowish calcareous breccia. Two faults, apparently of moderate displacement, were encountered in this tunnel, the first about 25 feet from the portal and the second about 70 feet. Between the portal and the first fault the material exposed is coarse breccia. Between the two faults a fine yellowish-white breccia is exposed, and from the second fault to the face, as it appeared in June, 1928, the tunnel was in homogeneous fine-grained light-gray to yellowish limestone.

Tunnel 2 starts at a point 600 feet north of tunnel 1 and has been driven a distance of 250 feet, approximately at right angles to the shore line and roughly parallel to tunnel 1. This tunnel throughout its length exposes material consisting of either solid gypsum or lumps of gypsum embedded in a claylike mass which is believed to be gypsite that has been formed by the disintegration of solid gypsum. The gypsum appears to be very pure in quality and resembles closely in appearance the white variety that was produced at the mine of the Pacific Coast Gypsum Co.

Tunnel 3 is 270 feet north of tunnel 2, and its general course is parallel to that of the other tunnels. The main section of this tunnel is about 225 feet in length. At 10 feet from the face a crosscut has been driven N. 14° E. a distance of 25 feet. From a point 100 feet in from the portal a slope has been driven on the north side of the tunnel and at an angle of about 30° from the tunnel line. This slope inclines downward at an angle of about 12° and has a length of about 75 feet. From a point in the tunnel opposite the top of this incline a vertical shaft was sunk to a depth of 40 feet, from the bottom of which a drift was driven west for a distance of about 80 feet approximately parallel with the adit tunnel above.

For a distance of 130 feet from the portal tunnel 3 penetrates partly cemented fine-grained beach sand containing perfectly preserved marine shells. A continuous narrow band of small shells in this section of the tunnel shows that the sand stratum has an inclination toward the present beach of about 4 feet to 100 feet. At a distance of 130 feet from the portal a band of partly cemented coarse beach gravel from 2 to 3 feet thick that underlies the sand stratum appears in the walls of the tunnel at the floor level and continues with an upward inclination of about 14 feet to 100 feet to the face, where it occupies the upper third of the tunnel. At a point 160 feet from the portal solid gypsum is exposed at the floor level of the tunnel, and from that point to the face gypsum is exposed in both walls of the tunnel, either solid or as lumps embedded in gypsite clay. At the face the lower two-thirds of the tunnel is in solid gypsum.

At the time of the writer's visit to the property, in 1928, the presence of water in the incline below the tunnel level at the 100-foot

station prevented a complete examination. The sand and gravel strata were observed in the walls, however, occupying the same relative positions as in the tunnel above. The owners of the property report that the incline penetrated gypsum at a point 50 feet down from the top and continued in gypsum to the face, a distance of 25 feet. The vertical shaft at the 100-foot station has been filled and was inaccessible. The owners report that this shaft penetrated a foot of solid gypsum at the bottom, that in the drift which was driven west from that point solid gypsum was exposed in the floor for about 35 feet, and that thence to the face, a distance of 45 feet, the drift was entirely in gypsum.

About 300 feet northeast of the portal of tunnel 3 yellowish cherty limestone crops out on the shoreward side of the terrace. Immediately northeast of these limestone beds is a zone of yellowish limestone breccia that extends between 200 and 300 feet to the mouth of a small stream, where the breccia is in contact with folded beds of bluish-gray limestone. The strata of the breccia zone strike S. 70° E. and dip steeply to the southwest.

Geologic conditions have not been observed in the area lying inland from the shoreward face of the marine terrace. Within the limits of the Gypsum-Camel group this area consists wholly of bench land sloping gently upward from the shore terrace. It is covered by overburden and a thick growth of underbrush, and bedrock exposures are lacking.

SUMMARY OF INDICATIONS

Underground conditions, as revealed by the development work so far accomplished, indicate that tunnels 2 and 3 and the workings connected with No. 3 have penetrated the upper portion of a body of gypsum of undetermined extent. It also seems evident that this body of gypsum lies unconformably on tilted and folded beds of cherty limestone and limestone breccia and is overlain by partly consolidated beach gravel and sand of recent geologic age. The entire area described has been elevated since the marine sediments were deposited. It is also apparent that the geologic relations of the indicated body of gypsum at this locality are similar in all essential respects to those existing at the deposit on Gypsum Creek and that the gypsum itself is of similar type and quality.

A moderate amount of additional underground work should serve to demonstrate the continuity and extent of the gypsum deposit. Extension of tunnels 2 and 3 and the sinking of additional winzes therefrom are suggested as the logical program for such development. The low-lying bench land, which extends for a considerable distance back from the shore line, also affords favorable topographic condi-

tions for the drilling of the area beyond the limits of underground development.

If a body of gypsum of minable extent exists at this place conditions would be much more favorable for mining the deposit at low cost than at Gypsum Creek. Deep water sufficient for ocean-going vessels extends almost to the shore at this point, and a wharf would need to be only of sufficient size to accommodate bunkers and other requisites for loading. The bench land adjacent to the beach would afford an excellent site for a mine camp and also for a working shaft. The menace of flooding by surface water is absent at this locality.

INDEX

SELECTED LIST OF GEOLOGICAL SURVEY PUBLICATIONS ON ALASKA

[Arranged geographically]

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

1. The reports are sold, at the prices indicated, by the Superintendent of Documents, Washington, D. C., to whom remittances should be sent by money order. No copies are available of those marked with an asterisk (*); they may be consulted at many public libraries.

2. 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.

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.

GENERAL

REPORTS

* The geography and geology of Alaska, by A. H. Brooks. Professional Paper 45, 1906, 827 pp.

The Alaskan mining industry in 1930 by Philip S. Smith. In Bulletin 836, 1932, — cents. The preceding volumes in this series and years covered 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, 50 cents; 642, 1915, 35 cents; 662, 1916, 75 cents; * 692, 1917 (692–A, 5 cents); * 712, 1918; * 714, 1919 (714–A, 25 cents); 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, 50 cents; 813, 1928, 40 cents; 824, 1929, — cents.

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.

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, 1921, 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.

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, 1930, 123 pp., 87 pls. 80 cents.

Glaciation in Alaska, by S. R. Capps. In Professional Paper 170, 1932, pp. 1–8. — cents.

In preparation

Tertiary flora of Alaska, by Arthur Hollick.

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

TOPOGRAPHIC MAPS

Map of Alaska (A); scale, 1:5,000,000; 1931. 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; 1931. 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. 91–186.

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.

The occurrence of gypsum at Iyoukeen Cove, Chichagof Island, by B. D. Stewart. In Bulletin 824, 1931, pp. 173–177. — cents.

Notes on the geography and geology of Lituya Bay, by J. B. Mertie, jr. In Bulletin 836, 1931, pp. ——. — cents.

Surface water supply of southeastern Alaska, by F. F. Henshaw. In Bulletin 836, 1932, pp. ——. — 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.

Kassan 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; by J. W. Bagley, C. E. Giffin, and R. E. Johnson. In Bulletin 502, 1912, 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, 1:250,000; 1931, by R. H. Sargent (preliminary edition). Free on application.

In preparation

Wrangell district; scale, 1:250,000, by R. H. Sargent.

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 gravel 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 778, 1925, pp. 141–158. 40 cents.

Notes on the geology of the upper Nizina River, by F. H. Moffit. In Bulletin 813, 1930, pp. 143–163. 40 cents.

The Slana district, upper Copper River region, by F. H. Moffit. In Bulletin 824, 1931, pp. 111–124. — cents.

In preparation

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, 25 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.

Headwater regions of Gulkana and Susitna Rivers; scale, 1:250,000; by D. C. Witherspoon, J. W. Bagley, and C. E. Giffin. In Bulletin 498, 1912, 35 cents. Not issued separately.

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 Iliamar 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 retail or 6 cents wholesale. Also published in Bulletin 745, 1923, 40 cents.

Valdez and vicinity (No. 602B); scale, 1:62,500; 1929, by J. W. Bagley, C. E. Giffin, and R. H. Sargent. 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.

Geology and coal fields of the lower Matanuska Valley, by G. C. Martin and F. J. Katz. Bulletin 500, 1912, 98 pp. 30 cents.

The Yentna district, by S. R. Capps. Bulletin 534, 1913, 75 pp. 20 cents.

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

The Willow Creek district, by S. R. Capps. Bulletin 607, 1915, 86 pp. 25 cents.

The Broad Pass region, by F. H. Moffit and J. E. Pogue. Bulletin 608, 1915, 80 pp. 25 cents.

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

Platinum-bearing gold placers of Kahiltna Valley, by J. B. Mertie, jr. In Bulletin 692-D, 1919, pp. 233-264. 15 cents.

* Mining developments in the Matanuska coal fields, by Theodore Chapin. In Bulletin 714, 1921. (See also Bulletin 692-D, 1919, 15 cents; and Bulletin *712, 1920.)

* Lode developments in the Willow Creek district, by Theodore Chapin. In Bulletin 714, 1921. (See also Bulletin 642, 1916, 35 cents; Bulletin 692-D, 1919, 15 cents; and Bulletin *712, 1920.)

Geology of the vicinity of Tuxedni Bay, Cook Inlet, by F. H. Moffit. In Bulletin 722, 1922, pp. 141–147. 25 cents.

The Iniskin Bay district, by F. H. Moffit. In Bulletin 739, 1922, pp. 117–132. 25 cents.

Chromite of Kenai Peninsula, by A. C. Gill. Bulletin 742, 1922, 52 pp. 15 cents.

Geology and mineral resources of the region traversed by the Alaska Railroad, by S. R. Capps. In Bulletin 755, 1924, pp. 73–150. 40 cents.

An early Tertiary placer deposit in the Yentna district, by S. R. Capps. In Bulletin 773, 1925, pp. 53–61. 40 cents.

Mineral resources of the Kamishak Bay region, by K. F. Mather. In Bulletin 773, 1925, pp. 159–181. 40 cents.

A ruby-silver prospect in Alaska, by S. R. Capps and M. N. Short. In Bulletin 783, 1927, pp. 89–95. 40 cents.

The Iniskin-Chinitna Peninsula and the Snug Harbor district, Alaska, by F. H. Moffit. Bulletin 789, 1927, 71 pp. 50 cents.

Geology of the upper Matanuska Valley, Alaska, by S. R. Capps, with a section on the igneous rocks, by J. B. Mertie, jr. Bulletin 791, 1927, 92 pp. 30 cents.

Geology of the Knik-Matanuska district, Alaska, by K. K. Landes. In Bulletin 792, 1927, pp. 51–72. 25 cents.

The Skwentna region, by S. R. Capps. In Bulletin 797, 1929, pp. 67–98, 80 cents.

The Mount Spurr region, by S. R. Capps. In Bulletin 810, 1930, pp. 141–172. 50 cents.

The Chakachamna-Stony region, by S. R. Capps. In Bulletin 813, 1930, pp. 97–123. 40 cents.

The Lake Clark-Mulchatna region, by S. R. Capps. In Bulletin 824, 1931, pp. 125–154. — cents.

In preparation

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

TOPOGRAPHIC MAPS

Matanuska and Talkeetna region; scale, 1:250,000; by T. G. Gerdine and R. H. Sargent. In Bulletin 327, 1907, 25 cents. Not issued separately.

Yentna district; scale, 1:250,000; by R. W. Porter. Revised edition. In Bulletin 534, 1913, 20 cents. Not issued separately.

*Mount McKinley region; scale, 1:625,000; by D. L. Reaburn. In Professional Paper 70, 1911. Not issued separately.

*Kenai Peninsula; scale, 1:250,000; by R. H. Sargent, J. W. Bagley, and others. In Bulletin 587, 1915. Not issued separately.

*Moose Pass and vicinity; scale, 1:62,500; by J. W. Bagley. In Bulletin 587, 1915. Not issued separately.

The Willow Creek district; scale, 1:62,500; by C. E. Giffin. In Bulletin 607, 1915, 25 cents. Not issued separately.

Lower Matanuska Valley (No. 602A); scale, 1:62,500; 1931, by R. H. Sargent. 10 cents retail or 6 cents wholesale.

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

Iniskin-Chinitna Peninsula, Cook Inlet region; scale, 1:62,500; 1922, by C. P. McKinley, D. C. Witherspoon, and Gerald FitzGerald (preliminary edition). Free on application. Also published in Bulletin 789, 1927. 50 cents.

Iniskin Bay-Snug Harbor district, Cook Inlet region, Alaska; scale, 1:[illegible]; 1924, by C. P. McKinley and Gerald FitzGerald (preliminary edition). Free on application. Also published in Bulletin 789, 1927. 50 cents.

The Alaska Railroad route: Seward to Matanuska coal field; scale, 1:[illegible]; 1924, by J. W. Bagley, T. G. Gerdine, R. H. Sargent, and others. 50 cents retail or 30 cents wholesale.

The Alaska Railroad route: Matanuska coal field to Yanert Fork; scale, 1:250,000; 1924, by J. W. Bagley, T. G. Gerdine, R. H. Sargent, and others. 50 cents retail or 30 cents wholesale.

The Alaska Railroad route: Yanert Fork to Fairbanks; scale, 1:250,000; 1924, by J. W. Bagley, T. G. Gerdine, R. H. Sargent, and others. 50 cents retail or 30 cents wholesale.

Upper Matanuska Valley; scale, 1:62,500; by R. H. Sargent. In Bulletin 791, 1927, 30 cents. Not issued separately.

In preparation

Mount Spurr region; scale, 1:250,000; by R. H. Sargent, Gerald FitzGerald, E. C. Hamilton, W. S. Post, D. L. Reaburn, and K. W. Trimble.

Lake Clark-Mulchatna River region; scale, 1:250,000; by R. H. Sargent, Gerald FitzGerald, C. E. Giffin, and D. C. Witherspoon.

SOUTHWESTERN ALASKA

REPORTS

*Geology and mineral resources of parts of Alaska Peninsula, by W. W. Atwood. Bulletin 467, 1911, 137 pp.

A geologic reconnaissance of the Iliamna region, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 188 pp. 35 cents.

Mineral deposits of Kodiak and the neighboring islands, by G. C. Martin. In Bulletin 542, 1913, pp. 125–136. 25 cents.

The Lake Clark-central Kuskokwim region, by P. S. Smith. Bulletin 655, 1917, 162 pp. 30 cents.

Beach placers of Kodiak Island, by A. G. Maddren. In Bulletin 692-E, 1919, pp. 299–319. 5 cents.

Sulphur on Unalaska and Akun Islands and near Stepovak Bay, by A. G. Maddren. In Bulletin 692-E, 1919, pp. 283–298. 5 cents.

The Cold Bay-Chignik district, by W. R. Smith and A. A. Baker. In Bulletin 755, 1924, pp. 151–218. 40 cents.

The Cold Bay-Katmai district, by W. R. Smith. In Bulletin 773, 1925, pp. 183–207. 40 cents.

The outlook for petroleum near Chignik, by G. C. Martin. In Bulletin 773, 1925, pp. 209–213. 40 cents.

Mineral resources of the Kamishak Bay region, by K. F. Mather. In Bulletin 773, 1925, pp. 155–181. 40 cents.

*Aniakchak Crater, Alaska Peninsula, by W. R. Smith. In Professional Paper 132, 1925, pp. 139–149.

Geology and oil developments of the Cold Bay district, by W. R. Smith. In Bulletin 789, 1927, pp. 63–83. 40 cents.

Geology and mineral resources of the Aniakchak district, by R. S. Knappen. In Bulletin 797, 1929, pp. 161–223. 80 cents.

TOPOGRAPHIC MAPS

* Herendeen Bay and Unga Island region; scale, 1:250,000; by H. M. Eakin. In Bulletin 467, 1911. Not issued separately.
* Chignik Bay region; scale, 1:250,000; by H. M. Eakin. In Bulletin 467, 1911. Not issued separately.
Iliamna region; scale, 1:250,000; by D. C. Witherspoon and C. E. Giffin. In Bulletin 485, 1912. 35 cents. Not issued separately.
Kuskokwim River and Bristol Bay region; scale, 1:625,000; by W. S. Post, In Twentieth Annual Report, pt. 7, 1900. $1.80. Not issued separately.
Lake Clark-central Kuskokwim region; scale, 1:250,000; by R. H. Sargent, D. C. Witherspoon, and C. E. Giffin. In Bulletin 655, 1917. 30 cents. Not issued separately.
* Cold Bay-Chignik region, Alaska Peninsula, 1924; scale, 1:250,000; by R. K. Lynt and R. H. Sargent (preliminary edition).
Kamishak Bay-Katmai region, Alaska Peninsula, 1927; scale, 1:250,000; by R. H. Sargent and R. K. Lynt (preliminary edition). Free on application.
Aniakchak district, Alaska Peninsula, 1927; scale, 1:250,000; by R. H. Sargent (preliminary edition). Free on application.
Pavlof region, Alaska Peninsula, 1929; scale, 1:250,000; by C. P. McKinley (Nat. Geog. Soc. Expedition) (preliminary edition). Free on application.
Goodnews Bay district, 1930; scale, 1:250,000; by R. H. Sargent and W. S. Post (preliminary edition). Free on application.

In preparation

Nushagak region; scale, 1:250,000; by Gerald FitzGerald.

YUKON AND KUSKOKWIM BASINS

REPORTS

The Fortymile quadrangle, Yukon-Tanana region, by L. M. Prindle. Bulletin 375, 1909, 52 pp. 30 cents.
Water-supply investigations in the Yukon-Tanana region, 1907 and 1908 (Fairbanks, Circle, and Rampart districts), by C. C. Covert and C. E. Ellsworth. Water-Supply Paper 228, 1909, 108 pp. 20 cents.
Mineral resources of the Nabesna-White River district, by F. H. Moffit, Adolph Knopf, and S. R. Capps. Bulletin 417, 1910, 64 pp. 25 cents.
*Mount McKinley region, by A. H. Brooks, with descriptions of the igneous rocks of the Bonnifield and Kantishna districts, by L. M. Prindle. Professional Paper 70, 1911, 234 pp.
The Bonnifield region, by S. R. Capps. Bulletin 501, 1912, 64 pp. 20 cents.
A geologic reconnaissance of a part of the Rampart quadrangle, by H. M. Eakin. Bulletin 535, 1913, 38 pp. 20 cents.
A geologic reconnaissance of the Fairbanks quadrangle, by L. M. Prindle, F. J. Katz, and P. S. Smith. Bulletin 525, 1913, 220 pp. 55 cents.
The Koyukuk-Chandalar region, by A. G. Maddren. Bulletin 532, 1913, 119 pp. 25 cents.
A geologic reconnaissance of the Circle quadrangle, by L. M. Prindle. Bulletin 538, 1913, 82 pp. 30 cents.
Surface water supply of the Yukon-Tanana region, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 342, 1915, 343 pp. 45 cents.

Gold placers of the lower Kuskokwim, with a note on copper in the Russian Mountains, by A. G. Maddren. In Bulletin 622, 1915, pp. 292–360. 30 cents.

Quicksilver deposits of the Kuskokwim region, by P. S. Smith and A. G. Maddren. In Bulletin 622, 1915, pp. 272–291. 30 cents.

The Chisana-White River district, by S. R. Capps. Bulletin 630, 1916, 130 pp. 20 cents.

The Yukon-Koyukuk region, by H. M. Eakin. Bulletin 631, 1916, 88 pp. 20 cents.

The gold placers of the Tolovana district, by J. B. Mertie, jr. In Bulletin 662, 1918, pp. 221–277. 75 cents.

Lode mining in the Fairbanks district, by J. B. Mertie, jr. In Bulletin 662, 1918, pp. 403–424. 75 cents.

Lode deposits near the Nenana coal field, by R. M. Overbeck. In Bulletin 662, 1918, pp. 351–362. 75 cents.

The Lake Clark-central Kuskokwim region, by P. S. Smith. Bulletin 655, 1918, 162 pp. 30 cents.

The Cosna-Nowitna region, by H. M. Eakin. Bulletin 667, 1918, 54 pp. 25 cents.

The Anvik-Andreafski region, by G. L. Harrington. Bulletin 683, 1918, 70 pp. 30 cents.

The Kantishna district, by S. R. Capps. Bulletin 687, 1919, 118 pp. 25 cents.

The Nenana coal field, Alaska, by G. C. Martin. Bulletin 664, 1919, 54 pp. $1.10.

* The gold and platinum placers of the Tolstoi district, by G. L. Harrington. In Bulletin 692, 1919, pp. 339–351.

* Mineral resources of the Goodnews Bay region, by G. L. Harrington. In Bulletin 714, 1921, pp. 207–228.

Gold lodes in the upper Kuskokwim region, by G. C. Martin. In Bulletin 722, 1922, pp. 149-161. 25 cents.

The occurrence of metalliferous deposits in the Yukon and Kuskokwim regions, by J. B. Mertie, jr. In Bulletin 739, 1922, pp. 149–165. 25 cents.

The Ruby-Kuskokwim region, by J. B. Mertie, jr., and G. L. Harrington. Bulletin 754, 1924, 129 pp. 50 cents.

Geology and gold placers of the Chandalar district, by J. B. Mertie, jr. In Bulletin 773, 1925, pp. 215–263. 40 cents.

The Nixon Fork country, by J. S. Brown. In Bulletin 783, 1927, pp. 97–144. 40 cents.

Silver-lead prospects near Ruby, by J. S. Brown. In Bulletin 783, 1927, pp. 145–150. 40 cents.

The Tokiat-Tonzona River region, by S. R. Capps. In Bulletin 792, 1927, pp. 73–110. 25 cents.

Preliminary report on the Sheenjek River district, by J. B. Mertie, jr. In Bulletin 797, 1929, pp. 99–123. 80 cents.

The Chandalar-Sheenjek district, by J. B. Mertie, jr. In Bulletin 810, 1930, pp. 87–139. 50 cents.

Mining in the Fortymile district, by J. B. Mertie, jr. In Bulletin 813, 1930, pp. 125–142. 40 cents.

Geology of the Eagle-Circle district, by J. B. Mertie, jr. Bulletin 816, 1930, 168 pp. 50 cents.

Mining in the Circle district, by J. B. Mertie, jr. In Bulletin 824, 1931, pp. 155–172. — cents.

Geologic reconnaissance of the Dennison Fork district, by J. B. Mertie, jr. Bulletin 827, 1932, pp. ——. —— cents.

Tatonduk-Nation district, by J. B. Mertie, jr. In Bulletin 836, 1932, pp. ——. — cents.

Eastern portion of Mount McKinley National Park, by S. R. Capps. In Bulletin 836, 1932, pp. ——. — cents.

Kantishna district, by F. H. Moffit. In Bulletin 836, 1932, pp. ——. — cents.

Mining developments in the Tatlanika and Totatlanika Basins, by F. H. Moffit. In Bulletin 836, 1932, pp. ——. — cents.

In preparation

Geology of the Yukon-Tanana region, by J. B. Mertie, jr.

TOPOGRAPHIC MAPS

Circle quadrangle (No. 641); scale, 1:250,000; 1911, by T. G. Gerdine, D. C. Witherspoon, and others. 50 cents retail or 30 cents wholesale. Also in Bulletin 538, 1913, 20 cents.

Koyukuk and Chandalar region, reconnaissance map; scale, 1:500,000; by T. G. Gerdine, D. L. Reaburn, D. C. Witherspoon, and A. G. Maddren. In Bulletin 532, 1913, 25 cents. Not issued separately.

Fairbanks quadrangle (No. 642); scale, 1:250,000; 1911, by T. G. Gerdine, D. C. Witherspoon, R. B. Oliver, and J. W. Bagley. 50 cents retail or 30 cents wholesale. Also in Bulletin 337, 1908, 25 cents, and Bulletin 525, 1913. 55 cents.

Fortymile quadrangle (No. 640); scale, 1:250,000; 1902, by E. C. Barnard. 10 cents retail or 6 cents wholesale. Also in Bulletin 375, 1909, 30 cents.

Rampart quadrangle (No. 643); scale, 1:250,000; 1913, by D. C. Witherspoon and R. B. Oliver. 20 cents retail or 12 cents wholesale. Also in Bulletin 337, 1908, 25 cents, and part in Bulletin 535, 1913, 20 cents.

Fairbanks special (No. 642A); scale, 1:62,500; 1908, by T. G. Gerdine and R. H. Sargent. 20 cents retail or 12 cents wholesale. Also in Bulletin 525, 1913, 55 cents.

Bonnifield region; scale, 1:250,000; by J. W. Bagley, D. C. Witherspoon, and C. E. Giffin. In Bulletin 501, 1912, 20 cents. Not issued separately.

Iditarod-Ruby region; scale, 1:250,000; by C. G. Anderson, W. S. Post, and others. In Bulletin 578, 1914, 35 cents. Not issued separately.

Middle Kuskokwim and lower Yukon region; scale, 1:500,000; by C. G. Anderson, W. S. Post, and others. In Bulletin 578, 1914, 35 cents. Not issued separately.

Chisana-White River region; scale, 1:250,000; by C. E. Giffin and D. C. Witherspoon. In Bulletin 630, 1916, 20 cents. Not issued separately.

Yukon-Koyukuk region; scale, 1:500,000; by H. M. Eakin. In Bulletin 631, 1916, 20 cents. Not issued separately.

Cosna-Nowitna region; scale, 1:250,000; by H. M. Eakin, C. E. Giffin, and R. B. Oliver. In Bulletin 667, 1917, 25 cents. Not issued separately.

Lake Clark-central Kuskokwim region; scale, 1:250,000; by R. H. Sargent, D. C. Witherspoon, and C. E. Giffin. In Bulletin 655, 1917, 30 cents. Not issued separately.

Anvik-Andreafski region; scale, 1:250,000; by R. H. Sargent. In Bulletin 683, 1918, 30 cents. Not issued separately.

Marshall district; scale, 1:125,000; by R. H. Sargent. In Bulletin 683, 1918, 30 cents. Not issued separately.

Upper Tanana Valley region; scale, 1:250,000; 1922, by D. C. Witherspoon and J. W. Bagley (preliminary edition). Free on application.

* Lower Kuskokwim region; scale, 1:500,000; 1921, by A. G. Maddren and R. H. Sargent (preliminary edition).

Ruby district; scale, 1:250,000; 1921, by C. E. Giffin and R. H. Sargent (preliminary edition). Free on application. Also in Bulletin 754, 1924, 50 cents.

Innoko-Iditarod region; scale, 1:250,000; 1921, by R. H. Sargent and C. G. Anderson (preliminary edition). Free on application. Also in Bulletin 754, 1924, 50 cents.

Nixon Fork region; scale, 1:250,000; 1926, by R. H. Sargent (preliminary edition). Free on application.

Chandalar-Sheenjek district; scale, 1:500,000; by Gerald FitzGerald and J. O. Kilmartin. In Bulletin 810, 1930, 50 cents. Not issued separately.

Goodnews Bay district, 1930; scale, 1:250,000, by R. H. Sargent and W. S. Post (preliminary edition.) Free on application.

SEWARD PENINSULA

REPORTS

The Fairhaven gold placers, Seward Peninsula, by F. H. Moffit. Bulletin 247, 1905, 85 pp. 40 cents.

The gold placers of parts of Seward Peninsula, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin 328, 1908, 343 pp. 70 cents.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 71 pp. 15 cents.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, by P. S. Smith. Bulletin 433, 1910, 234 pp. 40 cents.

A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, by P. S. Smith and H. M. Eakin. Bulletin 449, 1911, 146 pp. 30 cents.

Geology of the Nome and Grand Central quadrangles, by F. H. Moffit. Bulletin 533, 1913, 140 pp. 60 cents.

Surface water supply of Seward Peninsula, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology, by P. S. Smith, and a description of methods of placer mining, by A. H. Brooks. Water-Supply Paper 314, 1913, 317 pp. 45 cents.

* The gold and platinum placers of the Kiwalik-Koyuk region, by G. L. Harrington. In Bulletin 692, 1919, pp. 368–400.

Metalliferous lodes of southern Seward Peninsula, by S. H. Cathcart. In Bulletin 722, 1922, pp. 163–261. 25 cents.

The geology of the York tin deposits, by Edward Steidtmann and S. H. Cathcart. Bulletin 733, 1922, 130 pp. 30 cents.

Pliocene and Pleistocene fossils from the Arctic coast of Alaska and the auriferous beaches of Nome, Norton Sound, by W. H. Dall. Professional Paper 125–C, 1921, 15 pp. 10 cents.

TOPOGRAPHIC MAPS

Seward Peninsula; scale, 1:500,000; compiled from work of D. C. Witherspoon, T. G. Gerdine, and others, of the Geological Survey, and all other available sources. In Water-Supply Paper 314, 1913, 45 cents. Not issued separately.

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.

Seward Peninsula, northwestern portion, reconnaissance map (No. 657); scale, 1:250,000; 1907, by T. G. Gerdine and D. C. Witherspoon. 50 cents retail or 30 cents wholesale. Also in Bulletin 328, 1908, 70 cents.

Seward Peninsula, southern portion, reconnaissance map (No. 656); scale, 1:250,000; 1907, by E. C. Barnard, T. G. Gerdine, and others. 50 cents retail or 30 cents wholesale. Also in Bulletin 328, 1908, 70 cents.

Seward Peninsula, southeastern portion, reconnaissance map; scale, 1:250,000; by D. C. Witherspoon, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 449, 1911, 30 cents. Not issued separately.

Nulato-Norton Bay region; scale, 1:500,000; by P. S. Smith, H. M. Eakin, and others. In Bulletin 449, 1911, 30 cents. Not issued separately.

Grand Central quadrangle (No. 646A); scale, 1:62,500; 1906, by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents retail or 6 cents wholesale. Also in Bulletin 533, 1913, 60 cents.

Nome quadrangle (No. 646B); scale, 1:62,500; 1906, by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents retail or 6 cents wholesale. Also in Bulletin 533, 1913, 60 cents.

Casadepaga quadrangle (No. 646C); scale, 1:62,500; 1907, by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents retail or 6 cents wholesale. Also in Bulletin 433, 1910, 40 cents.

Solomon quadrangle (No. 646D); scale, 1:62,500; 1907, by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents retail or 6 cents wholesale. Also in Bulletin 433, 1910, 40 cents.

NORTHERN ALASKA

REPORTS

A reconnaissance in northern Alaska in 1901, by F. C. Schrader, with notes by W. J. Peters. Professional Paper 20, 1904, 139 pp. 40 cents.

Geology and coal resources of the Cape Lisburne region, by A. J. Collier. Bulletin 278, 1906, 54 pp. 15 cents.

Geologic investigations along the Canada-Alaska boundary, by A. G. Maddren. In Bulletin 520, 1912, pp. 297–314. 50 cents.

The Noatak-Kobuk region, by P. S. Smith. Bulletin 536, 1913, 160 pp. 40 cents.

The Koyukuk-Chandalar region, by A. G. Maddren. Bulletin 532, 1913, 119 pp. 25 cents.

The Canning River region of northern Alaska, by E. de K. Leffingwell. Professional Paper 109, 1919, 251 pp. 75 cents.

Pliocene and Pleistocene fossils from the Arctic coast of Alaska and the auriferous beaches of Nome, Norton Sound, by W. H. Dall. Professional Paper 125–C, 1921, 15 pp. 10 cents.

*A reconnaissance of the Point Barrow region, by Sidney Paige and others. Bulletin 772, 1925, 33 pp.

Summary of recent surveys in northern Alaska, by P. S. Smith, J. B. Mertie, jr., and W. T. Foran. In Bulletin 783, 1926, pp. 151–168. 40 cents.

Geologic investigations in northern Alaska, 1925, by Philip S. Smith. In Bulletin 792, 1927, pp. 111–122. 25 cents.

Surveys in northwestern Alaska in 1926, by Philip S. Smith. In Bulletin 797, 1928, pp. 125–142. 80 cents.

Preliminary report on the Sheenjek River district, Alaska, by J. B. Mertie, jr. In Bulletin 797, 1928, pp. 99–123. 80 cents.

The Chandalar-Sheenjek district, by J. B. Mertie, jr. In Bulletin 810, 1930, pp. 87–139. 50 cents.

Geography and geology of northwestern Alaska, by Philip S. Smith and J. B. Mertie, jr. *Bulletin* 815, 1930, 351 pp. $1.

TOPOGRAPHIC MAPS

Koyukuk River to mouth of Colville River, including John River; scale, 1:1,250,000; by W. J. Peters. In Professional Paper 20, 1904, 40 cents. Not issued separately.

Koyukuk and Chandalar region, reconnaissance map; scale, 1:500,000; by T. G. Gerdine, D. L. Reaburn, D. C. Witherspoon, and A. G. Maddren. In Bulletin 532, 1913, 25 cents. Not issued separately.

Noatak-Kobuk region; scale, 1:500,000; by C. E. Giffin, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 536, 1913, 40 cents. Not issued separately.

Canning River region; scale, 1:250,000; by E. de K. Leffingwell. In Professional Paper 109, 1919, 75 cents. Not issued separately.

North Arctic coast; scale, 1:1,000,000; by E. de K. Leffingwell. In Professional Paper 109, 1919, 75 cents. Not issued separately.

Martin Point to Thetis Island; scale, 1:125,000; by E. de K. Leffingwell. In Professional Paper 109, 1919, 75 cents. Not issued separately.

Chandalar-Sheenjek district; scale, 1:500,000; by Gerald FitzGerald and J. O. Kilmartin. In Bulletin 810, 50 cents. Not issued separately.

Northwestern Alaska; scale, 1:500,000; by Gerald FitzGerald, E. C. Guerin, R. K. Lynt, and O. Lee Wix. In Bulletin 815, 1930, $1. Not issued separately.

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