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MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN 1927

BY

PHILIP S. SMITH AND OTHERS

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CONTENTS

[The letters in parentheses preceding the titles are those used to designate the papers for advance publication]

		Page
(A)	Mineral industry of Alaska in 1927, by P. S. Smith	[illegible]
	Administrative report, by P. S. Smith	85
(B)	The Chandalar-Sheenjek district, by J. B. Mertie, jr	87
(C)	The Mount Spurr region, by S. R. Capps	141
	Index	173

ILLUSTRATIONS

		Page
PLATE	1. Topographic map of Chandalar-Sheenjek district	In pocket.
	2. Geologic map of Chandalar-Sheenjek district	In pocket.
	3. Geologic map of Mount Spurr region	154
	4. Map showing distribution of timber in the Mount Spurr region	154
FIGURE	1. Index map showing location of Chandalar-Sheenjek district	[illegible]
	2. Sketch map showing distribution of timber in the Chandalar-Sheenjek district	[illegible]

MINERAL RESOURCES OF ALASKA, 1927

MINERAL INDUSTRY OF ALASKA IN 1927

By Philip S. Smith [1]

INTRODUCTION

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

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

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

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

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

It is evident that with such a mass of information available the resulting report should correctly and adequately reflect the actual conditions, and every effort is made to see that this result is attained so far as possible. Unfortunately, however, there are many causes of inaccuracy. For instance, the same term may be differently interpreted by different persons so that answers to the same question are not always made from the same viewpoint. To the lode miner the value of the production from his mine will probably mean tons of ore mined times the assay value of its metallic contents. To others knowing the inevitable loss that occurs in the metallurgical or milling treatment of this ore the value of the production will probably mean value of the metal recovered. To still others it may mean the amount they received from the bank for their product after deducting assaying and handling charges, insurance, etc., or it may mean the amount the local trader paid for their gold, even though that amount may have a wholly fictitious relation to its mint value. So far as possible these various standards have been reconciled to the single one represented by the value of the metal recovered, as shown generally for placer or lode gold by bank assays or receipts without deductions. Many of the mineral products, however, are not disposed of during the year they are produced at the mine, so that for these the only accurate record available is the gross quantity produced and its approximate metal tenor. This condition is especially common for the larger lode mines, whose production of ore may continue up to the last day of the year but the ore thus produced may not reach the mill, smelter, or mint until many months later. This same condition also occurs to a lesser degree with some of the placer product. In fact, during the current canvass an example was found of a small lot of placer gold that had been produced during 1919 but did not reach a mint until 1927, and of course a considerable amount of nugget gold is annually diverted directly by the producer for jewelry or pocket pieces, never gets into the usual trade channels, and is not reported except in the Geological Survey estimates of production. It is readily evident that there will always be differences between the quantities of metals reported by different agencies, though on the whole many of these differences tend to offset one another. Thus for a mine that has been in operation for some time at approximately the same rate its production that did not reach the mill, smelter, or mint during the current year is usually about balanced by its similar production during the last part of the preceding year, which is reported by the mint or smelter during the current year.

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

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

ACKNOWLEDGMENTS

From the foregoing description of the way in which the data have been obtained for this report, it is evident that a great many persons have contributed information essential for its preparation. The list of contributors would include most of the mining men of the Territory and scores of others. The list, in fact, is so long that it is impracticable to distinguish by name all who may be regarded as collaborators in this work. A number, however, have given special assistance, and individual mention of these is gratefully given.

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MINERAL PRODUCTION

GENERAL FEATURES

The total value of the mineral production of Alaska in 1927 was $14,404,000. This was furnished by a number of mineral products, the most valuable of which were copper and gold. The total value was considerably less than in the preceding year, or, for that matter, for a number of years. This condition is interpreted as due not to a permanent waning in mining but to a temporary setback resulting from a number of causes, some of which were purely local, others were regional, and still others affected mining not only in Alaska but in the States. In other words, there is no indication that the curve of production has begun a permanently downward trend, but rather that it shows a sag which will undoubtedly be checked when the reports for 1928 become available.

One of the reasons for a widespread decline in mining was the low price at which most metals sold in 1927. This had the direct effect of reducing the value of Alaska's mineral production a few hundred thousand dollars, but its indirect effect in curbing production was probably many times greater. The average selling price of metals in 1927 as compared with the price for the same metals in 1926 affords convincing proof of this condition. For instance, according to the Bureau of Mines, which computes the average price of metals for each year, copper brought 13.1 cents a pound in 1927, 14 cents in 1926; silver 56.7 cents an ounce in 1927, 62.4 cents in 1926; lead 6.3 cents a pound in 1927, 8 cents in 1926; platinum $85 an ounce in 1927, $111 in 1926. It is obvious that these low prices reduced the value of the mineral output, but it may not be so apparent that during a period of low prices it is only the part of wise management to reduce the quantity of output and to await more favorable markets. Of course certain output must be maintained to fulfill contracts or to carry fixed charges, but the general tendency during a time of low prices is to reduce operations to a minimum.

The foregoing explanation, of course, does not apply to gold mining, for, as is well known, the price of gold is constant. Even in the gold mines, however, the effect of the low price of some of the metals is recognized, because many of the gold lode mines recover also considerable quantities of silver and lead. As an example, the output of lead from the gold mines was about 460,000 pounds more in 1927 than in 1926, yet its value was only $2,600 greater. The decline in gold production is entirely attributable to decreased production from the gold placers, for there was an increase in the quantity and value of the gold output from the lode mines. The explanation of the decrease in placer gold production lies largely in the adverse climatic conditions that prevailed at almost all the placer camps throughout the Territory during 1927. The winter of 1926-27 had a light snowfall, so that the run-off from the snow when it melted furnished little water for mining. Moreover, the early part of the open season was exceptionally dry, so that at many camps water for mining was not available until August, and by that time many of the smaller plants had been closed up by their owners, who had become discouraged. Even at the large camps the shortage of water forced curtailment of work so that some of them were operating at only half their normal rate. In many of the districts the summer season opened unusually late, and as a result seasonal frost in places lasted until August, thus badly hampering mining. To round out the tale of misfortune, winter set in rather early at many of the districts and so further shortened the length of time that the mines were able to keep open.

In spite of this rather disappointing record for 1927, there were indications of a real and sound revival of interest in mining throughout the Territory. Some of the large projects that have been under way for several years are now finishing their preparatory stages and are about to become producers. As these enterprises have been carefully and thoroughly planned, their success can be predicted with certainty. It is, however, not only in their direct effect on increasing the mineral output that these larger mines are having an influence on the development of the Territory, but also through affording places at which prospectors can obtain work and thus funds to go out and prospect on their own initiative, and through training and educating the prospector in sound mining methods, some of which can be applied to the problems that confront him on his own claims. The prospectors themselves are feeling the need of more study of mining and geologic matters and are availing themselves of the educational advantages afforded by the Alaska School of Mines in some of the fundamental aspects of the subject. The Territorial legislature is taking a hand in encouraging prospectors to search for new deposits or to develop old ones and during its last session passed measures to defray some of the cost of transportation for bona fide prospectors, under certain conditions. These things, even though they are rather small of themselves, give promise of revival of interest in mining in the Territory—not mining of the old type that was a wild stampeding orgy of staking claims, but a thoughtful, intelligent undertaking that assures development of a sound mining industry.

In the following table is stated the total value of the minerals produced from the Territory and of each of the minerals that contributed a considerable amount to this total. In addition, the production is shown for each year as far back as records are available. Of the total to the end of 1927 nearly 97 per cent was in gold and copper.

Value of total mineral production of Alaska, 1880–1927

By years				By substances	
1880–1890	$4,193,919	1910	$16,875,226	Gold	$366,235,000
1891	1,014,211	1911	20,720,480	Copper	194,913,000
1892	1,019,493	1912	22,581,943	Silver	11,220,000
1893	1,104,982	1913	19,547,292	Coal	5,552,000
1894	1,339,332	1914	19,109,731	Tin	1,007,000
1895	2,588,832	1915	32,790,344	Lead	1,322,000
1896	2,885,029	1916	48,386,508	Marble and other products (including platinum metals)	5,125,000
1897	2,539,294	1917	40,694,804		585,374,000
1898	2,329,016	1918	28,218,935		
1899	5,425,262	1919	19,626,824		
1900	7,995,209	1920	23,330,586		
1901	7,306,881	1921	16,994,302		
1902	8,475,813	1922	19,420,121		
1903	9,088,564	1923	20,330,643		
1904	9,627,495	1924	17,457,333		
1905	16,490,720	1925	18,220,692		
1906	23,501,770	1926	17,664,800		
1907	20,840,571	1927	14,404,000		
1908	20,092,501				
1909	21,140,810		585,374,000		

For comparison the production of minerals in 1927 and 1926 is given in somewhat greater detail in the following table, which shows that the largest change was a decrease in the quantity and value of copper and a somewhat smaller decrease in gold. On the other hand, coal, tin, and lead showed an increase. Each of the different mineral products is discussed in more detail in the following pages, which record such facts as are available regarding the amount of each product and the districts from which it came.

Mineral output of Alaska, 1927 and 1926

	1927		1926		1927 (increase or decrease)	
	Quantity	Value	Quantity	Value	Quantity	Value
Gold....fine ounces..	286,720	$5,927,000	324,450	$6,707,000	−37,730	−$780,000
Copper....pounds..	55,343,000	7,250,000	67,778,000	9,489,000	−12,435,000	−2,239,000
Silver....fine ounces..	627,800	356,000	690,000	430,500	−62,200	−74,500
Coal....short tons..	104,300	548,000	87,300	459,000	+17,000	+89,000
Tin, metallic....do....	26.7	34,000	8	10,400	+18.7	+23,600
Lead....do....	1,008	127,000	778	124,400	+230	+2,600
Miscellaneous mineral products, including petroleum, platinum metals, marble, gypsum, etc.	....	162,000	....	444,500	....	−282,500
	....	14,404,000	....	17,664,800	....	−3,260,800

GOLD

TOTAL PRODUCTION

The total value of the gold produced in Alaska in 1927 amounted to $5,927,000, which is about $780,000 less than was produced in 1926. The following table gives the record of the total production of gold from the Territory from the earliest days and the annual production for the last 12 years. By 1916, the earliest year for which the detailed analysis is given in the table, the period of bonanza mining that commenced in 1900 was decidedly on the wane, and decrease in gold production continued until 1923. The decrease during this period would have been even more marked had there not been a constant growth of production from mines of the less spectacular types through the introduction of more efficient and larger-scale mining methods. By 1924 the utilization of these methods had checked the decline, so that for the next few years there was successively a small but significant increase in production, and in spite of the decrease reported in 1927 there is good reason to believe that there will be a continued upward trend to the gold production from Alaska for many years to come, as mining enterprises already under way become increasingly remunerative and through their success induce the undertaking of other well-planned and adequately financed enterprises.

Gold and silver produced in Alaska, 1880–1927

Year	Gold		Silver		Value of gold by sources	
	Fine ounces	Value	Fine ounces	Value	Placer mines	Lode mines
1880–1915	12, 592, 121	$260, 302, 243	4, 923, 198	$2, 821, 911	$185, 200, 444	$75, 101, 799
1916	834, 068	17, 241, 713	1, 379, 171	907, 495	11, 140, 000	6, 101, 713
1917	709, 049	14, 657, 353	1, 239, 150	1, 021, 060	9, 810, 000	4, 847, 353
1918	458, 641	9, 480, 952	847, 789	847, 789	5, 900, 000	3, 580, 952
1919	455, 984	9, 426, 032	629, 708	705, 708	4, 970, 000	4, 456, 032
1920	404, 683	8, 365, 560	953, 546	1, 039, 364	3, 873, 000	4, 492, 560
1921	390, 558	8, 073, 540	761, 085	761, 085	4, 226, 000	3, 847, 540
1922	359, 057	7, 422, 367	729, 945	729, 945	4, 395, 000	3, 027, 367
1923	289, 539	5, 985, 314	814, 649	668, 012	3, 608, 500	2, 376, 814
1924	304, 072	6, 285, 724	669, 641	448, 659	3, 564, 000	2, 721, 724
1925	307, 679	6, 360, 281	698, 259	482, 495	3, 223, 000	3, 137, 281
1926	324, 450	6, 707, 000	690, 000	430, 500	3, 769, 000	2, 938, 000
1927	286, 720	5, 927, 000	627, 800	356, 000	2, 982, 000	2, 945, 000
	17, 717, 620	366, 235, 000	14, 964, 000	11, 220, 000	246, 661, 000	119, 574, 000

In the preceding table the source from which the gold was derived is indicated by separation into two main types of mines, placers and lodes. The placers are those deposits of sand and gravel which have been worn from the hard rocks in their general vicinity and in which the gold or other valuable minerals have been more or less concentrated by geologic processes that were effective because of some distinctive physical or chemical property of the material thus concentrated. The lodes, on the other hand, are the mineralized veins or masses of ore in the country rock that were formed in general through deep-seated geologic processes and represent material in place.

All gold that occurs in nature contains some silver. It has therefore been convenient to show in one table all the silver that was produced from Alaska mines, though the detailed discussion of the mines whose ore is most valuable for some other metal is postponed to a later section. It is not always evident which is the most valuable mineral in an ore, for the value may be determined by the total mineral content. Thus certain mines could not be profitably worked except for the combined content of gold, silver, lead, and perhaps copper in their ore. It is therefore impossible, except by undesirably minute classification, to tabulate in detail the source of all the gold and silver bearing material that is produced in Alaska. In the following table all the ores from lode mines that yielded gold are segregated from the ores from lodes that carry principally copper, and the gold recovered from placers is stated separately. In some of these annual reports for earlier years the ores that were principally valuable for their silver content were separated from those that were principally valuable for their gold content, but in view of the relatively small production in 1927 of ores that were principally valuable for their silver content that separation has not seemed desirable in this report, as it might disclose the operation of individual mines. No gold is attributed to the ores here classed as principally valuable for their copper content, though those ores are the source of most of the silver that is produced. The absence of any appreciable quantity of gold in the ores from which the bulk of the Alaska copper is produced is well known, though the reason for its absence is not understood. From this table it is evident that approximately equal amounts of gold were produced from the lodes and the placers. This relation differs from that in 1926, when the ratio between lode gold and placer gold was 44 to 56, because in 1927 there was a marked decrease in the amount of placer gold produced.

Gold and silver produced in Alaska, 1927, by sources

Source	Gold		Silver	
	Fine ounces	Value	Fine ounces	Value
Gold ores (4,352,000 tons)	142,465	$2,945,000	79,400	$45,000
Copper ores			525,100	297,800
Placers	144,255	2,982,000	23,300	13,200
	286,720	5,927,000	627,800	356,000

GOLD LODES

Approximately one-half of the gold produced in Alaska in 1927 came from lodes, which, though known in almost all parts of the Territory, have been most extensively developed in the southern part and most notably in southeastern Alaska.

Gold and silver produced from gold-lode mines in Alaska in 1927, by districts

District	Ore mined (short tons)	Gold		Silver	
		Fine ounces	Value	Fine ounces	Value
Southeastern Alaska	4,320,000	128,727	$2,661,000	76,720	$43,500
Willow Creek	18,000	7,643	158,000	570	300
Fairbanks district	6,000	2,467	51,000	880	500
Other districts	8,000	3,628	75,000	1,230	700
	4,352,000	142,465	2,945,000	79,400	45,000

As is readily apparent from this table, more than 90 per cent of the entire gold lode production in 1927 came from southeastern Alaska, and of this about seven-eighths was produced by the mines operated by the Alaska Juneau Gold Mining Co. The magnitude of this company's mining operations is set forth in its annual report,[3]

[3] Alaska Juneau Mining Co. Thirteenth Ann. Rept., for 1927, 14 pp., 1928.

from which the following statements are abstracted: The total rock mined and trammed to the mill in 1927 was 4,267,810 tons, or an average of practically 11,700 tons a day. Of this amount 2,428,115 tons of coarse tailings were rejected and 1,839,695 tons were fine milled. The average assay of all the material mined was 77 cents a ton. The amount of gold in the part of the rock that was rejected was about 19 cents a ton, and the value of the mineral content of the rock that was further treated was about $1.55 a ton. Of this value 28 cents a ton was lost in treatment, 97 cents was recovered as bullion, and 30 cents was recovered in galena and other concentrates which were later smelted. The following table has been compiled from the published reports of this company:

Production of Alaska Juneau mine, 1893–1927

Year	Ore (tons)			Metals recovered			
	Total	Fine milled	Coarse tailings rejected	Gold	Silver (ounces)	Lead (pounds)	Total value
1893–1913	507,254	330,278	176,976	$707,730	Lost in tailing.		$707,730
1914–1915	242,328	239,918	2,410	251,655	6,192	117,031	261,326
1916	180,113	180,113	-----	115,022	2,844	61,068	121,370
1917	677,410	677,410	-----	429,262	12,248	296,179	460,666
1918	592,218	574,285	17,933	430,124	11,828	273,297	459,445
1919	692,895	616,302	76,593	499,002	16,431	359,762	542,714
1920	942,870	637,321	305,549	732,870	23,348	487,574	791,300
1921	1,613,600	904,323	709,277	969,708	46,619	550,913	1,035,251
1922	2,310,550	1,108,559	1,201,991	1,296,157	49,404	687,315	1,388,679
1923	2,476,240	1,134,759	1,341,481	1,427,199	41,876	755,423	1,514,774
1924	3,068,190	1,367,528	1,700,662	1,907,374	63,191	1,256,857	2,055,782
1925	3,481,780	1,537,884	1,943,896	2,030,067	55,971	1,288,974	2,184,384
1926	3,829,700	1,649,678	2,180,022	1,931,052	51,004	1,300,915	2,067,836
1927	4,267,810	1,839,695	2,428,115	2,328,540	61,232	1,513,306	2,463,262
	24,882,958	12,798,063	12,094,905	15,055,757	436,186	8,948,614	15,054,618

This report shows an exceedingly creditable record, in that nearly 400,000 tons more rock was mined and 190,000 tons more milled in 1927 than in any year heretofore. In 1927 the recovery of gold in bullion from the ore milled was 5 cents a ton higher than the average for the whole period the mine has been in existence, and 5 cents a ton more was recovered from the concentrates than the average for that period. Hand in hand with this excellent showing, the losses in milling decreased, so that the loss in that part of the rock which was rejected was 1 cent a ton below the average for the whole period, and in that part which is fine milled 2 cents a ton below the average. At the same time the cost of milling was held down during the year to the exceedingly low average cost of 22.57 cents a ton of rock mined. An even better showing is predicted for next year by the management, as during most of 1927 the mill was supplied with ore of less than average grade, but developments that have been in progress began to yield better ore, the effects of which are already apparent.

In addition, plans have been completed to equip the mill with flotation apparatus whereby much of the zinc contained in the ore will be concentrated and shipped to the electrolytic zinc plant at Kellogg, Idaho, for recovery. This will result not only in yield of zinc but also of gold, as considerable gold is now carried away with the zinc minerals. The projected sale of the Alaska properties of the Alaska Treadwell [4] and Alaska Mexican Gold Mining Companies to the Alaska Juneau Gold Mining Co. is significant, although its effects may not soon result in increasing the actual mineral output of the Territory. This sale has been formally proposed to the stockholders of the former companies in the president's report, dated March 17, 1928.

The two next most productive gold mines in southeastern Alaska are those of the Hirst-Chichagof Mining Co. and the Apex-El Nido Mining Co., both in the northern part of Chichagof Island. No new developments of striking character have been reported at either of these properties during the year, but at both the work of mining and milling has been carried on actively with gratifying results. During the year the Hirst-Chichagof Mining Co. acquired several adjacent claims on which veins have long been known, thereby increasing its reserves. The Apex-El Nido mine produced enough to pay a substantial dividend, and though the mine was closed toward the last of the year owing to severe weather conditions, the operators report that an abundance of ore is in sight to supply the mill for the entire coming season. At the mine of the Chicagoff Development Co., which for several years has been among the large producers in the Chichagof district, productive work was largely suspended during the year, and most of the time was spent in development work only. Elsewhere on Chichagof Island are a number of small properties on which prospecting and development work is being continued, and at several of them promising leads have been found. At the property of the West Coast Development Co. exploration was in progress, and a small shipment of ore was made to a smelter in the States for a test.

Another of the productive mining districts in southeastern Alaska is that near the head of Portland Canal, known as the Salmon River or Hyder district. The ore from this district is principally valuable for its silver and lead content, but it also carries considerable amounts of gold and small amounts of copper. The largest and most productive mine in the district is that of the Riverside Mining & Milling Co., not far from the international boundary. Shipments of several hundred tons of concentrates have been made to the Selby smelter in San Francisco, and gold is also recovered in the company's mill near the mine. Many smaller companies and prospectors were active

[4] Treadwell-Yukon Co. Ann. Rept. for 1927, 14 pp., 1928.

in scouting and development work in the district, and several small test shipments of ore from the district have been sent to smelters in the States. Many of these have shown encouraging results, and there is every reason to believe that this district will continue to show an increasing production of minerals.

In the Ketchikan district gold lodes have long been known, and some of them have produced considerable gold in the past. At present the most productive mine is that of the Kassan Gold Mining Co., near Hollis. This mine has been undergoing development for some time and is now reported to have reached a stage where adequate reserves of ore have been blocked out and the mine put into shape to maintain all the production that can be handled by the company's mill. In fact, the principal difficulty at the present time is said to be to obtain sufficient power to operate the mill continuously. Because of inadequate power it was practicable to run the mill at most only one shift a day during 1927. In spite of this handicap, the company recovered considerable gold from the mill and from the concentrates which it shipped to one of the smelters in the States. A small amount of copper was also recovered from these concentrates. Development work at the mine of the Peerless Consolidated Mining Co., on Thorne Arm, is reported to have been brought to such a condition that the owners are contemplating the erection of a mill on the property at a not distant date. A test shipment of a few tons of ore is reported to have given encouraging returns.

The mine of the Alaska Palladium Co., in the Ketchikan district, which, as its name implies, was worked principally for the palladium content of its ore but nevertheless yielded also a good deal of gold and some copper, was not in operation during the year and, in fact, was finally sold for a trivial sum to cancel outstanding debts. Some of the ore which had been produced at this mine in 1926 and shipped to a smelter in the States was treated during the year, and this gave rise to the report that the mine was again active.

Near the head of Windham Bay, some 45 miles southeast of Juneau, development work was in active progress throughout the year on the mining properties of the Jacob Marty Mines. Efforts have been largely directed to construction of the surface plant of this company and starting such underground developments as were required to supply the mill with ore. This work occupied most of the summer, and it was late in the fall before the plant was in a condition to operate. The results of this preliminary work have continued to be encouraging, and the mine is said to be in condition to show a good production of gold next year.

Throughout southeastern Alaska, in addition to the mining already mentioned, are many small mining prospects which yielded some gold during the year or at which renewed mining activity indicates that they may shortly become producers. Among these may be mentioned the properties in the vicinity of Funter Bay and Hawk Inlet, near the northern part of Admiralty Island. Plans for driving a long adit for prospecting the claims of the Lake Virginia Mining Co., near Wrangell, were also under discussion. The Inspiration Point Mining Co., whose property lies a short distance north of Skagway and whose ore, though containing principally silver-lead, carries also some gold, is reported to have continued prospecting and development work.

The Willow Creek district, north of the head of Cook Inlet, continued to be, as it has been so long, the largest of the Alaska gold-lode camps outside of southeastern Alaska. Its total production, however, showed a very marked decrease in 1927, being less than half as much as in 1926. The largest mines in the district are those of the Willow Creek Mines, the Fern Gold Mining Co., and the Marion-Twin Gold Mining Co., but there are a few other properties that produced a little ore and a number on which some development work was done. No new discoveries of economic significance were reported to have been made during the year. The principal mines operated by the Willow Creek Mines were the War Baby and Lucky Shot, but leases on other parts of the company's properties in this district have been given to small groups of miners, and this system is said to have been so satisfactory that more grants of this sort may be made in the future. The recent work at the Fern mine has been directed largely toward determining the extent of moderately good ore rather than restricting mining principally to rich shoots. It is expected that by increasing the volume of material handled costs can be reduced and at the same time the production boosted. To handle a larger quantity of ore will necessitate the development of more power, and plans are under consideration for installing a hydroelectric plant. The mine that is being developed by the Marion-Twin Mining Co. was formerly known as the Gold Mint or Hatcher property, on Little Susitna River, 5 or 6 miles northeast of Fishhook Inn. The mill of this company was run for one shift a day almost continuously throughout the open season. The results were so satisfactory to the owners that they propose putting in additional stamps before next season.

Gold-lode mining in the Fairbanks district continues to be centered more or less closely around Pedro Dome, northeast of Fairbanks, and around Ester Dome, west of the town. In the northeastern tract the principal work was mainly of a developmental or prospecting character. Small amounts of ore were recovered in the course of this work from the properties of Crites & Feldman, a short distance west of Fairbanks Creek; the McCarthy prospect, near the head of Fairbanks Creek; the Wyoming and the old Rhoads-Hall mine, on Chatham Creek; and a property near Ridgetop. It is reported that renewed prospecting was carried on at the old Spaulding mine, on Dome Creek, and that plans are under consideration for continuing work there, as the indications appeared decidedly encouraging. In the area west of Fairbanks the most productive work was at the Elmes and Mohawk mines, on Happy and Ace Creeks, respectively, where much of the season was spent in development work, both on the surface and underground, and the shortage of water seriously handicapped the continuous operation of the mills. The great number and small size of the veins make them difficult to trace without actually following them by drifts, and as this is a slow and expensive process, the work has not made conspicuous progress, though it continues to give encouragement that profitable ore bodies may be developed. During the year negotiations for the purchase of the old Ryan lode, which lies between Eva and St. Patrick Creeks, have been in progress, and according to local reports an English company has acquired the property. This lode, unlike most of the others on Ester Dome, is a large body of low-grade quartz, so that, if it is to be successfully developed, the mining and milling of a large amount of material will be required. Developments at this place will be watched with interest, not only because the lode is well known and has been examined by numerous engineers in the past, but because this will be the first attempt to mine a large body of quartz in interior Alaska and thus will give facts from actual practice by which it will be possible to estimate more closely the tenor that ore in this part of Alaska must contain to be profitably mined. In addition to the main large lode on the Ryan property there is geologic evidence which indicates that some small richer veins similar to those that crop out at other places on Ester Dome may be discovered here also.

Grouped together under the heading "Other districts" in the table on page 10 are a number of widely scattered properties whose production can not be stated separately because to do so would disclose the output of individual mines. At most of these mines activities have been continued at about the same rate as heretofore, though in all there have been indications of increased interest in gold-lode prospecting and development. The three districts in which this increased activity was most marked appear to have been near Medfra, in the Nixon Fork section of the Kuskokwim Valley; the Nuka Bay district, near the southern extremity of Kenai Peninsula; and the Prince William Sound region, including the vicinity of Valdez, Tiekel, Port Wells, and the country adjacent to the Sound.

The old Pearson & Strand mine, on Ruby Creek, a tributary of Nixon Fork, had an especially good season, and although no new discoveries at that place were reported, it is distinctly encouraging to list this region as one of the producers of lode gold. From earlier geologic investigations in this region[5] the ore in this district is known to contain considerable copper in additon to gold. Apparently, however, only the gold was recovered in the mill, as the Geological Survey has received no record of shipment of copper ore or concentrates from it during the year. At the Whalen mine, on Hidden Creek, which is about a mile south of the Pearson & Strand mine, prospecting was resumed after a discontinuance of about two years, but no production was reported. There was no new prospecting elsewhere in this district in 1927.

Prospecting and development work was carried on at many points in the vicinity of Nuka Bay, and several new leads were found. The principal producing mine is that of the Alaska Hills Mines on its Paystreak claim. Some discouragement has been expressed that this district has not more rapidly increased its production, but this is not at all surprising, even if its lodes are as good as the most optimistic partisans predict, for it is an expensive and time-consuming job to develop lode mines in a rather remote area unless undertaken by amply financed companies, and so far developments at Nuka Bay have been carried on by a small number of men with very meager capital. The returns so far seem entirely commensurate with the expenditures of time, effort, and money that have been made.

Gold-lode mining or prospecting at a number of places in the vicinity of Prince William Sound was carried on at about the same scale as formerly, and though quantitatively the contribution from this region to the total gold production of Alaska was relatively small, it is significant as indicating that there are lodes here that invite examination and development. Among the more promising properties may be mentioned that of the Ethel Mining Co., on Mineral Creek, a short distance west of Valdez, where development work has now been carried to such a stage that the owners are said to feel justified in building a mill and will probably take steps to do so in 1928. Other claims in the same neighborhood are the Little Giant, Big Four, and Millionaire groups. Prospecting in the vicinity of Mineral Creek should be much facilitated by the new road that is being built up the creek by the Government. Some lode gold is said to have been produced at the old Ramsay-Rutherford mine, east of Valdez Glacier, but no details are available regarding the work at this place. Northeast of Valdez, in the Tiekel district, the search for quartz lodes has been carried on at several points, and it is locally reported that the claims formerly owned by Knowles & Backman

[5] Brown, J. S., The Nixon Fork Country: U. S. Geol. Survey Bull. 792, pp. 127–136, 1926.

on Stuart Creek were taken over, toward the end of the year, by an experienced mining engineer in the interests of eastern purchasers who propose to press development work on them.

In the Port Wells district of the Prince William Sound region the main item of interest is that late in the fall the Merrill Mining Co. completed the erection of a mill on its property on Bettles Bay, so that, although it made no noteworthy production this year, it should be in good condition for continuous operation next season. Several other properties in the Port Wells district were continuing work on the claims at about the same rate as heretofore.

Among the districts which produced a small amount of lode gold in 1927 or in which some new developments in the search for gold lodes were recorded may be mentioned the Copper River region, northern Kenai Peninsula, Valdez Creek, Seward Peninsula, and northern Alaska. In the Copper River region a number of lode claims formerly organized as the Lucky Six group are said to have been acquired by eastern people who propose to develop them as soon as plans are completed. Near the head of the Left Fork of Kotsina River a prospector found a large body of mineralized rock which carries some gold, though the tenor is low, so that it could not be mined unless it were handled on a large scale. In the Kenai Peninsula prospecting has been resumed at several places in the environs of Seward, which, though not yet yielding returns in gold, is a hopeful indication of renewed interest in this business. Still farther north, in the vicinity of Moose Pass, rumors of the finding of enormous bodies of low-grade quartz that, because of their proximity to the railroad, can be economically mined continue to crop up and are probably based more on sanguine hopes than on coldly analytical sampling. However, there are in this same general region a number of small properties, most of which have been known for some time but have lately been lying idle, at which some prospecting and development work was in progress during the year. No production is reported from the mines of the Alaska Minerals Co. in the Palmer Creek Valley. Farther north, in the Crow Creek Valley, the Monarch Mining Co. continued work on the lodes on its property near the head of the stream.

In the Valdez Creek region, near the head of Susitna River and about 50 miles east of Cantwell, on the Alaska Railroad, search for and the development of gold lodes have been continued with undiminished activity. In fact, during the year a number of the business men of Anchorage, together with the original locators of a number of claims, organized the Alaska Range Mining & Development Co., with a view to raising adequate capital to continue the development of the known leads and really open them up, so that their true character and gold content may be satisfactorily determined.

At a number of places in Seward Peninsula lode prospecting still continues, but no significant production has been reported from any of them during the year, with the possible exception of the old lode claims near Bluff. The mineralization of the Bluff locality has long been known and described, but during 1927 the claims were visited by an outside consulting engineer, and a few tons was shipped to a smelter in the States as a sample for test. The main significance of this shipment lies in its indication of renewed interest in the search for minable lodes in this region. In northern Alaska the only prospecting for lodes during the year which has come to the attention of the Geological Survey consists of the reported find of quartz on the Noatak side of the divide northwest of Shungnak, about which there has been a little local excitement. No accurate details of the find are available, and the remoteness of the region and the attendant difficulties of development throw doubt on the possibility that the find may be of economic importance, even if the ore should prove to be somewhat richer than the ordinary run of good ore.

GOLD PLACERS

GENERAL CONDITIONS

Placer mining in Alaska returned much less gold in 1927 than in 1926. Much of this decrease is to be attributed to the exceptionally dry weather that prevailed in practically all the placer districts during the early part of the summer, whereby supplies of water for mining were very short. Not only was there little rainfall during the early part of the season but the snowfall during the preceding winter in many of the districts had been light, so that only a little water was produced by its melting. The shortage of water not only adversely affected the small operators but seriously hampered even the large companies. Thus in the Nome region during most of the early part of the season the Hammon Consolidated Gold Fields was able to operate only two of its three dredges for much of the time, and the loss from that source alone accounted for a decrease of several hundred thousand dollars in the value of the company's production. Furthermore, the weather was so cold during the early part of the season in many of the camps that the seasonal frost was unusually late in disappearing, and this hampered many of the smaller plants, especially dredges mining shallow-creek deposits like those in parts of the Solomon River Valley. The relatively low water in many of the streams and the setting in of cold weather again early in the fall forced suspension of mining in many of the districts earlier than usual, thus further curtailing production.

When all these adverse conditions are taken into consideration the decline in production is seen to be due to temporary causes and therefore not indicative of a lasting decline in the industry. In fact, ability in the face of these handicaps to sustain the production at the amount recorded is clear evidence that the industry as a whole is in a healthy state and that there is every promise of its showing real advance when conditions are less adverse. Furthermore, it should be remembered that in comparing the placer production of 1927 with that of 1926 we are making a comparison with an unusually productive year rather than with an ordinary one, for in 1926 the recovery of placer gold was more than $540,000 in excess of that in 1925.

Confidence in the growth of the placer-mining industry is further warranted by the knowledge that several enterprises that were in process of development during the year are fast approaching the stage where they will become productive. The expectation that many of these enterprises will be successful is amply guaranteed by the careful planning and accurate determination of the several factors in advance, so that the uncertainties of speculative mining have been largely removed. This more businesslike method of approaching mining ventures is not only apparent in the undertakings of the larger companies but is noticeable in many of the smaller enterprises. Even the prospector is learning to test his optimistic dreams by more rigorous analysis of the available facts. It is true that in the main the larger areas in Alaska that have promise of placer wealth have already been roughly delimited, but there still remain in these tracts many places where profitable mining can be conducted on a large scale by companies able to put in the necessary equipment, to finance the necessary dead work that is required to put the ground into shape for mining, and to employ competent and careful technical management. Moreover, it is not only for the large companies that opportunities still remain, because there are many places where intelligent prospecting should handsomely repay the effort of the individual or small group of miners. It is true that these places do not promise fabulously rich bonanzas, such as were found in the boom days when the places where gold could be obtained easily in great quantity had not yet all been discovered. They do, however, still promise a better living than many enterprises in which people now slave to make both ends meet. It is discouraging to one interested in the development of the mineral resources of the Territory that so few prospectors are now in the hills engaged in searching for minerals. The cost of supplies is admittedly high in the more remote districts, but each year facilities are improving greatly over those of the early days and knowledge of conditions is becoming more readily accessible, so that while the returns that may be expected are lower, there still remains a favorable balance that should be an incentive for the enterprising prospector, whether a large company or an individual.

From the description already given of the general methods used in collecting and interpreting the data that form the basis of this report, it is evident that the problem of obtaining accurate data regarding the production of placer gold is greater that that for any of the other items, owing to the great number of small producers, who are widely scattered, some in the most remote regions, and many of whom do not furnish complete information because they do not have the means of giving precise details. However, every effort has been made to check the information from various sources and to adjust discrepancies. As a result it is believed that the figures for the total placer production are as closely in accord with the actual facts as they can reasonably be made. The correct distribution of this total among the different districts may involve considerably greater errors, and although efforts have been made to guard against errors of this sort the quality of the data used does not justify estimates for the different districts closer than the nearest thousand dollars. It should be realized, however, that in spite of rounding off the figures in this way the computations that gave the ground work for the estimates were carried out wherever possible to the nearest dollar.

Statistics of placer mining in Alaska in 1926 and 1927

Region	Value of gold produced		
	1926	1927	Decrease or increase, 1927
Southeastern Alaska	$8,000	$20,000	+$12,000
Copper River Region	102,000	89,000	−13,000
Cook Inlet and Susitna region	126,000	66,000	−60,000
Yukon Basin	1,529,000	1,282,000	−247,000
Kuskokwim region	124,000	151,000	+27,000
Seward Peninsula	1,873,000	1,365,000	−508,000
Kobuk region	7,000	9,000	+2,000
	3,769,000	2,982,000	−787,000

SOUTHEASTERN ALASKA

Although the preceding table shows that southeastern Alaska made a very large proportionate increase in its placer production in 1927 over that for 1926, the amount of gold represented by that increase is actually very small and does not indicate any very marked change in the placer-mining activity of the region. As is well known, the physical character of most of southeastern Alaska is not such as to hold much promise of extensive placers. The topography of most of the area is mountainous, with precipitous slopes leading down from the crests to the ocean waters or to the valley floors. In the "panhandle" there are almost no beaches along the coasts in which concentration by the sea has been effective, and the under-water slopes in most places prolong the steep above-water slopes to considerable depths. Even in the lowlands of the larger streams sorting action, which might have produced placers, has been relatively ineffective, because most of the valleys have been occupied so recently by glaciers that normal erosion processes have not long been at work, and any deposits that may have been formed long ago have been more or less thoroughly removed or distributed by the glaciers. The three principal districts in which placer gold is mined in southeastern Alaska are near Juneau, in the Porcupine district, and near Yakataga.

In the vicinity of Juneau practically the only placer mining in 1927 was in the Silver Bow Basin, where a little work has been in progress for several years.

In the Porcupine River district the most active placer mining was on claims of the Porcupine Mining Co. During the season the long flume which the company had started building the year before was completed, so that water was available for hydraulicking. Although this work was not finished until late in the season, the company should be in condition to make an early start in 1928 and demonstrate the placer possibilities of its claims. A few small developments were also under way on the Alaskan side of the boundary, and renewed activity is reported on the Canadian side.

Placer mining in the Yakataga district was confined to three small camps that were engaged in mining the beach deposits that extend along the coast. The returns from the individual properties were comparatively small, so far as the amount of gold was concerned, but large in view of the low cost of production. The exposure of these deposits to the waves of the Pacific precludes mining there on a large scale with extensive equipment, but for small camps of one or two men each they continue to yield several thousand dollars a year in gold.

COPPER RIVER REGION

Placer gold is produced in three principal districts in the Copper River region—the Nizina, Chistochina, and Nelchina districts. In the Nizina district practically the entire production came from properties of the Nicolai Placer Mines on Dan Creek, and the Chititu Mines, on Chititu and Rex Creeks. Work at both these camps was interrupted for many days during the later part of the season by heavy rains that started about the middle of August. Although the equipment was not seriously damaged, most of the bridges were taken out and hydraulicking was suspended. As a result the production of placer gold was somewhat less than in 1926. In the Chistochina district the Slate Creek Mining Co., on Slate Creek, was the only operator that reported any noteworthy production, though production at that place was on a considerably smaller scale than in 1926, probably owing to the drought in the early part of the season and the heavy rains in the fall. In the Nelchina district all the mining operations were small and yielded a total of only a few thousand dollars. In addition to the larger mines already mentioned there were a number of one or two man parties on several of the streams engaged in prospecting or development work that yielded small amounts of gold. One party of this sort was prospecting and doing assessment work on the claims of the Alaska Middle Fork Mining Co. on the Middle Fork of Chistochina River.

COOK INLET AND SUSITNA REGION

In the Cook Inlet-Susitna region are included the placer camps in Kenai Peninsula and adjacent country, the Yentna-Cache Creek district and neighboring fields west of Susitna River, and the Valdez Creek district, near the head of Susitna River. Dry weather in the early part of the season and heavy rains in the fall hampered mining, so that the production from the region showed a considerable decrease from that of 1926. Another cause of lessened production was idleness of the dredge on Cache Creek, which had been damaged late in the summer of 1926, and which in the past has mined a great deal of gold.

In the Yentna-Cache Creek district no new discoveries were made or new mines opened up. The greatest amount of mining was done on Cache Creek and its tributaries, Nugget, Thunder, Falls, and Windy Creek, where about 35 men were mining more or less continuously throughout the season. On Peters Creek and its tributaries, Bird, Poorman, Willow, Gopher, and Cottonwood Creeks were a number of small camps, employing in all about 20 men in mining work. To the north, in the basin of Tokichitna River, three parties of a single man each produced a little gold from Bear, Ramsdyke, and Long Creeks, tributaries of the main stream from the west. To the southwest, in the Fairview district, the season was spent mainly in prospecting and development work which yielded only a small amount of gold. The only production that was reported to the Geological Survey from this district came from Mills Creek and Notobac Gulch.

All the placer mining in Kenai Peninsula in 1927 was done at a number of widely distributed small camps, none of which produced more than a few thousand dollars in gold and many of them only a few hundred dollars. Probably not more than 20 men have been engaged in placer mining at any one time in 1927 in this whole region. The largest mines were on Crow Creek, near Girdwood, north of Turnagain Arm; on Resurrection River south of Hope; and on Lynx Creek, in the Sunrise district. All these placers have been known and mined more or less extensively for a number of years, so that their production, although encouraging to the owners, does not indicate any new strike.

In the Valdez Creek district, which lies some 125 miles north of Anchorage and near the head of Susitna River, about 40 miles in an air line east of the Alaska Railroad, prospecting for both lodes and placers has taken on new activity within the last two years. There is practically only one camp, however, which produced more than a few hundred dollars worth of placer gold during 1927. This larger camp employed at times as many as five men and was mining bench claims on the north side of Valdez Creek. The work was practically a continuation of that which has been in progress in this district for a number of years, and no noteworthy new discoveries have been reported.

YUKON VALLEY

The Yukon Valley embraces a tremendous extent of territory, and scattered through it from one end to the other are many camps that have produced some placer gold. These camps, for convenience of description, may be grouped into seventeen more or less distinct tracts whose boundaries in some places nearly overlap those of an adjacent tract or in other places lie far remote from their nearest neighbor. The boundaries of these tracts do not necessarily correspond with those of any of the legal subdivisions or recording districts, but have been adopted because of the related interests of the mining camps which are thus brought together. For instance, the mines in the western part of the Yukon Valley have been grouped together and described under the term Marshall district, because Marshall is the principal supply point for a large area, embracing all the mining activities in the Wade Hampton and adjacent recording districts.

The gross result of placer mining in all these districts was a production of gold worth $1,282,000, nearly $250,000 less than the production of the same region in 1926. This decrease is largely attributable to the adverse climatic conditions whereby in most of the districts there was an acute shortage of water during the early part of the season, and the rather early close of the season by cold weather in the fall. In the following table the several districts are arranged in the order of their placer production in 1927. It should be noted, however, that although the total placer production credited to the

Yukon Valley is believed to be correct as stated, there is some uncertainty as to the correctness of the distribution of this total among the districts, because of the large number of small producers, their widely scattered distribution, and the failure of many of them to supply essential data. Checks on the estimates for these districts are especially difficult to obtain, because the same gold may pass through several hands before it finally reaches a bank, assay office, or mint and thus may appear to come from a different district than the one that really produced it, or a man going out from one of the remote districts may take along with him the gold from many mines other than his own, though when an assay receipt is issued it appears that the gold came entirely from one property. In spite of these uncertainties, however, every reasonable precaution has been taken to guard against errors and to keep the estimates in accord with all the available facts.

In the following table two small districts, the Richardson and Chandalar, have been grouped with larger ones, the Fairbanks and Koyukuk, respectively, and two other small districts, the Kantishna and Bonnifield, have been combined, mainly to avoid disclosing individual production from some of the small districts where the bulk of the placer gold has been derived from one or two mines. None of these small districts, however, produced as much as $10,000 in placer gold, 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.

Value of placer gold produced in Yukon Basin, 1926 and 1927, by districts

District	1927	1926	District	1927	1926
Fairbanks and Richardson	$350,000	$468,000	Fortymile	$37,000	$60,000
Innoko	244,000	242,000	Eagle	19,000	28,000
Tolovana	151,000	148,000	Chisana	15,000	18,000
Iditarod	150,000	196,000	Kantishna and Bonnifield	12,000	14,000
Koyukuk and Chandalar	86,000	73,000	Rampart	10,000	12,000
Hot Springs	75,000	65,000	Marshall	9,000	7,000
Circle	72,000	162,000			
Ruby	52,000	36,000	Total	1,282,000	1,529,000

The region adjacent to Fairbanks has long been and still is the main placer district in the interior of Alaska, though it suffered the greatest decrease in placer production of all the districts in the Yukon Valley. Part of this decrease arises from the fact that in the records for 1926 the Nome Creek dredge was considered by the Geological Survey to be in the Fairbanks district, but as it more correctly belongs in the Tolovana district, it has been accredited to that district for 1927. The greater part of the decrease, however, must be attributed to adverse climatic conditions. In the Fairbanks district the outstanding items of interest continue to relate to the prospecting being carried on by the Fairbanks Exploration Co. Many of the diverse lines of work that have been in progress by this company in getting ready to mine certain of its extensive holdings on Chatanika River and its tributaries approached completion during the year. The construction of most of the siphons on the big Chatanika ditch, the completion of a great powerhouse for generating electric power from coal for the operation of the dredges, and the thawing of extensive tracts of ground in Goldstream and Chatanika Valleys were among the major accomplishments of the year. The culmination of the first stage of a part of this enterprise may be considered to have been achieved when in December the materials for the first two of the great dredges that the company plans to use in mining its placer ground arrived in Alaska and were expeditiously carried by the Alaska Railroad to the sites at which they are to be assembled and start work. These dredges are equipped with buckets having a capacity of 10 cubic feet each and, in all parts that are subjected to severe strains, are more ruggedly constructed than is usual for dredges of 50 per cent greater capacity. The assembling of these dredges should be completed so that they will be in shape to run for several months during 1928 and greatly swell the production from the Fairbanks district. Although these first large dredges mark the culmination of one stage of the company's enterprise, it must be remembered that the entire project calls for the building of several more dredges and entails work lasting for more than a score of years. There still remains much preparatory work to be done before the entire project is in full swing, and even then it will take many years before all the placer ground that the company now owns has given up the last of its treasure of gold.

The greatest amount of placer gold received in the Fairbanks district in 1927 was produced by the dredges of the Fairbanks Creek Gold Dredging Co., the Tanana Valley Gold Dredge Co. on Fish Creek, and the Chatham Gold Dredging Co. on Chatham Creek. Most of the placer gold that was produced in the Fairbanks district by hydraulic or open-cut methods of mining or drifting came from Ester, Pedro, Twin, Dome, Smallwood, Big Chena, Chatanika, and Little Eldorado Creeks and their tributaries. Several thousand dollars' worth of gold in addition to the production from the dredges was also reported from Fairbanks Creek and Fish Creek. There were a number of smaller camps in the valleys of several other streams, whose production, though individually only a few hundred dollars or at most a few thousand dollars, yet in the aggregate equaled or exceeded the production from some of the creeks already named.

In the Richardson district five camps, comprising a total of eight men, were engaged in mining during the season of 1927. Two of these camps were on Democrat Gulch, a tributary of Banner Creek, two were on Tenderfoot Creek, and one was on Moore Creek, a tributary of Buckeye Creek. The total production from this district amounted to only a few thousand dollars, and the work was done on deposits which have long been known and on which there has been desultory mining for many years. Not far from Richardson and south of Tanana River two groups of prospectors have been prospecting placer ground on Savage Creek and its tributaries, in the Jarvis Creek basin, and on Rainy Creek and its tributaries, in the Big Delta River basin. East of Richardson in the valley of Goodpaster River two small groups of properties are reported to have been developing placer ground on Central Creek and Michigan Creek. This work was mainly of an exploratory type, and no reports of the results have been received by the Geological Survey.

In the Innoko district about 80 men were engaged in placer mining during 1927. The greater part of the gold recovered was mined by the two dredges belonging to the Flume Dredging Co. on Yankee and Little Creeks, and the dredge of the Innoko Dredging Co. on Ganes Creek, which was under lease to Frank Joaquin. All mining was much handicapped by the shortage of water during the early part of the mining season, which was followed by an early freeze-up. Next to dredging, the most productive placer mining was on Ophir Creek, where four separate companies were at work. Of these Collins & Hard and Meier & Berg were the most successful. On Little Creek the largest producer was N. J. Vibe, who mined with a slip-line scraper. On Spruce Creek were two active placer camps, and on Victor Gulch there was one. Little mining was in progress in the Tolstoi district, which lies to the north of the Innoko district. On the whole, there were no notable new mining developments during the year. The event that seems to have been regarded by the miners as of most significance to them was the partial completion of a good road between Ophir and Takotna on the Kuskokwim and a road up Little Creek. Both of these roads should assist in reducing the cost of transporting supplies and thus encourage new developments.

The shortage of water in the Tolovana district, which reduced the amount of gold that was won by open-cut or drifting methods of mining, was largely offset by the production by the Nome Creek dredge, which was built in 1926 and ran only a short period in that year but in 1927 mined for more than 150 days. This dredge, because of its proximity to Fairbanks, was counted among the Fairbanks dredges in the 1926 report, but as it really lies in the Tolovana drainage basin it has been counted in that district this year. Exclusive of the gold mined by the dredge, considerably more than half of the placer output from the Tolovana district was recovered by drift mining, so that the camp is busy the year around. Most of the larger producing mines are on Livengood Creek, but a considerable amount came from some of its tributaries and a little from small northern tributaries to Tolovana River. Even under ordinary conditions the supply of water in this district is small, and with a dry season such as 1927 the miners have been hard put to it to get their dumps sluiced, and some of them report that they have only partly succeeded, so that some of the gravel that was mined during the winter of 1926–27 has not yet yielded up its gold content. Although this gold-bearing material was mined in 1927, only the amount of gold that was actually recovered from it is counted in the production recorded for that year.

The record for placer production in the Iditarod district shows that in 1927 the greater part of the gold was recovered by means of two dredges on Otter Creek in the vicinity of Flat, one operated by the J. E. Riley Investment Co. and the other by the North American Dredging Co. Records of the production from the individual claims in the district are exceptionally incomplete, so that reliable details concerning the different mines are not available. The markedly smaller production in 1927 than in 1926 is to be attributed to the dry season and the early freeze-up.

The Koyukuk district really consists of three rather distinct and widely separated placer areas namely, Hughes and vicinity, near the south-central part of the Koyukuk Valley; Hogatza and vicinity, a short distance to the north; and the northern part of the Koyukuk Valley from Bettles to the head. Mining in the two more southern placer camps was practically negligible, so that the record of their small output has been combined with that of the more productive northern tract. To this already extensive tract has been added the Chandalar region, as it is more or less closely tied geographically and geologically to the Koyukuk. The amount of gold produced in the Chandalar district is relatively but a small part of that produced from the tributaries of the upper Koyukuk, so that its inclusion has little effect on the total. In the northern part of the Koyukuk Basin there were between 15 and 20 camps that are reported to have recovered some gold. At some of these camps mining was in progress during both the winter and the summer, but at others the work was carried on only in one season or the other. Mining was most active on Nolan Creek, including Smith and Archibald Creeks. In this valley five separate parties of miners were employed in the winter and four during the summer. On Hammond River, including with it Vermont and Swift Creeks, three different camps were engaged in mining during the winter and two during the summer. The Detroit Mining Co., which for the last two years has been perfecting plans for mining the deep ground at the mouth of the Hammond River, was further delayed this season by the low water, which prevented completion of the task of freighting supplies from Bettles to the claims. As a result of this delay no progress was made on opening up the company's ground at that place or in the construction of the projected ditch from the North Fork of Koyukuk River to the benches of Nolan Creek. Other creeks in the northern part of the Koyukuk Valley where some mining was in progress were Wakeup, Porcupine, Lake Creek (the one tributary to Bettles River), and Myrtle, and smaller prospecting parties reported having recovered a few hundred dollars in gold from placers on several other creeks. There are few mining districts in Alaska that are as inaccessible by regular means of transportation as the Koyukuk. It is not surprising, therefore, that many of the operators are finding that the hire of commercial airplanes to take them in to the camps in the spring and bring them out in the fall is a real economy.

The most noteworthy new development of the year in the Hot Springs district was the completion of the dredge of the American Creek Mining Co. and the beginning of mining with it. As it was not completed until late in August and as the season closed early in October, it was running only a short time, but all reports indicate that the tests under working conditions were satisfactory, and the owners look forward with assurance to a successful season in 1928. The greatest production from the Hot Springs district was reported from drift mines of the Mohawk Association on Woodchopper Creek. In addition to gold, considerable placer tin was recovered. There were 12 to 15 other mining camps scattered through the region. A few of these recovered several thousand dollars in gold, but in general the camps consisted of only one or two individuals each and their production of gold ranged in value from a few hundred to a few thousand dollars. Shortage of water for mining seriously curtailed the production of many of the small camps.

Next to the Fairbanks district the greatest decrease in placer-gold production was in the Circle district. The largest single cause of this decrease was the idleness of the dredge of the C. J. Berry Dredging Co., which has yielded so much gold in the past. The reason given was that the ground ahead of the dredge is too shallow for it to handle economically. All the mines using open-cut methods report an unusually dry season and consequent shortage of water for mining. The largest operating mines were those of the Berry Holding Co., on Eagle Creek; the hydraulic plant of the C. J. Berry Dredging Co., on Mastodon Creek; and the mine of John A. Anderson, on Mastodon Creek. Although there were nearly a score of smaller placer camps, none of them produced more than a few thousand dollars in gold, and some of them not more than a few hundred dollars.

In the Ruby district the greatest amount of gold was mined on Poorman Creek, where three separate camps were drift mining during the winter and four camps were engaged in either drift or open-cut mining during the summer. Other creeks on which some productive mining was done during both the winter and the summer were Duncan, Greenstone, and Solomon. Winter mining only was done on Timber and Monument Creeks and Cox Pup, a tributary to Big Creek, and open-cut mining during the summer on Flat Creek. The occurrence of placer tin in many of the deposits of the Ruby district has long been known, and during the summer of 1927 a number of miners reported finding considerable placer tin in their concentrates. So much interest was thereby aroused that a mining engineer was engaged by private interests to look over part of the district with a view to determining its resources in both placer and lode tin and the possibility of working the deposits for this metal.

Lack of water for mining seriously handicapped all placer operations in the Fortymile district, but this shortage was especially keenly felt at the mine of the Walker Fork Corporation, which uses a drag-line scraper, and at the large hydraulic camp on Jack Wade Creek. Mining in the Fortymile district is conducted at many of the mines both winter and summer, but the winter production is not more than a fifth of the summer production. About 50 men are engaged in mining in the district, and most of the camps consist of only one or two miners. Thus 26 camps were reported to be producing in 1927, and one of these employed 18 men, so that the average of all the others was less than two men. In addition to the gold from the mines on Walker Fork and Jack Wade Creek, already mentioned, some was produced from camps on Chicken, Ingle, Canyon, and Franklin Creeks and Fortymile River and two other small camps on Jack Wade Creek.

Like the other camps in the eastern part of the Yukon Valley in Alaska those in the Eagle district were so short of water in the early part of the summer that mining was largely at a standstill for more than a month. Seventymile River and its tributaries saw most of the mining activity, and its mines yielded about two-thirds of the total placer-gold production for the district. On Fourth of July Creek three placer camps that together employed about 10 men did some work. One small camp of two men reported some production from American Creek. Elsewhere in the district a little prospecting and development work was done during 1927, but the yield of gold from these placers amounted at most to only a few thousand dollars.

No new discoveries of note were reported from any part of the district.

Little definite information has been received by the Geological Survey as to mining activities in the Chisana district (locally called Shushana) in 1927. From less authoritative sources it was estimated that the production from that district did not exceed $15,000 and possibly was several thousand dollars less. There were only a few small camps in the district, and they were all badly hampered by the extremely dry season, which seriously curtailed the amount of water available for mining.

Production of placer gold from the Rampart district in 1927 was about the same as in 1926. The principal mine was on Little Minook Creek, and the rest of the gold came from a number of small camps scattered through the district, none of which produced more than a few thousand dollars in gold and most of them only a few hundred.

Willow Creek was the source of most of the placer gold that was mined in the Marshall district in 1927. In the northern part of the valley of this stream are several small camps of one or more prospectors each, and farther south and east, a short distance below the point where the creek leaves the hills, is a larger camp that is mining with a special form of loose-line scraper. The ground that is being developed with the scraper is especially difficult to mine, as it contains many boulders of greenstone that are too large to be handled by the scraper and must be disposed of by hand labor. Much of the early part of the season was spent in construction work, so that this plant was in operation only a few months. Prospecting by two men, which yielded a small amount of gold, is reported to have been continued in the central part of Stuyahok Valley, about 50 miles northeast of Marshall, and one prospector did a little mining on Buster Creek.

Very little mining work was in progress in the Bonnifield and Kantishna districts in 1927, and almost no details are available regarding any of the individual projects. Slightly more gold appears to have been mined in the Kantishna than in the Bonnifield district, but it is evident from the smallness of the total production that the output from either district was, at most, worth only a few thousand dollars. This amount of gold was mined by a number of prospectors, few of whom recovered gold worth as much as a thousand dollars. Water for mining was extremely scanty at most of the claims throughout the first part of the summer, and some of the small creeks were absolutely dry through July and early August—a condition that has not happened before in the last 20 years.

KUSKOKWIM REGION

There are three principal districts included in the Kuskokwim region where gold placers were mined in 1927. These, for convenience, are here called the Mount McKinley district, the Georgetown-Tuluksak-Aniak district, and the Goodnews Bay district. The Mount McKinley district embraces all of the eastern part of the Kuskokwim Valley, but mining work in it was more or less localized around McGrath, Takotna, and Medfra. The Georgetown-Tuluksak-Aniak district embraces the west-central part of the Kuskokwim Valley: Georgetown is a small settlement on Kuskokwim River about 45 miles south of Iditarod, and Tuluksak and Aniak Rivers enter the Kuskokwim from the south about 30 and 80 miles, respectively, east of Bethel. Goodnews Bay is on the east side of Kuskokwim Bay about 40 miles north of Cape Newenham and about 125 miles in an air line south of Bethel.

The largest individual producer in these districts was the dredge of the New York-Alaska Gold Dredging Co. on Bear Creek, in the Tuluksak district. Details regarding work at this place are not available, but as the production was approximately the same as in 1926, it seems evident that no new noteworthy developments took place during the year, but that work was successfully carried on at about the same rate as during 1926. No other dredges were operated in the Kuskokwim region in 1927. The dredge of the Kuskokwim Dredging Co., which for several years has been mining on Candle Creek and in the vicinity of McGrath, was idle throughout the season, and no suggestion has been heard of its early resumption of mining.

In the Mount McKinley region the greatest amount of gold was produced by miners on Candle Creek and its tributaries, but several camps on streams adjacent to Medfra, farther up the Kuskokwim, report a larger production than heretofore. Among the streams on which gold placers were mined may be mentioned Hidden, Eagle, Ruby, and Birch Creeks. Some rumors of placer prospects in remote parts of the district have been heard, and several inquiries have been received regarding the possibility of finding placers in the southern parts of the Kuskokwim Basin that lie adjacent to the headwaters of streams draining south and westward into Bristol Bay. So far no reports of the production of any appreciable quantities of gold from those areas have been confirmed, though much of the unexplored area to the south of the Kuskokwim deserves intelligent prospecting.

In the Georgetown district practically the only mining that furnished any appreciable amount of placer gold in 1927 was on Donlin

Creek. In the Aniak-Tuluksak district, in addition to the dredge, a fairly large production was reported from Marvel Creek, tributary to Solomon River, which in turn flows into Aniak, and from Canyon Creek, to Kwethluk River on the west slopes of the Kuskokwim Mountains east of Bethel. Small amounts of placer gold were reported to have been recovered in the course of prospecting in the vicinity of Marvel Dome and at a few points in the Bear Creek Valley east of the dredge.

In the Goodnews Bay region the placer-gold production came from five camps, one each on Watermuse, Kowkow, Olympic, Bear, and Butte Creeks. In addition to these small producing camps, one man spent practically all summer in prospecting with a hand drill on Arolik River and its tributaries. Much of the tract that was drilled is said to have had about 20 feet of gravel overlying bedrock and to have yielded encouraging prospects of gold. The Goodnews Bay district is practically the only one in Alaska in which the miners report that there was an "abundance" of water in 1927. A short distance south of Goodnews Bay there has been considerable interest shown in prospecting for platinum. Further statements regarding this work are given in a later section of this report which treats of platinum. The fact of significance so far as the production of placer gold is concerned, is that almost no gold is associated with the platinum, only a few colors of gold being found with more than 3 ounces of platinum.

SEWARD PENINSULA

The production of placer gold in Seward Peninsula in 1927 was about $500,000 less than in 1926. This bald statement at first is decidedly disquieting to anyone concerned with continuity of placer production in this region. When, however, the decline is analyzed more closely, it is seen to be a regrettable incident rather than an ominous sign of the waning of the industry. In the first place, it should be remembered that in comparing the production of 1927 with that of 1926 we are using a very high standard, because in 1926 the placer-gold production from Seward Peninsula was $784,000 greater than in 1925. Furthermore, the opening of the season in 1927 was exceptionally late. Thus it was almost the last of June before the first boats reached Nome from the States. On these boats were many of the miners and mine officials who had spent the winter in the States and whose return was essential to putting some of the properties into full operation. In many places the seasonal frost remained much longer than usual and therefore delayed the beginning of some of the projects or reduced the amount of work that could be accomplished. At several of the small dredges, where the seasonal frost lasted even into August, the buckets would be hoisted up only partly filled or the dredge would have to leave the more solidly frozen material and keep trying to find thawed spots, thus consuming time and reducing the amount of yardage handled. Coupled with the late season was an unusual shortage of water for mining, and this continued into August. This still further hampered production, and many of the smaller camps simply discontinued mining, so that when more plentiful rains came, later in the season, they had closed up their plants and were not in condition to take advantage of the water during the short time remaining. The dearth of water was not only felt acutely by the smaller mines but was also extremely hard on the largest mines. For instance, the Hammon Consolidated Gold Fields was not able to supply sufficient water to maintain its three dredges and the attendant thawing and so was forced to keep one dredge idle for many weeks. This item alone would account for a very appreciable part of the total decrease.

More than 83 per cent of the total placer production of Seward Peninsula is mined by 17 dredges, 1 or more of which were active in practically every one of the larger districts of the peninsula. Additional data regarding dredge mining in 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 1927 the districts of Seward Peninsula stood as follows: Nome, Fairhaven, including the Inmachuk, Solomon, Council, Kougarok, Koyuk, Port Clarence, Casadepaga, and Bluff. So much of the placer gold from certain of the districts came from only one or two producers that it has not been deemed advisable to publish the amount of placer gold produced by the individual districts. The total placer-gold production from mines throughout the peninsula was worth $1,365,000. Of this amount $1,136,000 was mined by dredges and $229,000 was recovered by all other forms of placer mining.

The outstanding mining enterprise in the Nome district continues to be that of the Hammon Consolidated Gold Fields, with its three dredges between Little and Wonder Creeks, its scores of claims, and its extensive ditch lines and other necessary equipment. Not only through its direct development of the resources of the region, however, is this company making itself a force in the district, but also through the studies of its engineers to solve the problems of mining under northern conditions. Experiments by the company on the application of cold-water thawing to preparing ground in advance of dredging are yielding data that will be of importance to all engineers and miners engaged in placer mining, not only in Alaska but throughout the Northern Hemisphere where frozen ground must be mined. In fact, the practical demonstration by this company of the value of reducing mining to a sound engineering basis, which is being taught unconsciously by the way its affairs are handled, is one of the lessons that is of inestimable value for the whole mining world to learn. The two other dredges in the Nome district made a very favorable showing, and were active throughout the season on Dry and Anvil Creeks. Ordinary open-cut mining or underground drifting on any considerable scale were carried on at only a few places in the more remote parts of the field. The only mining that was in progress was by camps of one or two prospectors, whose production of gold was often less than would have been won by working for wages.

Mining is carried on in the Fairhaven district at three principal centers—Candle Creek, Inmachuk River, and Bear Creek. On Candle Creek and its tributaries, Patterson and Jump Creeks, the greatest amount of gold was mined by the dredges of the Golden Center Mines (Inc.). Although this company operates two dredges only one was mining for more than a few days in 1927, and even that dredge was closed down for the season by the middle of September. Three open-cut placer mines employing a total of 8 to 10 men were at work on Patterson Creek, and camps of 2 men each were on Jump Creek and in the main valley of Candle Creek. In the Inmachuk Valley the principal producer was a hydraulic mine on the main river near the mouth of Arizona Creek. At this mine the average number of men employed during the season was 22. A little placer mining was also done at other points in the valley of Inmachuk River and by one prospector on Cunningham Gulch, a tributary of Hannum Creek, which in turn, is a tributary of Inmachuk River. On Bear Creek, which is a tributary of Buckland River and lies some 30 miles in an air line southeast of the town of Candle, three camps of placer miners employing a total of about 12 men were active during the season. In addition to these three principal centers of mining activity, small camps reporting production of placer gold ranging in value from a few hundred to a few thousand dollars each were mining on Alder, Quartz, Glacier, and Goldrun Creeks, and Kugruk and Koopuk Rivers. The Koopuk is a tributary to the Buckland, east of Candle.

Almost all the placer gold that was mined in the Solomon region in 1927 came from the three dredges on the main river operated by the Goldsmith Dredging Co. near the mouth of Coal Creek and the Eskimo Dredging Co. (name later changed to Lomen Reindeer & Trading Corporation) and Solomon River Dredging Co. a short distance south of the mouth of Jerome Creek, and from the one dredge operated by the Shovel Creek Gold Dredging Co. on Shovel Creek, a tributary of Solomon River from the west. To these might be added the dredge of the Casadepaga Mining Co. that mined in the main valley of Casadepaga River near the mouth of Canyon

Creek and was practically the only producer of any appreciable amount of gold in the entire Casadepaga region in 1927. In the Bluff region, which lies east of Solomon, and, for convenience of description, is here treated as part of the Solomon district, only a few thousand dollars in placer gold was produced in 1927. There were less than six small camps in that entire region, and the largest was a scraping plant which has been built near the mouth of Daniels Creek to mine the beach deposits along the shore. This plant was not put into commission until late in the season, owing to delay in the arrival of the operators.

By far the greater part of the placer gold produced in the Council district came from four dredges. All of them were much handicapped by shortage of water, and one encountered an unsually large amount of frozen ground, which reduced its production. Everywhere in the Council district open-cut mining was retarded by the shortage of water, and many of the miners who would have been busy became discouraged waiting and stopped all operations early in the season.

No dredging was in progress in the Kougarok district in 1927, and the old dredge that had so long been active had sunk south of the mouth of Henry Creek and been allowed to go more or less to ruin. On the whole such work as was in progress on the placer deposits in this district was mainly of a prospecting type, and there were few camps that produced more than a thousand dollars each. In the southern part of the district two small camps of one or two men each had been established on the benches near Coffee Creek and three small mines were running on Dahl Creek above the roadhouse. No mining was in progress in the main Kougarok Valley, but a small amount of mining or prospecting was being done on some of the side streams, by two small camps on Harris Creek about a mile or so above the mouth, one at the mouth of North Fork, three on Henry Creek and its tributary Merritt Gulch, one near the mouth of Homestake Creek, three men on Macklin Creek about a mile above its mouth, and one prospector near the head of Kougarok River. To the north of Kougarok Valley the most active mining in the district was in progress on the claims of the Dick Creek Mining Co. on Dick Creek, a tributary of a stream flowing into Serpentine River. Here seven men were engaged most of the summer in hydraulicking, though their supply of water was so scanty that several hours was required to accumulate enough to allow piping for even half an hour. Work under these conditions would have been practically impossible had it not been for the use of an ingenious stacker, driven by a gasoline engine, that piled the waste from the sluice on both sides of the cut and thus obviated the necessity of keeping the discharge drain open by constant hand labor. Northeast of the head of Kougarok River a camp of three men was reported to have been fairly successful in mining placer deposits in the upper part of the valley of Humboldt Creek, which is a tributary of Goodhope River. West of the Kougarok in the valley of American River three camps were engaged in mining and development work.

In the Koyuk district the production of placer gold was about equally divided between that mined by the dredge and that produced by other methods. Most of the gold produced by other methods than dredging came from open-cut mines that were worked only during the summer. One drift mine, however, was active during the winter and reported a fair return to the miners. Dime and Sweepstake Creeks are the only streams in the district from which any production was reported, and on them only five camps, in addition to the dredge and the drift mines, yielded gold worth as much as a thousands dollars each.

In the Port Clarence district a little placer gold was mined on Bluestone River and some of its tributaries, especially Windy and Gold Run Creeks. On Coyote and Dese Creeks, which enter Grantley Harbor from the south 2 and 6 miles east of Teller, respectively, and on Canyon Creek, which empties into Imuruk Basin about 18 miles southeast of Teller, productive mining was done by a single camp on each stream, though the work on Canyon Creek was essentially only prospecting. North of Grantley a camp of three men mined on Allene Creek, which is a tributary of Agiapuk River. There has recently been a move on foot by a company that claims to have acquired more than 5,000 acres of placer ground lying along Bluestone River and certain of its tributaries to build a dredge and construct a hydraulic plant to mine its property. No construction work on this project has yet been started.

Lying southeast 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 placer gold. Prospecting has been carried on at a number of places in this general area and for the last few years has been especially active on deposits lying in the narrow strip of country east of Norton Bay and west of the low hills that bound the coastal plain at that place. The results of the earlier prospecting have been so encouraging that during the summer of 1927 a mining engineer made an examination of the properties in that field with a view to extensive developments if the showings were favorable. No announcement of the findings has yet been made public.

NORTHWESTERN ALASKA

The Kobuk is the only valley in northwestern Alaska that is reported to have been the site of any placer mining in 1927. There are two principal areas in the valley of the Kobuk and its tributaries in which placer mining is being done. The western area is near Kiana, especially in the valley of Squirrel River and its tributary Klery Creek. The eastern area is in the vicinity of Shungnak, which is about midway between the mouth and the head of Kobuk River. Kiana is about 60 miles in an air line east of the mouth of the Kobuk, and Shungnak is about 90 miles in an air line east of Kiana. Both of these tracts are so remote and so poorly equipped with any means of transportation or communication that their development is much retarded by high costs, unavoidable delays, and short working seasons.

In the area near Kiana prospecting and development work were most active on Klery Creek and in near-by parts of Squirrel River. Four individual miners spent part of the winter looking over and prospecting different tracts in the region, and during the summer some productive work was done on five separate claims. Although the total output was relatively small, the revival of interest in mining in this region is encouraging.

In the vicinity of Shungnak the placer deposits occur in the lowland of the Kobuk close to the places where the small side streams debouch from the hills to the north or along the courses of the streams that traverse the hills. Small veins of quartz carrying in places free gold clearly indicate a source for much of the placer gold. During 1927 there were four camps in this district, three on Dahl Creek consisting of only one miner each and one on California Creek that employed six men. At the large mine a hydraulic plant was used, but the smaller ones were worked simply by pick and shovel. No new developments of other than local interest are reported from these camps.

Information of considerable economic importance, though, unfortunately, discouraging to the searcher for placer gold, was obtained by a prospector, J. C. Cross, who spent much of the summer examining parts of Salmon River, a stream that lies about midway between Kiana and Shungnak. As practically no information has been available heretofore regarding the northern part of this stream, the following rather full abstract of Mr. Cross's statements is given. He writes that the conglomerate belt shown at the mouth of Salmon River on the Geological Survey maps continues for about 20 miles upstream and then gives place to schist, which forms very sharp crested hills and occupies a belt of country about 50 miles wide. No limestone was observed in place, and only a little limestone and greenstone were found as pebbles in the creek deposits. Near the head of the stream the hills give way to more rolling country, which extends all the way to the Noatak divide. Although Mr. Cross made repeated tests of the gravel of the side streams within the tract where schist is the country rock, he was unable to find colors of gold; and even in the deposits of the main Salmon River he found only a few very fine colors, even though the tests were made at places where exposed reefs of bedrock cutting across the river appeared to make especially favorable natural riffles that would produce concentration of gold near them.

Another item that may have some bearing on the development of the mineral resources of this region is the report that several prospectors are proposing to unite and by the use of an airplane to undertake the prospecting of some of the more inaccessible parts of the headwater regions of Noatak and Kobuk Rivers. Although the project will necessitate a considerable outlay of funds, it seems entirely practicable; in fact, in the long run, if the men's time is counted as worth even the lowest customary daily wage, it would probably cost less than any other means of putting men and equipment into remote parts of the region.

DREDGING

Over 58 per cent of the placer gold produced in Alaska in 1927 was mined by dredges. The total gold recovered by dredges was $1,740,000, of which about two-thirds came from 17 dredges on Seward Peninsula and the rest from 11 dredges in other parts of Alaska. This total was about $550,000 less than the dredge output in 1926. The accompanying table gives the records back to 1903, the earliest year in which records of dredge production are available.

Gold produced by dredge mining in Alaska, 1903–1927

Year	Number of dredges operated	Value of gold output	Gravel handled (cubic yards)	Value of gold recovered per cubic yard
1903–1915		$12,481,000		
1916	34	2,679,000	3,900,000	$0.69
1917	36	2,500,000	3,700,000	.68
1918	28	1,425,000	2,490,000	.57
1919	28	1,360,000	1,760,000	.77
1920	22	1,129,932	1,633,861	.69
1921	24	1,582,520	2,799,519	.57
1922	23	1,767,753	3,186,343	.55
1923	25	1,848,596	4,645,053	.40
1924	27	1,563,361	4,342,667	.36
1925	27	1,572,312	3,144,624	.50
1926	32	2,291,000	5,730,000	.40
1927	28	1,746,000	6,084,000	.29
		33,891,000		

The total amount of gold produced by dredges since 1903 is about 16 per cent of the total amount of gold from all other kinds of placer mining since 1880, but with the constant increase in the proportion of gold mined by dredges during the last few years the difference between the two totals is constantly becoming smaller.

In the foregoing table the yardage mined and the value of gold recovered per cubic yard as stated are open to some question, because several of the dredge operators have not furnished specific information on that subject for their individual properties, and the figures for these properties have therefore had to be estimated. In making these estimates the following procedure was adopted to determine the unknown factors: Operators of dredges that produced approximately $1,216,652 in gold, or a little less than 70 per cent of the total mined by dredges, report that that amount came from 4,249,606 cubic yards of gravel. The average yield thus shown is about 28.6 cents in gold to the cubic yard. Applying this average to the unknown quantities indicates that the total amount of material mined by dredges, if worth 28.6 cents a yard, was 6,084,000 cubic yards, and this figure has been adopted in the table. This procedure is open to criticism because the companies which report fully the amount of ground mined were the larger ones, and doubtless they worked lower-grade ground than the smaller companies. As a result the average value adopted may be too low and consequently give too large an amount of gravel mined. This method, however, has been followed for the last four years, so that the quantities and values given for 1927 are comparable with those reported before and are therefore for practical purposes essentially correct.

The length of time that different dredges were operated varied widely. The longest season reported was 176 days for one of the dredges of the Hammon Consolidated Gold Fields in the Nome district. The shortest season reported was only a few days for one of the dredges of the Golden Center mines in the Fairhaven district. The length of the working season was not determined wholly by climate or other similar conditions beyond human control, however, but in part by breakage or purely personal reasons. Therefore, the dates of earliest and latest closing for any or all the dredges may be more significant than the record of any single dredge. In 1927, the earliest date for commencing dredging was June 1, by a dredge of the Hammon Consolidated Gold Fields, and the latest date for closing dredge work was November 24, by the dredge of the New York Alaska Gold Dredging Co. on Bear Creek, in the Kuskokwim region. It should be noted, however, that 1927 was an unusually late season in opening and that it closed unusually early in the fall, so that the operating records noted above were made under relatively adverse conditions. That the records do not represent an uncommon length of working season is shown by the fact that in 1926 a dredge in the Yentna district began work on May 5 and a dredge of the Hammon Consolidated Gold Fields did not shut down until December 4. In other words, a dredging season of 160 to 175 days may be counted on with a high degree of assurance in any of the larger placer camps in Alaska, for well-equipped dredges of moderate size when skillfully handled. However, the record of the 14 dredges that reported in detail the length of time worked in 1927 shows that they averaged only 112 days each. For practically all these dredges the difference is believed to be due to some cause that prevented taking full advantage of the entire available season or to the small size of the dredge or the shallowness of the placer that was being mined.

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

Yukon Basin:	
Fairbanks district—	
Chatham Gold Dredging Co.	Chatham Creek.
Fairbanks Gold Dredging Co.	Fairbanks Creek.
Tanana Valley Gold Dredging Co. (Ltd.)	Fish Creek.
Hot Springs district—	
American Creek Dredging Co.	American Creek.
Iditarod district—	
J. E. Riley Investment Co.	Otter Creek.
North American Dredge Co.	Otter Creek.
Innoko district—	
Flume Dredge Co. (2)	Yankee Creek Little Creek.
Innoko Dredge Co.	Ganes Creek.
Tolovana district—	
Nome Creek Dredging Co.	Nome Creek
Kuskokwim region:	
Tuluksak-Aniak district—	
New York Alaska Gold Dredging Co.	Bear Creek.
Seward Peninsula:	
Casadepaga district—	
Casadepaga Mining Co.	Casadepaga River.
Council district—	
Crooked Creek Dredging Co.	Albion Creek.
Melsing Creek Dredge	Basin Creek.
Northern Light Mining Co.	Ophir Creek.
Ophir Gold Dredging Co.	Ophir Creek.
Fairhaven district—	
Golden Centre Mines (Inc.) (2)	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.
Solomon district—	
Goldsmith Dredging Co.	Solomon River.
Lomen Reindeer & Trading Corporation	Solomon River.
Shovel Creek Dredge Co.	Shovel Creek.
Solomon Valley Dredge	Solomon River.

During the year several dredges that had formerly been active were idle, and only one new dredge was built and commenced operations. The dredges that had been active in 1926 but were not operated during 1927 were those of the Cache Creek Dredging Co. on Cache Creek, in the Yentna district of the Susitna Valley; the C. J. Berry Dredging Co. on Mastodon Creek, in the Circle district; the Guinan & Ames Dredging Corporation on Ganes Creek, in the Innoko district; the Kuskokwim Dredging Co. on Candle Creek, in the Mount McKinley district of the Kuskokwim Valley; and the Behring Dredging Corporation on Kougarok River, in the Kougarok district of Seward Peninsula. The new dredge that was completed in 1927 and commenced mining was that of the American Creek Dredging Co. on American Creek, in the Hot Springs district of the Yukon region.

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

The largest and practically the only new dredging enterprise on which marked progress was made is that of the Fairbanks Exploration Co., which has already been mentioned. The preliminary work of part of the project has been completed, so that by the end of the year material for two of the dredges was beginning to be delivered on the ground, and the dredges should be ready to start in productive work by the middle of the season of 1928. None of the other projects has yet reached a stage where the certainty of its being carried out can be predicted with any degree of assurance, and further discussion of them may be omitted here, though a few of them have been mentioned in the notes given in earlier sections of this report which treat of the different districts.

COPPER

Deposits containing some copper minerals are found throughout most of the length and breadth of Alaska. Copper, however, is a relatively cheap metal, being worth only about one eighteen-hundredth of an equal amount of gold. A ton of pure copper at the price that prevailed in 1927 would be worth only about $260, or about as much as a pound of gold. Furthermore, only a negligible amount of the copper from Alaska occurs as metallic copper but instead is in chemical combination with a number of other elements, and these valuable minerals are associated with more or less worthless material. To separate the copper minerals from the worthless ones and then to extract the copper in a metallic state requires extensive milling and metallurgical treatment and more or less expensive transportation. It is for these reasons that copper deposits, unless of exceptionally high grade or especially advantageously situated with regard to transportation, can not be mined at a profit in the more remote parts of Alaska under present conditions. Even the search for copper deposits in these remote areas is hardly justified under existing conditions, and it will probably be many years before conditions change enough to permit profitable exploitation of any of the small deposits now known in the remote parts of the Territory away from developed lines of transportation.

[a] Wimmler, N. L., Placer Mining Methods and Costs in Alaska: Bur. Mines. Bull. 259, 236 pp., 1927. Price 55 cents from Superintendent of Documents, Government Printing Office, Washington, D. C.

At present practically all of the Alaska copper comes from two mines in the Copper River region that are operated practically as a single unit, though owned by different companies, and one mine on Latouche Island that is owned and operated by the same company that operates the two mines in the Copper River region. In addition, a very small amount of copper is reported to have been recovered by smelters in the States from the concentrates sent in by miners in the Ketchikan, Hyder, Juneau, and Willow Creek districts. One of the smelters also reports the recovery of several tons of copper from concentrates sent in by one of the mines in the Ketchikan district that is known to have been idle during 1927. Undoubtedly, therefore, the ore must have been mined in 1926 but did not reach the smelter in that year, and the copper it contained was not recovered until 1927. This copper has therefore not been included in the amount of copper produced from the Alaska mines in 1927 as given in this report.

A bare statement of the quantity of copper produced from any region is practically meaningless unless the basis to which it refers is stated, because in all the processes that the ore undergoes, from the time it is broken out of the vein in the mine 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 the same. Even though the losses may be small compared with the quantity saved, the Alaska copper production amounts to more than 50,000,000 pounds, and a difference of only 1 per cent is equal to more than 500,000 pounds. It is therefore obviously important to state just what stage in the process of converting ore into metal is represented by the figures given. As an illustration of this condition the following facts, taken from the report of the Mother Lode Coalition Mines Co.,[7] are significant. This company in 1927 mined 104,444 tons of ore that assayed on the average 10.57 per cent of copper, which would be equivalent to 22,079,462 pounds of copper. Shipments to the smelter from this mine, however, contained only 20,588,160 pounds of copper. Evidently over 1,490,000 pounds of copper was lost during the processes of handling and milling by which the valuable copper minerals were separated from part of the worthless material with which they were associated. This at first sight seems an enormous loss, but when it is realized that this represents a loss of only about 6¾ per cent it is evident that the mill recovery is really very high and represents exceptionally good practice.

[7] Mother Lode Coalition Mines Co. Ninth Ann. Rept., for 1927, 7 pp., 1928.

The total copper-bearing ore mined in Alaska in 1927 is estimated to have been 645,000 tons, which contained 58,670,000 pounds of copper. When this ore had been concentrated and was ready for shipment to the smelter it had been reduced to approximately 94,500 tons, having a copper content of 55,343,000 pounds, which represents a recovery of over 94 per cent of the original copper content. For the purposes of the present report this quantity of copper is taken as being the output of the Alaska mines during the year.

In attempting to set a value for this copper many different methods may be employed, and the results obtained from them will vary widely. Obviously, the copper in the ore as it comes from the mines is not of itself worth the current market price of the metal, inasmuch as all of it can not be recovered, and even that part which is recovered will require the expenditure of considerable money before it is available as metal. Although the same conditions in a measure are true of the ore and concentrates that are shipped to the smelters, the losses that they undergo are generally much less. Consequently, the value of the copper is computed on the assumption that the copper in the ore or concentrates that are shipped is worth the average market price at which metallic copper sold during the year. The average price of all copper sold in 1927 in the United States, according to computations of the Bureau of Mines, was 13.1 cents a pound. The total value of the copper in the ore and concentrates shipped from Alaska during the year is therefore regarded as $7,250,000. It is recognized that this method of calculating the value does not take any account of the fact that an efficient or fortunate selling agent would probably be able to take advantage of fluctuations in the price of copper and thus dispose of the copper from his mine, as far as possible, during periods of high prices. That both the Kennecott Copper Corporation and the Mother Lode Coalition Mines Co. maintain very efficient selling organizations is shown by the statements in their annual reports that they disposed of their copper at average prices of 13.289 and 13.248 cents, respectively, or more than 0.15 cent higher than the average price of the year. If the actual prices reported by the companies had been used, the value of the total production would have been increased nearly $100,000. The figures relating to value can not therefore be regarded as representing the amounts received by the companies that produced the copper nor the amounts received for specific lots of copper. They do, however, serve to indicate within reasonable limits the approximate magnitude of the industry and allow a fair degree of comparison with the production of earlier years. The Alaska copper-mining industry is thus seen to have produced about 12,435,000 pounds less copper in 1927 than in 1926, and the total value was about $2,240,000 less. The difference in the average prices of copper in 1927 and 1926 alone accounts for nearly $500,000 of the decrease in the total value.

Copper, silver, and gold produced at Alaska copper mines, 1880, 1900–1927

Year	Ore mined (tons)	Copper		Silver	
		Pounds	Value	Fine ounces	Value
1880		3,933	$826		
1900–1915	1,232,396	220,773,969	35,031,225	2,351,726	$1,297,756
1916	617,264	119,654,839	29,484,291	1,207,121	794,286
1917	659,957	88,793,400	24,240,598	1,041,153	857,911
1918	722,047	69,224,951	17,098,563	719,391	719,391
1919	492,644	47,220,771	8,783,063	488,034	546,598
1920	766,095	70,435,363	12,960,106	682,033	743,416
1921	477,121	57,011,597	7,354,496	544,311	544,311
1922	581,384	77,967,819	10,525,655	623,518	623,518
1923	731,168	85,920,645	12,630,335	715,040	586,333
1924	761,779	74,074,207	9,703,721	572,078	383,292
1925	860,023	73,855,298	10,361,336	596,607	412,131
1926	670,000	67,778,000	9,489,000	605,190	377,600
1927	645,000	55,343,000	7,250,000	525,100	297,800
	9,217,300	1,108,058,000	194,913,000	10,671,100	8,184,800

No new developments of note were reported at the mines of the Kennecott Copper Corporation at Kennecott, in the Copper River region, during 1927. The ore from this property, as in the past, was largely high-grade copper sulphide and carbonate containing considerable silver but no gold. The highest-grade ore is sacked and shipped directly to the smelters, but the lower-grade ores are concentrated before shipment. According to the published statements of this company[8] 90,393 tons of ore was mined during the year, which was estimated to have an average content of 12.44 per cent of copper and 2.10 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 company, 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[9] shows that during the year 104,444 tons of ore was mined, which had an estimated content of 10.57 per cent of copper and 1.67 ounces of silver to the ton.

The ore of the Beatson mine of the Kennecott Corporation, on Latouche Island, is entirely different from that of the mines in the Copper River region, just described. The ore produced is a low-grade copper-iron sulphide and is 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 pub-

[8] Kennecott Copper Corporation Thirteenth Ann. Rept., for 1927, p. 6, 1928.
[9] Mother Lode Coalition Mines Co. Ninth Ann. Rept., p. 3, 1928.

lished report of this company[10] 448,200 tons of ore was produced in 1927, which had an estimated content of 1.571 per cent of copper and 0.307 ounce of silver to the ton.

At all three of these large mines prospecting is constantly under way in order to find any new ore bodies that may lie on the properties. During the summer of 1927 extensive tests by modern methods of geophysical prospecting were carried on at all three properties. These tests are said to have been made by experienced engineers, using the most up-to-date instruments and with every opportunity to do the necessary work thoroughly. No authoritative statement has been given out regarding the outcome of this work, but it is currently said to have given, on the whole, negative results. No new ore bodies are reported to have been discovered during the year, so that the production has come entirely from the bodies already known. Fortunately, however, the original estimates of the volume of the ore bodies from which this ore was taken had been so conservative that the known reserves were not depleted to the full extent of the amount of ore taken out. Thus, at the mine of the Mother Lode Coalition Mines Co. the reserves were depleted to an extent of only about 80 per cent of the quantity trammed.[11] This in effect is equivalent to finding new ore bodies of a size equal to the difference.

The quantity of copper produced by mines other than those already mentioned was practically negligible, amounting to little more than 10,000 pounds. The largest part of this copper was derived from concentrates from the Riverside mine, in the Hyder district of southeastern Alaska, but three other prospects in that same district shipped concentrates that yielded a little copper. The Chichagof Development Co., and the Willow Creek Mines, in the Cook Inlet-Susitna region, are also credited with having shipped concentrates containing some copper. All these mines are more truly gold mines than copper mines and are so counted in this report. Therefore, to avoid duplication, though their copper is included in the table on page 45, their silver content is not included in that table but is carried in the table of gold-lode mines on page 10 and in the table of silver production on page 48.

Prospecting for copper lodes or further development of the lodes already known has been active during the year at only a few places in the Copper River and Prince William Sound regions. Probably the most active work that was in progress on any of the properties that are in a developmental stage was at the Copper Creek mines, in the Kotsina district, where, under the trusteeship of George H. Hur-

[10] Kennecott Copper Corporation Thirteenth Ann. Rept., p. 6, 1928.
[11] Mother Lode Coalition Mines Co. Ninth Ann. Rept., for 1927, p. 4, 1928.

lock, several men were employed for part of the season in prospecting, constructing the necessary buildings, and installing machinery. In the valley of Nabesna River the Alaska Nabesna Corporation was more or less continuously engaged in drilling certain parts of its holdings with a view to determining the extent and tenor of the ore. This work was interrupted by the extremely dry season, which made water for drilling scarce. The company has made no announcement of the results of its tests or of its plans for the future, evidently wisely preferring to wait until facts are in hand on which it can base a sound policy. No productive work was in progress on the old Green Butte mine, on McCarthy Creek a short distance east of the Kennecott group of mines. The ore at this property resembles the high-grade sulphide and carbonate ores of the mines near Kennecott and seems to occur under relatively similar geologic conditions. This property has been opened up by an inclined shaft that reaches a depth of 700 feet and has in the past produced a considerable amount of good ore. The present is not, however, a time to stimulate renewal of copper mining in that region, though doubtless, with a higher price for copper, it would open up again.

Little new prospecting for copper lodes is reported anywhere within the Prince William Sound region. At several of the deposits formerly discovered, some prospecting and development work was done, but at all these camps 1927 was relatively a period of marking time, and no new discoveries were reported. As almost all the properties are patented to their owners, prospecting simply to fulfill certain legal requirements is not necessary, so that the owners of many properties have preferred to allow them to lie absolutely idle rather than waste their time and money in engaging in futile activities. It was currently reported early in the summer that renewed interest was being shown in certain of the copper claims south of Iliamna Bay, on the west side of Cook Inlet, and that engineers of one of the large copper companies examined the properties with a view to their purchase. Although no authoritative statement has been made regarding the results of this examination, the fact that no action has been taken indicates that either it was impossible for the parties to reach an agreement on terms of sale or that the results of the tests did not indicate that the deposits carried as much copper as the prospective purchaser thought desirable. In any event, no further developments have been reported at that place.

SILVER

None of the ores that are mined in Alaska are valuable solely for their silver content, and there is only a relatively small tonnage of ore produced that is valuable principally for its silver. By far the greater part of the silver that is produced occurs as a relatively minor constituent of ores whose principal value lies in some other constituent. Thus, as shown by the table below, silver worth nearly $300,000 was recovered in 1927 from the ores that are valuable principally for the copper they contain. This source alone accounts for more than 83 per cent of all the silver that was produced in Alaska in 1927. The amount of silver in this copper ore is really relatively small, as shown by the fact that the average content of the ore mined at the mine of the Kennecott Copper Corporation, which had the highest average of all the large mines, was only 2.1 ounces of silver to the ton.

For several reasons it has been impracticable to state separately the quantity of silver that was produced from the ores that are principally valuable for their silver content. The most cogent of the reasons is that practically all the ore of this sort comes from a single mine, and to state it separately would disclose rather closely the production of this mine. All the Alaska ores whose value lies principally in their silver content also carry considerable gold, so that in this report they have been included with the gold lode mines. Much silver is produced from gold mines in which the value of the silver is but a minor item. Thus, the mine of the Alaska Juneau Gold Mining Co., though worked principally for its gold, yielded 61,232 ounces of silver in 1927.[12] Even though silver may not be apparent nor occur as any recognizable distinctly separate mineral in gold, it is never entirely absent, so that all native gold, whether it is derived from lodes or placers, carries some silver.

Data regarding the production of silver have been referred to at several places in the preceding pages and set down in a number of the tables which cover the production of other metals. For convenience the sources and the quantity and value of the production from each source in 1926 and 1927 are set forth in the following table:

Silver produced in Alaska in 1926 and 1927

Source	1926		1927	
	Ounces	Value	Ounces	Value
Gold lodes	59,940	$37,400	79,400	$45,000
Gold placers	24,870	15,500	23,300	13,200
Copper lodes	605,190	377,600	525,100	297,800
	690,000	430,500	627,800	356,000

It is evident from this table that the output of silver in 1927 was worth about $75,000 less than the output in 1926. It should be re-

[12] Alaska Juneau Gold Mining Co. Thirteenth Ann. Rept., p. 13, 1928.

membered, however, that the silver in the copper lodes and gold placers is not produced for itself alone, so that the quantity produced from those sources merely fluctuates with the production of the principal metals. As already pointed out, the production of copper fell off more than 12,000,000 pounds and the value of the gold produced from placers nearly $800,000, so that naturally there was a corresponding decrease in the silver that was mined with those metals. Although there was some slight increase in the amount of lode gold produced in 1927 over that produced from the same source in 1926 and although this might account for some slight increase in the silver from that same source, the table shows a much larger increase than could be attributed to that cause. The explanation lies in large measure in the greater production of ores that are valuable principally for their silver, and the increase is an encouraging sign pointing toward still greater production from this source in the future.

The principal region that is now producing ore valuable largely for its silver is the Hyder district, at the head of Portland Canal in southeastern Alaska. Prospecting and development of the silver-lead ores in this district was going on throughout the year somewhat more energetically than heretofore. Although several small lots of ore and concentrates were sent out to the States for testing from properties in the Hyder district, the largest production still comes from the Riverside mine, a short distance northwest of Hyder. The company that operates this mine also operates its own concentrating mill from which it ships the product to a smelter in the States. In addition to the silver and lead the ore carries considerable gold, a good deal of which is recovered in the course of the milling operations but part of which is recovered in smelting. In many of the veins in the Hyder district silver minerals are found, and in some of the smaller veins in adjacent parts of British Columbia these minerals form important constituents of the ore. No startling new developments in this region have been reported during the year, but the general impression gained is that progress is being made in its development and that sincere and earnest efforts are being made to prospect it adequately. This must necessarily take time, much effort, and considerable capital, but the geologic conditions are favorable, and the proved occurences of ore on both sides of the international boundary support the belief that other profitable ore bodies exist in the region.

In the notes on the gold lodes mention has been made of the scattered occurrences of lead-silver ores in some of the districts. Obviously the difficulty and cost of treatment of ore of this type in remote districts are too great to make such ventures profitable at this time. Some of the deposits of this sort that were formerly mined in southeastern Alaska and are relatively close to deep-water transportation, if carefully and skillfully managed, might well pay for reopening. The experience that was gained by trying to develop the silver-lead deposits in the Kantishna district seems to prove fairly conclusively that under existing conditions, unless the ores are phenomenally rich, the cost of getting them to market is so great as to discourage development. These conditions, however, are being modified as the country becomes better opened up, so that the alert engineer or capitalist might well review at intervals the then existing conditions to determine whether or not they had changed enough to warrant trying to mine some of the more promising deposits.

At the Mint mine, which is about 9 miles east of Chulitna station on the Alaska Railroad, is a unique silver prospect in which the value of the ore depends on the presence of ruby silver, a complex sulphide mineral containing silver. Work at this place during 1927 consisted mainly in surface developments, the driving of about 150 feet of tunnel, and the starting of three stopes. Some differences having arisen over the handling of the property, work was discontinued, but the operator is so well satisfied with the general indications of ore that he does not propose to let the property lie idle long but will continue the development work.

LEAD

The lead produced from Alaska ores in 1927 amounted to 2,016,000 pounds, an increase over the production in 1926 of 460,000 pounds. This output stands as the greatest quantity of lead that Alaska has ever produced in a single year. The value of the lead produced in 1927, at 6.3 cents a pound, which was the average market price for the year as determined by the Bureau of Mines, was $127,000, only $2,600 more than the value of the lead produced in 1926. That there was not a much more marked increase in value was due to the fact that on the average lead sold for 1.7 cents a pound less in 1927 than in 1926.

Lead produced in Alaska, 1892–1927

Year	Tons	Value	Year	Tons	Value	Year	Tons	Value
1892	30	$2,400	1905	30	$2,620	1918	564	$80,088
1893	40	3,040	1906	30	3,420	1919	687	72,822
1894	35	2,310	1907	30	3,180	1920	875	140,000
1895	20	1,320	1908	40	3,360	1921	759	68,279
1896	30	1,800	1909	69	5,934	1922	377	41,477
1897	30	2,160	1910	75	6,600	1923	410	57,400
1898	30	2,340	1911	51	4,590	1924	631	100,899
1899	35	3,150	1912	45	4,050	1925	789	140,571
1900	40	3,440	1913	6	528	1926	778	124,400
1901	40	3,440	1914	28	1,344	1927	1,008	127,000
1902	30	2,460	1915	437	41,118			
1903	30	2,520	1916	820	113,160		9,811	1,322,000
1904	30	2,580	1917	852	146,584			

By far the larger part of the lead was recovered in connection with the mining of the gold ores of the Alaska Juneau mine, in southeastern Alaska. According to the published reports of this company, it produced 1,513,306 pounds of lead in addition to other metals in 1927. This represents a recovery of a little less than five-sixths of a pound of lead from each ton of ore milled. The remainder of the lead came principally from the silver-lead mines in the Hyder district, of which the Riverside mine was by far the largest. A little lead was also recovered from concentrates shipped to a smelter in the States by the Kassan Gold Mining Co., whose mine is near Hollis, on Prince of Wales Island, in the Ketchikan district.

The statements relating to certain of the gold ores and to the silver-lead ores in the preceding section on silver give all the available data regarding lead mining in 1927. None of the deposits contain enough lead to be developed for their lead content alone. Although several deposits that are now lying idle or undeveloped seem to be nearly high enough in their combined lead, silver, and gold content to be mined at a profit, there does not seem to be any indication that in the near future any considerable increase in the production of lead is to be expected, except as a result of increased mining in the Hyder district and increased milling of the gold ores of the type represented by those now being mined at the Alaska Juneau mine. Both of these contingencies, however, seem very likely to happen, and an increase in the yield of lead from these sources is looked for with considerable assurance.

PLATINUM METALS

Platinum is one of a group of several metals which, because they are closely related in physical and chemical character, are often not differentiated by name or are not even identified specifically in the usual forms of assay or analysis but are spoken of as the platinum metals or, even more loosely, as platinum. Platinum, palladium, osmium, and iridium are some of the individual members of this group. Some of these metals have been found both in lodes and in placers in Alaska. The only occurrence in a lode that has produced any appreciable quantity of metal was at the mine of the Alaska Palladium Co. on Kasaan Peninsula, Prince of Wales Island, about 30 miles west of Ketchikan. The principal platinum metal found at this mine was palladium. Unfortunately, decrease in the price paid for palladium and some internal difficulties resulted in the closing of this mine in the fall of 1926. It was not reopened in 1927 and, according to local reports, was put up for sale to satisfy certain judgments and had been bid in for $15,000, and this offer was under consideration by the courts. As this mine while it was running produced several hundred thousand dollars' worth of platinum metals a year and in addition a good deal of gold and some copper, its cessation of production has not only made a very decided drop in the Alaskan output of platinum metals but has been felt in the total mineral production of the Territory.

The only platinum metals that were mined in Alaska in 1927 were recovered from placers, but no detailed reports are available as to the precise quantities obtained. However, from more general sources of information, which are believed to be reliable, it has been learned that the total production of crude platinum metals was about 21 ounces. This amount is probably equivalent to 17.5 fine ounces, which, at the average price of platinum for the year, was worth $1,500. The platinum came entirely from placers in the Dime Creek district, of Seward Peninsula, and in the Goodnews Bay region, south of the mouth of Kuskokwim River. The Seward Peninsula deposits have been known for a long time and have been more or less continuous producers in the past. Although the occurrence of platinum in the Goodnews Bay region has been known before, interest in the deposits at that place was especially keen during 1927, and for a time it appeared that a small stampede was in progress. Rumors of the richness of these claims seem to have become more glowing the farther they traveled away from their sources. However, in spite of the exaggeration of certain reports from this district, it is true that placer deposits containing platinum worth continued careful prospecting occur in the district and that about 10 men were engaged during the summer in the search for places where concentration had been great enough to form deposits that could be mined at a profit. The most extensive prospecting is reported to have been done in the vicinity of Salmon Creek, a stream about 9 miles long that drains the country lying about midway between Goodnews Bay on the north and Chagvan Bay on the south and enters Bering Sea about 2 miles north of the native village of Kiniginagimut. The country rock is a dark basic igneous rock allied to pyroxenite. Black sand from the pannings seems to consist mainly of magnetite without any chromite, though usually in platinum deposits chromite is common. Curiously, the concentrates from this region are said to carry almost no gold, a clean-up that yielded 3½ ounces of platinum having shown only a very few small colors of gold.

In the valley of Arolik River, which is considered part of the Goodnews Bay district but is 25 to 30 miles north of Goodnews Bay itself, a small amount of platinum was recovered in connection with placer gold mining on Kowkow and Butte Creeks. On these streams the association of platinum with gold is very different from that in the tracts south of Goodnews Bay, in that the platinum is many times less abundant than the gold, the ratio between the two metals being almost the reverse of the ratio of the deposits south of Goodnews Bay.

Although no other places are known to have produced platinum metals that were sold in 1927, it is not unlikely that small amounts were produced elsewhere but are held by the owners, for the occurrence of platinum in many of the placer deposits throughout the Territory has been demonstrated in the past. Thus, some platinum metals have at one time or another been recovered from placers in the Chistochina district, of the Copper River region; from Metal Creek, in the Kenai district; from the Kahiltna and other streams, in the Yentna and near-by districts of the Susitna region; from Boob Creek, in the Tolstoi district, and Granite Creek, in the Ruby district, both of which are in the central part of the Yukon Valley; from streams in the Marshall district, in the western part of the Yukon Valley; and from some of the beach placers of Kodiak Island.

TIN

Alaskan tin production showed a noteworthy increase in 1927, though the amount of metal recovered was far below that of the period from 1911 to 1919, when the industry was at its height. The increase, however, is regarded as indicating that the production of tin ore in Alaska is on the upward trend. 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 1927, however, did not come from lodes but from placer deposits, principally in the York district, of Seward Peninsula, and the Hot Springs district, of the Yukon Valley. In the York district the placer tin, or cassiterite, is mined principally for itself, though some placer gold is also found with it. In the Hot Springs district the tin ore is a by-product obtained from deposits that are mined primarily for their gold. In the York district the tin ore was mined by two small camps, the larger of which is on Goodwin Gulch. In the Hot Springs district the tin ore was mined at three small camps in the vicinity of Tofty. The largest of these was on Woodchopper Creek. The tin ore shipped from the York region is said to have had a content of 72 per cent of metallic tin; that from the Hot Springs district carried about 65 per cent.

The production of tin ore in Alaska in 1927 was 37.5 tons, which contained 26.7 tons of metallic tin. The average price of metallic tin for the year as computed by the Bureau of Mines was 64.37 cents a pound, so that the value of the Alaska production was $34,000. Practically all of 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 shipped is sent to Singapore for reduction.

Considerable interest was shown in the reported discoveries of tin ores in the Ruby district that might justify further exploration. Late in the season a mining engineer spent several days examining three of the deposits, but the results have not yet been made public. That there is cassiterite in the district has been abundantly demonstrated by the placer miners, who find it in small quantities in most of their clean-ups. Whether it is sufficiently abundant to warrant placer miners in regarding it as more than a by-product can not, of course, be determined without further tests, and whether it may be found in the Ruby district in lodes of sufficiently high grade to be mined can be ascertained only by a great deal of prospecting and development work. The stream in the Ruby district on which prospecting for placer tin was most active seems to have been Cox Gulch, a tributary of Big Creek.

Tin produced in Alaska, 1902–1927

Year	Ore (tons)	Metal (tons)	Value	Year	Ore (tons)	Metal (tons)	Value
1902	25	15	$8,000	1916	232	139	$121,000
1903	42	25	14,000	1917	171	100	123,300
1904	23	14	8,000	1918	104.5	68	118,000
1905	10	6	4,000	1919	86	56	73,400
1906	57	34	38,640	1920	26	16	16,112
1907	37.5	22	16,752	1921	7	4	2,400
1908	42.5	25	15,180	1922	2.3	1.4	912
1909	19	11	7,638	1923	3	1.9	1,633
1910	16.5	10	8,335	1924	11	7	7,028
1911	92.5	61	52,798	1925	22.2	13.8	15,980
1912	194	130	119,600	1926	12.85	8	10,400
1913	98	50	44,103	1927	37.5	26.7	34,000
1914	157.5	104	66,560				
1915	167	102	78,845		1,696.0	1,051.0	1,007,000

COAL

More coal was produced from Alaska fields in 1927 than in any other year since coal mining began in the Territory with the single exception of 1923. Although this record is an encouraging sign, it must be remembered that the coal-mining industry of Alaska is still relatively small, as it entails a production of only about 100,000 tons a year, practically all of which is produced by two mines in the Matanuska field and one in the Nenana or Healy River field. The local output does not at all indicate the real size of the Alaskan market for coal, because each year 60,000 tons or more is imported into Alaska from fields in western United States and Canada. Thus, the total consumption of coal in Alaska in 1927 was 166,700 tons, only 62.5 per cent of which was supplied from Alaskan sources. The following table sets forth some of the significant facts regarding coal in Alaska as far back as records are available.

Coal produced and consumed in Alaska, 1880–1927

Year	Produced in Alaska, chiefly subbituminous and lignite		Imported from States, chiefly bituminous coal from Washington [a] (short tons)	Imported from foreign countries, chiefly bituminous coal from British Columbia [a] (short tons)	Total coal consumed (short tons)
	Short tons	Value			
1880–1915	71,633	$456,993	679,844	1,079,735	1,814,047
1916	12,676	57,412	44,934	53,672	111,282
1917	54,275	268,438	58,116	56,589	168,980
1918	75,816	413,870	51,520	37,986	165,322
1919	60,894	345,617	57,166	48,708	166,768
1920	61,111	355,668	38,128	45,264	144,503
1921	76,817	496,394	24,278	33,776	134,871
1922	79,275	430,639	28,457	34,251	141,983
1923	119,826	755,469	34,082	43,205	197,113
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
	986,454	5,552,000	1,164,842	1,598,875	3,732,000

[a] Compiled from Monthly Summary of Foreign Commerce of the United States, 1905–1927, Bureau of Foreign and Domestic Commerce. No figures on imports before 1899 are available.

Although the foregoing table accurately portrays the history of the coal industry in the Territory, it is a record of past accomplishment and must be viewed in that light and not given too great weight in forecasting the future. It is self-evident that as the country becomes more settled and large-scale enterprises, such as mining, develop, the use of coal must eventually increase. Even during 1927 the completion of the large power house of the Fairbanks Exploration Co. has made a new outlet for large quantities of coal, and this market alone will absorb increasing amounts as the placer-mining project which the power plant was designed to serve comes into active operation. Other power or heat users, such as canneries and even domestic consumers, many of whom are now using petroleum products or imported coal, could doubtless be induced to buy Alaska coal if they were assured of good coal at a reasonable price. That some of the Alaska coals are of at least as high grade as any of the foreign coals has been abundantly proved by careful comparisons. The preparation of the Alaska coals has not always received proper care, and in the past there have been shipments of dirty, poorly prepared coal that have lost rather than made customers for the coal producer. This condition arose mainly through inexperience and lack of business foresight and has now been practically eliminated, so that purchasers may feel assured of getting what they order in the form of a reliable, uniform product.

In attempting to forecast the future of the Alaska coal industry it must constantly be borne in mind that all the early developments were made by small groups of operators, many of whom were entirely inexperienced in handling business projects, especially those involving so many diffculties and technical problems as coal mining; and all of them were short of capital, so that programs of systematic development had to give way to getting out coal that would bring in cash. Under such conditions loss of effectiveness, here and there failures, and generally doing things in the way that will get by rather than the best way has been the price paid for gaining experience. The full price of this education has not yet been paid, and financial, labor, marketing, and other problems still beset some of the operators and make adequate development of their properties difficult.

In the foregoing table the total value of the coal produced in Alaska in 1927 is stated as $548,000. This value is only approximately correct, because the selling price of much of the output could not be determined exactly, and the average price paid by the railroad for the large quantities it purchased was abnormally low because of the size of the contracts. 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 1927 was approximately $5.25 a ton, which was the same as the average price of the coal produced in 1926 and about 50 cents a ton less than the average for the entire period shown in the table on page 55.

The two mines in the Matanuska field that produced the most coal in 1927 are those of the Evan Jones Coal Co. and the Premier Coal Mining Co. The Evan Jones mine is at Jonesville, on the Eska spur of the Chickaloon branch of the Alaska Railroad. This mine was closed during January and February and part of March, 1927, but from April to November it maintained a rather uniform output of coal. In December, however, it was closed again for the rest of the year. The Premier mine is in the Moose Creek Valley section of the Matanuska region and is reached by a narrow-gage railroad that connects with a short spur from the Chickaloon branch of the Alaska Railroad. This mine was in constant operation throughout the year, though in July its production dropped to only a small part of the monthly rate which it maintained during the rest of the year. Some complex faulting conditions were beginning to be disclosed in some of the workings of this mine, but the amount of dislocation appears to be relatively slight. Farther up Moose Creek Valley, at the mine of the Alaska-Matanuska Coal Co., mining was active during January, February, and the early part of March, but it was then discontinued. The mine produced no more coal during the year, and no suggestion that it is to be reopened in the near future has been heard. A little coal was also produced during the first three months of the year from the Rawson property, also in Moose Creek Valley, but the work was then discontinued, and during the rest of the year it has remained practically idle. The only other place in the Matanuska Valley where coal prospecting was reported was at the Heckey prospect, on Coal Creek south of Chickaloon. The work there was essentially of a prospecting character, though a few hundred tons of coal was produced. The old Government-owned mine at Eska was maintained in a more or less stand-by condition throughout the year, so that if anything should happen which might endanger the supply of coal needed for the railroad it could be quickly reopened and furnish coal. This necessitated considerable retimbering in the main passageways and other needed upkeep.

In the Nenana coal field the only producing property was the Suntrana mine of the Healy River Coal Corporation, on Healy River about 4 miles east of its junction with Nenana River. The mine is connected with the main line of the Alaska Railroad by a standard-gage spur track, which forks a short distance north of Healy station. There was a serious fire at the property in May which destroyed the tipple and was kept out of the mine only by good fortune and most strenuous exertions. Fortunately, the mine had enough coal ahead, so that it was able to supply coal uninterruptedly in spite of the fire. At once plans for the construction of a new tipple were prepared, and construction of a more adequate plant was begun. The facilities of the whole surface plant were rearranged to enable better handling of the coal, and as a result the owners came to look upon the losses caused by the fire as being in a measure offset by the great improvements brought about by the new equipment and layout. The new building and the reorganized railroad yards were completed in September, and the coal production from the property decidedly increased, attaining in December an average rate of over 200 tons for each working day. This mine has the contract for supplying coal for the power plant of the Fairbanks Exploration Co.

About 5 miles east of the Suntrana mine is a coal property that has created considerable local interest. By the end of 1926 negotiations had been entered into whereby the Alaska Railroad was to build a spur to the property if its cost were defrayed by the property owners. Attempts to interest outside capitalists in participating in the enterprise apparently were not successful, as no active work either on the construction of the spur or at the property was reported, though it was rumored at one time that a California shipping man was considering putting money into the project and that, if his decision was favorable, he would put on a fleet of colliers to carry the coal to San Francisco. The coal is of good quality, and as it lies nearly flat the owners believe that much of it can be mined by steam shovels.

A very little coal is reported to have been taken from the old mine on Chicago Creek, in northeastern Seward Peninsula. The coal is said to have been used locally by some of the placer miners, especially those of Candle Creek. This is the coal deposit to which it was proposed that the Government should extend the tram line that now runs from Nome to the vicinity of Shelton. This project was much discussed about a year ago, and a bill to put it into effect was introduced into Congress. The bill failed, and the agitation for the tram seems to have died down. From the chemical composition and physical character of this coal it is not likely to have more than local value, as most people who have used it report that they much prefer imported coal, even at a much higher price.

On Admiralty Island, in southeastern Alaska, considerable activity has been shown during the year in reopening some of the coal beds that have long been known there. Work is said to have been in progress throughout the open season, so that by the end of the year, the mine was almost in shape to begin production. According to reports the coal will be sold mainly in the local markets of Juneau and near-by districts. Analyses indicate that the coal is of good quality and of bituminous rank.

A small amount of coal is mined each year in extreme northern Alaska on Kuk Inlet, about 20 miles south of the settlement of Wainwright. This coal is dug from the beds that are exposed in the face of a cliff, sacked, and carried to Wainwright in skin boats and used locally by the white traders and natives. The customary charge is 50 cents for a sack weighing 100 pounds or less, which is at the rate of more than $10 a ton. Because of the poor conditions under which the coal is mined and subsequently handled, the coal is only moderately satisfactory, though a chemical analysis shows that it is a subbituminous coal of good quality.

No productive coal mining has been in progress in other parts of Alaska in 1927. A little prospecting is said to have been done on the coal exposures that lie north of the Yukon a short distance east of Tanana. Inquiries regarding the coal in the vicinity of Kaltag indicate that interest in these deposits still continues, but no steps looking toward their development have been taken. Reports from the Bering River coal field indicate that no new activities were in progress there during 1927. Several requests for extension of time in which to comply with certain of the Government's requirements regarding the permits it has issued for coal lands in this field indicate that some of the companies still contemplate the development of their projects if the necessary arrangements can be perfected.

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. The production from these wells was maintained at approximately the same rate as heretofore, and its value was also about the same. No new developments are reported to have taken place in this field during the year.

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

Petroleum products shipped to Alaska, from other parts of the United States, 1905–1927, 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	590,978	568,033	83,992
1907	9,104,300	636,881	510,145	100,145
1908	11,891,375	939,424	566,598	94,542
1909	14,119,102	746,930	531,727	85,687
1910	19,143,091	788,154	620,972	104,512
1911	20,878,843	1,238,865	428,750	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	271,961
1916	23,555,811	2,844,801	732,369	373,046
1917	23,971,114	3,256,870	750,238	465,693
1918	24,379,566	1,086,852	382,186	362,413
1919	18,784,013	1,007,073	3,515,746	977,703
1920	21,981,569	1,764,302	887,942	412,107
1921	9,209,102	1,403,683	2,021,033	232,784
1922	15,441,542	1,436,050	2,095,675	345,400
1923	12,285,808	4,882,015	473,826	454,090
1924	14,412,120	5,554,859	566,431	506,364
1925	16,270,746	6,993,560	562,844	580,321
1926	14,000,664	5,069,584	328,615	730,924
1927	17,628,744	8,141,574	516,306	320,450
	359,179,787	58,850,973	19,259,880	7,482,973

[a] Compiled from Monthly Summary of Foreign Commerce of the United States, 1905 to 1927, Bureau of Foreign and Domestic Commerce.

Search for new oil fields in Alaska has not been vigorously carried on during the year. At only two places was any drilling done, and at one of these the work was suspended before the end of the year, and early in 1928 formal notice was given of the company's intention to abandon the well that had been started. The property on which this well was drilled was in the Yakataga field, on the south coast of Alaska, on Johnson Creek near a seepage that had been known for some time. Work at this well was started by the General Petroleum Corporation of California in 1925, but active drilling was not begun until the summer of 1926. By the end of that year the well, known as Sullivan No. 1, had been sunk to a depth of 865 feet. During 1927 drilling was resumed and carried on uninterruptedly until about the middle of October, when a depth of 2,005 feet was reached and work suspended. The geologic formations encountered in this well were dominantly hard sandstone and sandy shale with minor amounts of limy beds. Small showings of gas were encountered at various depths from the surface to a depth of 232 feet and again at 1,643 feet. The size of casing used in different sections of this well was as follows: From surface to 60 feet 15½ inches, from 60 to 192 feet 12½ inches, from 192 to 555 feet 10 inches, from 555 to 2,005 feet 6 inches. This casing was left in the well when the company abandoned work on it.

The only other place at which drilling for oil was in progress during the year was in the Matanuska Valley a few miles west of Chickaloon, on the property of the Peterson Oil Association. Work at this place started in 1926 but was discontinued throughout the winter and renewed in 1927. Except for the deposit of glacial till and outwash material about 180 feet thick that formed a mantle covering bedrock at the place where drilling was started, the beds penetrated have been sandstone and shale of the coal series that is the general country rock of that region. Several beds of coal have been cut by the drill and evidently represent some of the coals that are characteristic of the Chickaloon formation. The rock formations in the vicinity of the well have a strong dip, so that the drill does not cut directly through them but angles across, thus making the thicknesses appear much greater than they actually are. For this reason identification of individual beds by their thickness is almost impossible without more data than are available. At a depth of about 225 feet considerable gas was struck in the well. This could be ignited readily with a match and burned with a yellowish flame. The presence of a coal bed in the well at about this same depth strongly indicated that the gas may have been evolved from the coal rather than from an accumulation of oil. To get information on this point a sample of the gas was collected and shipped to the Bureau of Mines laboratory in Pittsburgh for analysis, as the composition of the gas may shed light on its probable origin. The results of the analysis of this sample have not yet been made known. When work was discontinued for the winter of 1927 the well had reached a depth of 865 feet. The geologic conditions in the general vicinity of the well, so far as known, are not such as are usually associated elsewhere with commercial deposits of petroleum. The Peterson Oil Association, however, felt that the results it has so far accomplished were encouraging enough to warrant it in resuming drilling at this place as early in the spring of 1928 as practicable. So much effort and money have already been put into this work that the additional expense of continued drilling to obtain decisive proof whether or not oil is present is probably justified.

No further explorations by the Government of Naval Petroleum Reserve No. 4, in northern Alaska, were made during the year. A comprehensive report giving an account of the recent work that had been done by the Geological Survey in determining the major topographic and geologic features of the region, together with an analysis of the facts bearing on the presence of petroleum, was completed in 1927 and has been forwarded to the officials who are concerned with the problem and is also to be published by the Geological Survey.[13] No official announcement of the policy that will be followed by the Government with regard to this tract has been made. The general results of the exploration of this area by the Geological Survey have indicated that the Government is not warranted at this time in looking to this field as a potential source of oil for the Navy unless it is prepared to prospect the field adequately—a work that will entail considerable expense. The data already obtained indicate that such prospecting is likely to be worth while, but it is distinctly wildcatting and should not be regarded otherwise, either by the Government or by private companies if the reserve is thrown open to prospecting.

MISCELLANEOUS MINERAL PRODUCTS

The list of minerals of commercial value that have been found in Alaska is long. In addition to those described in the preceding sections of this report, the following have at one time or another been produced in sufficient quantity to arouse more than local interest, and some of them have been and still are the basis of profitable industries: Metallic minerals—antimony, arsenic, bismuth, chromium, iron, manganese, mercury, molybdenum, nickel, tungsten, zinc; nonmetallic minerals—asbestos, barite, clay, garnet, graphite, gypsum, jade, lime, marble, mica, stone, and sulphur. Unquestionably in 1927 small quantities of practically all these minerals were "produced" in the broadest sense of the word, but with the exception of stone, marble, and antimony, none of them were sold

[13] Smith, P. S., and Mertie, J. B., jr. Geography and Geology of Northwestern Alaska: U. S. Geol. Survey Bull. — (In preparation).

to an extent that justified their being considered to have contributed materially to the mineral output of the Territory.

Practically the entire output of Alaska marble comes from quarries owned and operated by the Vermont Marble Co. In the past the company's output of marble has come mainly from quarries at Tokeen, on Marble Island, off the northwest coast of Prince of Wales Island. Depletion of these deposits and demand for more of its product led the company to search the adjacent region for other deposits of the type desired. After a long hunt satisfactory masses of marble were found in the vicinity of Calder and El Capitan, and they will be developed as rapidly as conditions permit. At present all the marble shipped by the Vermont Marble Co. is rough stone that is dressed in the States for use in interior decoration. In the past several marble quarries were in operation in southeastern Alaska, and it seems strange that deposits so favorably situated with respect to ocean transportation have not been profitably developed. According to Burchard,[14] many different types of marble occur in these deposits, some even approaching statuary grade.

A new industry that is somewhat remotely related to the quarrying of marble was started during the year on Dall Island, in the extreme southwestern part of southeastern Alaska. This is the production of high-grade limerock required as one of the constituents of cement. This project is being carried on by the Pacific Coast Cement Co., whose principal plant is near Seattle. The company proposes to mine the limerock on Dall Island and transport it to Seattle in a fleet of its own ships and there grind the limestone and make the necessary mixture with other constitutents to produce cement. This plan was announced late in the year, though the search for a suitable limestone had been going on for some time, and active preparations were at once started for sending to Alaska the necessary personnel, equipment, and materials for the plant that the company will construct on Dall Island. The company expects to have the property in condition to begin shipping limestone early in the summer of 1928.

Antimony ore carrying approximately 35,000 pounds of the pure metal was produced as a by-product from concentrates of certain of the lode mines in the Fairbanks district. These concentrates were shipped to one of the smelters in the States for treatment. A considerable body of high-grade antimony ore was reported to have been discovered in the fall on claims on Cleveland Peninsula, in the Ketchikan district, southeastern Alaska. Rich antimony ore has been known in this same general region for several years. It is reported

[14] Burchard, E. F., Marble Resources of Southeastern Alaska: U. S. Geol. Survey Bull. 682, 118 pp., 1920.

that near the end of the season engineers made an examination of certain antimony prospects in the Kantishna district. This examination is said to have been made for English interests that would probably not be favorable to going into any development work there unless rather large tonnages were indicated.

The mill of the Alaska Juneau Gold Mining Co. is being equipped to recover the zinc that now goes to waste in the treatment of its ore. This project had not been under way long enough to affect the production of the mine for 1927, but its effect should be apparent in 1928.

Some prospecting and development work is said to have been continued on the nickel-bearing ores of the Chichagof district, but no ore is reported to have been produced for sale during the year.

No late information has been received regarding developments among the quicksilver deposits of the Kuskokwim. Probably prospecting has been in progress at some of the claims, but there is no record that any metallic mercury was produced or sold, and it seems extremely doubtful whether any was sold except for local use.

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 Ambler River. That these minerals occur in that district has long been known, but the expense and difficulty of developing them in that remote region, even if they should be of higher quality than any samples so far seen, seems to shut out the possibility of their being mined at a profit or in appreciable quantities at present.

During the late summer samples of manganese-bearing rock that was said to occur in large quantities in the Broad Pass region, at the head of Nenana River, were brought in by a prospector. The real quality and quantity of this material can not be determined positively without more thorough examination in the field, but the character of the sample did not appear to indicate a body of manganese ore of commercial value. A prospector in the Noatak region sent a small piece of rock to the Geological Survey for identification. Although it contained some manganese, the tenor was so low and the region from which it came so remote that the deposit from which it was derived is regarded as probably having no commercial value.

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

In many of the tables accompanying this report a group of so-called miscellaneous mineral products has been shown. This group includes not only the products mentioned in the foregoing paragraphs but also all the others that are produced in quantities so small that to list them separately would disclose the production of individual operators. Among the mineral commodities that are included in this miscellaneous group in the tables are stone, marble, petroleum, quicksilver, and platinum. A large part of the decrease in the reported production of these minerals in 1927 was due, as already noted, to the cessation of palladium lode mining.

Value of output of miscellaneous mineral products of Alaska, including platinum, petroleum, gypsum, marble, and other products, 1901–1927

Year	Value	Year	Value	Year	Value
1901	$500	1911	$141,789	1921	$235,438
1902	255	1912	165,342	1922	266,296
1903	389	1913	286,277	1923	229,486
1904	2,710	1914	199,767	1924	348,728
1905	710	1915	205,061	1925	454,207
1906	19,965	1916	326,737	1926	444,500
1907	54,512	1917	203,971	1927	162,000
1908	81,305	1918	171,452		
1909	86,027	1919	214,040		[a] 5,125,000
1910	96,408	1920	372,599		

[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.

ADMINISTRATIVE REPORT

By Philip S. Smith

INTRODUCTION

In 1867 the people of the United States bought Alaska, and in so doing they assumed, as a necessary result of that ownership, an obligation to and an interest in the new possession. For many years after the purchase, however, this obligation was not keenly felt and there was little interest in Alaska except for its strangeness. After the discovery of bonanza deposits of gold within its borders the people in general began to look upon "Seward's Folly" as a real asset. With the recognition of this value came the demand for authoritative information regarding all phases of its character and resources, so that as owners the people might wisely plan for the development of their possession. This was not done through any sense of paternalism or condescension but was simply the action that any landlord, owner, or trustee would take in handling property in his charge. The Federal Government, as the agency through which the whole people expresses its will, was early among the organizations that keenly felt the need of accurate information regarding Alaska, if it as trustee was to see that its client's interests were properly administered.

Obviously, among the first things people wished to know about Alaska were its geography, the character, extent, and distribution of its natural features, and its mineral resources. This information was sought by many of the people in the dual capacity of landlords and prospective tenants. It was the sort of information that naturally fell within the field of activities of the Geological Survey, many of whose geologists had made notable contributions to knowledge of the mineral resources of the West when that region was frontier country. So for more than 30 years to the Geological Survey has been intrusted the task of supplying information regarding the mineral resources of the Territory and using its best efforts to aid the mining industry in developing those resources, the legislative bodies in dealing with problems relating to the best utilization of those resources, and the people in general in understanding Alaskan geography and geology, which enters into every line of endeavor that pertains to the Territory. In fulfillment of its duties the Geological Survey has published hundreds of reports regarding all the known mineral-producing camps and much of the country adjacent to them, and hundreds of maps that show the geology and the topography of more than two-fifths of the entire Territory, answered thousands of inquiries of all sorts, and prepared annual statements of the production of the different mineral commodities from different parts of Alaska.

The task before the unit of the Geological Survey that is intrusted with the Alaskan work is therefore a major project whose entire accomplishment is still far in the future. Approach toward this end, however, is made by the continuous accumulation of facts through original surveys and investigations and the utilization of all results of work by others that bear on the general problem. The main task is therefore a continuing one, with no sharply marked breaks or interruptions that form natural regular intervals at which to report progress. However, it is obviously necessary that a periodical accounting of the Survey's stewardship of this trust should be given, and in accordance with general governmental practice, the fiscal year has long been used as the period to be covered by the annual report. The selection of any regular period leads to difficulties in properly describing any scientific or technical work, and the fiscal year is an especially inappropriate period to use in describing the Alaskan work of the Geological Survey. Even if the individual undertakings of a single year are considered to be specific projects, there is no uniformity in starting or completing them. The field projects begin whenever the conditions are suitable; some may be started in January and others in July, and the actual field work may close in July or in October, but there still will be a large amount of office work in preparing the reports and maps that is as much an integral part of the projects as the field work. Many times the preparation of the report and map may run over a year or more, so that it may or may not be considered two separate projects. Furthermore, the fiscal year for the Survey's Alaskan work is a most variable period, because most of the appropriations for this work are made immediately effective on the passage of the act through which the money is appropriated. Thus, the act may pass at any time from January to June, and the funds its authorizes may at once be allotted and expenditures commenced. It is therefore not at all uncommon for two projects to be carried on simultaneously and yet be paid for from two different appropriations for the same object. For instance, the appropriation for the Alaskan work in the 1928-29 act for the Interior Department became effective on March 7, 1928, and was available for expenditure at any time after that date until June 30, 1929. At the same time, the similar appropriation contained in the act for 1927-28 was available for expenditure until June 30, 1928. Therefore the determination to which of these appropriations a certain project should be charged was based more upon administrative convenience than upon difference in character or object of the work. To attempt to separate two jobs simply because they were paid for from different appropriations would fail to give a correct picture to one interested in the work rather than in the details of accounting procedure. For this reason in the following pages the projects have been described principally on the basis of what may be called field seasons, though not all of the time was spent in the field. Thus, the field season of 1927 began in the late winter or early spring of 1927 and continued, with related office work, into the spring of 1928, when the projects of the 1928 field season were started. Of course, some of the projects naturally fall better into other periods. For instance, 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 the year to which the statistics relate.

Although there is no direct relation of the field-season year to the fiscal year, the amount of money spent during any field season closely approximates the amount of money appropriated for the fiscal year. Thus, on the whole, expenditures for starting parties before July 1 in the field season of 1927, for example, which were paid from one appropriation, are about offset by the expenditures of the parties that start before July 1 of the next field season, which are paid from the next appropriation. In other words, the sum of the expenditures during a field season, though perhaps paid from two appropriations, is essentially identical with the total amount of the appropriation available for a single fiscal year, unless there is a very marked change in the amounts of money appropriated in the two 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 1926–27 the amount specified in this item was $50,000, in the act for 1927–28 it was $60,000, and in the act for 1928–29 it was $64,500. Each of these appropriations was available immediately on the passage of the act in which it was contained.

The other item is an allotment made from the appropriation "for the enforcement of the provisions of the acts of October 20, 1914, October 2, 1917, February 25, 1920, and March 4, 1921, and other acts relating to the mining and recovery of minerals on Indian and public lands and naval petroleum reserves, * * *." Appropriations carried under this item are available only during the specified fiscal year. In the fiscal year 1926–27 an allotment of $19,500 was made for the kind of work in Alaska that is described by the language of the act, and for the fiscal year 1927–28 the allotment was reduced to $14,500. The two types of work indicated by the different phraseology of the appropriation items will be described separately in the following pages and for convenience will be referred to briefly, as the work on mineral resources and the leasing work.

WORK ON MINERAL RESOURCES

PRINCIPAL RESULTS OF THE YEAR

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

Mineral industry of Alaska in 1925, by F. H. Moffit (Bulletin 792–A).

Administrative report, 1925–26, by F. H. Moffit (Bulletin 792–A).

Geology of the Knik-Matanuska district, by K. K. Landes (Bulletin 792–B).

The Toklat-Tonzona region, by S. R. Capps (Bulletin 792–C).

Geologic investigations in northern Alaska (1925), by Philip S. Smith (Bulletin 792–C).

Mineral resources of Alaska, 1925, by F. H. Moffit and others (Bulletin 792).

Mineral industry of Alaska in 1926, by Philip S. Smith (Bulletin 797–A).

Administrative report 1926–27, by Phililp S. Smith (Bulletin 797–A).

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

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

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

The Sheenjek River district, by J. B. Mertie, jr. (Bulletin 797–C).

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

Aerial photographic surveys in southeastern Alaska, by R. H. Sargent and F. H. Moffit (Bulletin 797–E).

The Aniakchak district, by R. S. Knappen (Bulletin 797–F).

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

Geology of Hyder and vicinity, with a reconnaissance of Chickamin River, southeastern Alaska, by A. F. Buddington (Bulletin 807).

Geology and mineral resources of northwestern Alaska, by Philip S. Smith and J. B. Mertie, jr.

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

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

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

The Mount Spurr region, by S. R. Capps.

The Chandalar-Sheenjek district, by J. B. Mertie, jr.

Geology of the Eagle-Circle district, by J. B. Mertie, jr.

The reports listed below have been in course of preparation by their authors as time permitted but have not yet approached near enough to completion to warrant any definite statement as to when they are likely to be printed and available:

The Tertiary floras of Alaska, by Arthur Hollick.

The igneous geology of Alaska, by J. B. Mertie, jr.

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

The geology and mineral resources of the Chitina quadrangle, by F. H. Moffit.

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

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

Several other manuscripts are in course of preparation by their authors, but so little progress has yet been made in getting them in shape for publication that they are not listed above.

Practically every one of the foregoing reports is accompanied by maps, the base of which has been made principally from surveys conducted by the topographers of the Alaskan branch. Among these maps the following were completed during the year by members of the branch under the general direction of R. H. Sargent or were issued by the Geological Survey either in a preliminary photolithographic edition or in complete form:

Topographic map of northwestern Alaska, a map compiled from all available sources but mainly from surveys by the Geological Survey and including many new topographic data, derived principally from recent plane-table surveys by Gerald FitzGerald; scale, 1:500,000. Not to be issued separately from the report on northwestern Alaska by Smith and Mertie now in preparation.

Topographic map of Aniakchak district, by R. H. Sargent; scale, 1:250,000. Issued as a free preliminary photolithographic edition and to be included in the report on the Aniakchak district, by R. S. Knappen, in Bulletin 797.

Topographic map of East Fork of Chandalar-Sheenjek region, by Gerald FitzGerald and J. O. Kilmartin; surveyed on scale of 1:250,000 but compiled on scale of 1:500,000. Not to be issued separately from report on Chandalar-Sheenjek region by J. B. Mertie, jr.

Drainage map of part of the Hyder-Ketchikan region, southeastern Alaska, compiled mainly from aerial photographs made by the Navy Department, at the request of the Geological Survey. Compilation made under direction of R. H. Sargent; scale, 1:250,000. Not to be issued separately from the report on aerial photographic surveys in southeastern Alaska by Sargent and Moffit in Bulletin 797.

Preliminary topographic map of part of the Mount Spurr region, Alaska, by R. H. Sargent; scale, 1:250,000. To be issued as part of the report on the Mount Spurr region by S. R. Capps. This map will probably later be combined with the results of other surveys and issued separately as a compiled map in a free photolithographic edition.

In addition to these more detailed maps the base map of Alaska on a scale of 1:5,000,000 was revised and brought up to date, and an edition was issued in 1927 for sale. This same map was also published during the year as an index map to show the progress of topographic mapping in the Territory, containing on the back a list of selected publications of the Geological Survey that describe the mineral deposits of Alaska and the features of its major geographic divisions.

Besides the official reports, several articles were prepared by the scientific and technical members or former members of the Alaskan branch for publication in outside journals, and a number of 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 excellent by-products of the regular work and serve to reach special audiences not readily reached by the regular form of official publication. Among the articles of this sort may be mentioned the following:

Some post-Tertiary changes in Alaska of possible climatic significance, by Philip S. Smith, published in National Research Council Bull. 61, pp. 35–39, 1927.

The Alaskan branch of the Geological Survey, by Philip S. Smith, published in Mining Congress Jour., vol. 14, pp. 165–166, 1928.

Aerial surveys in southeastern Alaska, by R. H. Sargent, published in The Military Engineer, vol. 20, pp. 189–195, 1928.

Types of mineralization of southeastern Alaska, by A. F. Buddington, published in Econ. Geology, vol. 22, pp. 158–179, 1927.

Mineral deposits of the Hyder district, by W. B. Jewell, published in Econ. Geology, vol. 22, pp. 494–517, 1927.

The Mount Spurr region, Alaska, by S. R. Capps, delivered at meeting of Geological Society of America, Cleveland, December, 1927.

PROJECTS IN PROGRESS DURING SEASON OF 1927

Many of the results that the Geological Survey has achieved in Alaska may be expressed in terms of area covered. The following tabular statement indicates the areas covered by the surveys of different types. It should be noted that the areas are stated by field seasons and that no report is made for the field season of 1928, because that work is still in progress and the parties are all out in the field beyond reach of communication, so that the extent of the work can not be predicted. The absence of this information is relatively immaterial for all practical purposes, because for the field season of 1927 all of the area surveyed during that season is counted, even though part of the work was done during the fiscal year which ended on June 30, 1927. Therefore the areas surveyed in the fiscal year 1926-27 on projects that fall within the 1927 field season may be considered to offset the areas surveyed in the fiscal year 1927-28 that fall within the field season of 1928 but have been disregarded in the tabulation.

Areas surveyed by Geological Survey in Alaska, 1898–1927, in square miles

Field season	Geologic surveys			Topographic surveys		
	Exploratory (scale 1:500,000, 1:625,000, or 1:1,000,000)	Reconnaissance (scale 1:250,000)	Detailed (scale 1:62,500 or larger)	Exploratory (scale 1:500,000, 1:625,000, or 1:1,000,000)	Reconnaissance (scale 1:250,000; 200-foot contours)	Detailed (scale 1:62,500; 25, 50, or 100-foot contours)
1898–1926	75, 150	163, 255	4, 277	55, 630	197, 400	4, 066
1927		6, 350			7, 465	
Correction [a]	75, 150	169, 605	4, 277	55, 630	204, 865	4, 066
		300			300	
	75, 150	169, 305	4, 277	55, 630	204, 565	4, 066
Percentage surveyed of total area of Alaska	42. 4			45. 1		

[a] See text for explanation.

In the table given above only the net areas surveyed are listed in the appropriate columns and there is no duplication of area within the three columns relating to geologic surveys nor in the three columns relating to topographic surveys, though of course most of the areas that have been surveyed geologically have also been surveyed topographically. In other words, none of the area that is reported in the column of reconnaissance geologic surveys, for example, is also reported in the columns for geologic exploratory or detailed surveys. It is by no means unusual that in the course of later surveys it becomes desirable to revise the mapping or to resurvey on a large scale an area that had already been surveyed on a smaller scale. To avoid duplication in the statement of areas thus surveyed, it is necessary to deduct the proper amount from the area previously reported. This deduction for 1927 is shown in the line labeled "Correction" in the foregoing table. An area of 300 square miles previously covered by reconnaissance topographic and geologic surveying was resurveyed in 1927 with greater precision in the course of the regular work.

The necessity for resurveying in more detail some areas that were once mapped on a smaller scale is not due to faulty execution of the earlier surveys or to poor judgment in determining the scale first used. For many areas in Alaska exploratory mapping is all that may be warranted at first. As development of the areas progresses more specific information may be required and a more detailed survey made, and in an intensely developed mining camp only a most detailed map would furnish the desired information. To spend money on making detailed surveys everywhere would be a waste of time and funds far more reprehensible than the resurvey of different tracts here and there as changed conditions call for better maps.

Even in those areas where it is anticipated that more detailed maps may be required it has usually seemed best to make rapid and relatively inexpensive exploratory surveys so as to supply the most urgent demands for immediate information and then follow with the necessarily slower and costlier detailed surveys. This was practically the course adopted when the first stampede to Nome was in progress, for within two or three months of the return of the Federal geologist from this camp an exploratory map of the environs of Nome was published by the Geological Survey. This was succeeded the next year by reconnaissance field surveys of much of the region within 100 miles of Nome, and only a few years later detailed mapping was undertaken of the tracts adjacent to the richest mining camps.

At present the scale most generally adopted for Alaskan work is 1:250,000, or about 4 miles on the ground represented by an inch on the map, with a contour interval of 200 feet. That scale is adequate for general purposes, and by its use surveys can be performed expeditiously and very cheaply. It is obvious, however, that this scale is entirely inadequate for furnishing the more specific data required in many problems. Therefore, though the area that has been surveyed geologically is about 42 per cent of the Territory, only about 30 per cent has been surveyed on a standard that can be regarded as of reconnaissance grade. Unquestionably a greater number of detailed surveys should be made, but when it is realized that at the rate at which the work is now being done it will still be about 50 years before all the parts of the Territory that appear to show promise of containing deposits of minerals that may be of commercial value are surveyed even on a reconnaissance scale, it is evident that detailed surveys are practically out of the question unless more funds are made available.

The regions in which the surveys were made in 1927 as tabulated above were the Nizina district, of the Copper River region; the Sheenjek-East Fork of Chandalar district, in the northeastern part of the Yukon Basin in Alaska; and the vicinity of Mount Spurr, in the Alaska Range of southwestern Alaska. The work in the Copper River region was in charge of F. H. Moffit, who, with a small camp equipment and one camp hand, was engaged in general reconnaissance geologic studies directed toward obtaining additional data on the occurrence of the copper deposits of that region. In the course of the work much new geologic information was collected, and several areas that had been given but passing attention during the earlier surveys were more critically examined. Incidentally to the regular work of this party, the mining camps in the Nizina and Chitina Valleys were visited, and late information regarding recent developments of the mineral resources of the whole district was collected.

The work in the Sheenjek-East Fork of Chandalar region was a combined geologic and topographic reconnaissance survey in charge of J. B. Mertie, jr., geologist, with Gerald FitzGerald, topographer, and two camp assistants. In order to utilize most effectively the short open season the topographer left Washington in February and went by ordinary means of transportation to Fairbanks, where a dog team was purchased and a camp assistant hired. This advance party then traveled by dog team to Circle and thence to Fort Yukon where necessary supplies and equipment needed for the rest of the season were bought. From Fort Yukon this party early in April struck across country for Christian River and Arctic Village, on the East Fork of Chandalar River, having hired natives to help freight in some of the supplies. Surveys were started, and while sledding on the snow was still possible caches of supplies were distributed at selected points so that they would be available during the summer. With the break-up of the ice on the rivers, so that travel by regular lines of transportation could be resumed, the geologist went to Fort Yukon, where with a small load of supplies in a canoe, he and one camp hand started up Chandalar River. Travel upstream was extremely slow because of the high water in the river and speed of the current, but eventually junction with the advance party was made and the work carried on by the combined unit. During the subsequent work the men traveled entirely on foot, and the only means of transporting their supplies was on their own backs or on those of their dogs. With the approach of cold weather the party descended East Fork of Chandalar River in skin boats until they reached the point where the geologist's canoe had been left in the course of the upstream journey in the spring, and then the return journey to Fort Yukon was resumed and carried on as rapidly as stops necessary to make the desired surveys permitted. This work resulted in approximately 3,700 square miles of geologic reconnaissance mapping and 4,900 square miles of topographic reconnaisance mapping of hitherto unmapped country and, in addition, the resurvey, both topographic and geologic, of 300 square miles of country that had been mapped with less precision in an earlier year. A fuller account of this work and its results is given in another section of this volume.

The field project in the vicinity of Mount Spurr was conducted by a combined geologic and topographic party in charge of S. R. Capps, geologist, with R. H. Sargent, topographer, and four camp assistants. These surveys were essentially a continuation of those made to the north of Mount Spurr in 1926. Through the courtesy of the Alaska Railroad the party, with all its equipment, was landed at Trading Bay, on the west side of Cook Inlet, about the middle of June and thence proceeded westward, mapping the country as it advanced. The coastal part of the region is exceedingly difficult to traverse because of the swampy lowlands, the large streams, and the tangle of trees and brush. In the mountainous part of the region the slopes are steep, the large streams are unfordable and flow with great velocity, and glaciers protruding from the valleys block the natural routes, so that passage is prohibited or made only after laborious effort. For instance, to build a trail passable for horses across one of the moraine-covered glaciers required the work of all members of the party for a time equivalent to the labor of one man for 20 days. Many interesting geologic and geographic facts were brought to light by the surveys of this party, besides the reconnaissance topographic mapping of 2,265 square miles of hitherto unmapped country and the reconnaissance geologic survey of 2,000 square miles. Among these items may be mentioned the discovery of a large river, numerous lakes, glaciers, mountains, and an active volcano. Unfortunately, the observations made by this party do not indicate that the region offers much promise of containing mineral deposits that are of present economic value. These facts, together with many more details concerning this region, are given in a separate chapter of this volume.

The only other field work in progress was a general reconnaissance of several of the placer-mining camps in Seward Peninsula and of a few of the camps along the western stretches of the Yukon and in the vicinity of the Alaska Railroad. This work, which was done by Philip S. Smith, does not lend itself to expression in terms of area and was undertaken mainly to provide information regarding recent mining developments and to permit the laying out of plans for future work, so as best to fit the needs of the industry. No separate report will be issued describing the results of that work, but many of the facts learned in the course of it have been incorporated in the chapter on the mineral industry of Alaska in 1927, which forms a part of this volume.

One other piece of field work which was done by the Geological Survey in Alaska, though not under the jurisdiction of the Alaskan branch or at its expense, comprised volcanologic studies conducted in the Aleutian Islands, Alaska Peninsula, and Kodiak Island by T. A. Jaggar, jr. This work was an outgrowth of studies that have been carried on for many years in the Hawaiian Islands and consisted in a general reconnaisance of the western part of the Territory and the installation of instruments that will record various seismologic data.

One of the most important pieces of work that was started in the winter of 1926–27 and will be continued for several years is the compilation and working up into maps of the aerial pictures taken by the Navy Department, at the request of the Geological Survey, of a large part of southeastern Alaska. This work has been largely under the technical direction of R. H. Sargent, with the cooperation of F. H. Moffit in special phases of the work. As the preparation of the photographs for cartographic use and their assembly into large-scale drawings is a type of work which the topographic branch of the Geological Survey is especially well prepared to do, arrangements were made for this part of the work to be done by that branch, and Messrs. J. H. Wheat, E. A. Shuster, Eric Haquinius, and R. K. Lynt were largely responsible for the excellent results achieved. These assembly sheets were then adjusted by members of the Alaskan branch to correct their scale and position and compiled to form a drainage map of a tract of about 2,000 square miles that includes all of Revillagigedo Island and some of the near-by islands. This map is included in the report on that work, which forms another chapter in this volume. No relief is represented on this map, and it was expected that the next step in converting this drainage base into a complete topographic map would be field surveys. While the compilation work was in progress a specially devised machine known as an aerocartograph, for determining relief directly from photographic plates by means of stereoscopic principles, was made available to the Geological Survey for experimental use. It at once became evident that, if the machine could do the work successfully, it might be a better means of performing the next step of the work than ordinary field methods. Experiments were therefore begun, in cooperation with the topographic branch, to test the quality and cost of this method. The results are not yet available for analysis, but so far as the tests have gone they appear to justify belief that the results may compare favorably with these obtained by other methods. The topography of southeastern Alaska furnishes a very severe test of the applicability of the method, for the relief in that region is so strong that distortion of scale by aerial photographs is especially great. It offers many advantages over ground methods, however, because of the difficulty of traversing the high ridges, precipitous ledges, and almost impenetrable forest and brush clad slopes.

Another of the major projects of the Alaskan branch is the annual compilation of statistics of the production of all the mineral commodities from the Territory. The production is reported on the basis of the calendar year, but the work of canvassing the producers and assembling data goes on uninterruptedly; for example, the work relating to the production of minerals in 1927 started on January 1, 1927, and was not finally completed until June, 1928, and during part of that period it was carried on coincidentally with the canvass that covers the production in 1928. The results of this annual survey of the mineral industry of Alaska are published as a separate section in this volume.

In addition to the office work that is an essential part of completing the current field projects, there are a number of former field projects on which the office work had not been completed during the season in which the field work was done. This work includes the critical reading of proof of reports that are being printed, the preparation of manuscript for copy, and even laboratory examination of some of the material collected. Considerable work of this sort was accomplished during the season, and as a result four reports that had been begun in earlier seasons were completed and are now in various stages of editing or publication. Those reports are as follows:

Geology and mineral resources of northwestern Alaska, by Philip S. Smith and J. B. Mertie, jr.

The Chandalar-Sheenjek district, by J. B. Mertie, jr. In Bulletin 810.

Geology of the Eagle-Circle district, Alaska, by J. B. Mertie, jr.

Geology of Hyder and vicinity, with a reconnaissance of Chickamin River, southeastern Alaska, by A. F. Buddington.

Geology and mineral deposits of southeastern Alaska, by A. F. Buddington and Theodore Chapin.

Some progress was also made during the year on the preparation of the reports listed on page 69 as still in the author's hands. Of these, the most active work was done on the "Igneous geology of Alaska," by J. B. Mertie, jr., and the "Geographic dictionary of Alaska," by James McCormick.

In all the office work on the technical reports the members of the Alaskan branch have received considerable assistance and 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, examined and reported on fossils collected in the course of the surveys. C. S. Ross made several tests of certain clay minerals, and the chemists of the geologic branch assisted in identifying and testing certain rocks and minerals from Alaska. The map editors of the topographic branch were also helpful in critically scrutinizing the maps that were in course of preparation to see that they conformed so far as practicable to the best Geological Survey standards.

PROJECTS FOR THE SEASON OF 1928

The projects for the field season of 1928 had been under way only a short time at the end of the fiscal year 1927-28, and as all the parties are out of touch with ordinary means of communication it is not practicable at this time to make any detailed statement of the work actually accomplished or to give much more than an outline of the principal objects of the different projects. Six field projects were under way before the end of the fiscal year 1927-28 and will continue through the open season. These are as follows: Reconnaissance topographic mapping in the Ketchikan district, southeastern Alaska; detailed topographic mapping on Admiralty Island, southeastern Alaska; geologic reconnaissance mapping in the Nizina district of the Copper River region; geologic reconnaissance mapping in the upper Tanana and Yukon regions west of the international boundary; combined geologic and topographic reconnaissance mapping in the Alaska Range region of southwestern Alaska; and a general inspectional trip to check up recent mining activities in the Territory and to visit some of the field parties.

The reconnaissance topographic mapping in the Ketchikan district, which is in charge of R. H. Sargent, was planned primarily to furnish an adequate topographic map of this important district. This is part of the area of which the drainage map compiled from aerial photographs, noted on page 75, has already been prepared. In addition, therefore, to furnishing a useful map, this survey should supply many valuable tests by which to compare the accuracy and the relative cost of the base made by phototopographic methods and a map made by ordinary ground methods. Very probably the tests will show that certain combinations of the two methods may be desirable. At any rate, all the data obtained will be extremely valuable in determining the best method of conducting the work and will give information that must be available before further compilation of the thousands of photographs already in hand can be undertaken with assurance as to the results.

The other topographic work in southeastern Alaska is being performed by a Geological Survey topographer, R. K. Lynt, who is attached to a timber-cruising party of the Forest Service. The cost of this work is being borne entirely by the Forest Service through transfer of funds to the Geological Survey, and it is therefore not included in the table of expenditures given on page 80. The work is regarded by the Forest Service as an indispensable part of its activities in developing the paper-pulp industry in southeastern Alaska. Obviously adequate topographic maps are among the first things needed in laying out plans for the efficient and economical utilization of the natural resources of the region. The work will be done on a scale of 1:62,500, which will give a much more detailed map than most of the Geological Survey's maps of Alaska, except those of areas in the immediate neighborhood of the richest mining camps. The area covered will therefore probably be small.

The work that is being undertaken in the Copper River region has been so planned as to form a continuation of the work that has been in progress there during the last three seasons by amplifying the observations of earlier geologists and reviewing their conclusions from the vantage ground of the added experience and information which have accumulated in the score of years that have elapsed since the earlier work was done. This work is to be done by a party consisting only of F. H. Moffit and one camp assistant. These more thorough studies seem to be essential to working out the true geologic history of the region, and until that history is better understood no satisfactory conclusions can be drawn regarding the origin of the great copper deposits of the region or their probable extension into the regions where they are not yet known. In addition to these more strictly geologic duties Mr. Moffit will collect general information regarding all the mining activities in the Copper River region and will visit such operating mines as time and other conditions permit.

The reconnaissance geologic and topographic survey in the Alaska Range region west of Mount Spurr is perhaps the most difficult project that is being undertaken in the summer of 1928. This work is in charge of S. R. Capps, geologist, with Gerald FitzGerald, topographer, and four camp assistants. The plans of the party contemplate the hire of commercial airplanes to transport perhaps half a season's supply of food and equipment and the geologist, topographer, and one assistant to a lake discovered by the party during its work in the season of 1927, where work that joins with those earlier surveys will be started. In the meantime a pack train of 13 horses and 3 camp assistants, with supplies for half the season, will go overland to this lake by way of the trail made in 1927. When the two sections of the party have united, the work will be pushed westward as rapidly as possible, and the mountains will be crossed at a pass discovered and described by R. H. Merrill, one of the aviators whose headquarters are at Anchorage, who has made many flights across the range. The party will then carry their surveys into the valleys of the streams on the west side of the range that are tributary to Kuskokwim River. If other passes across the range are discovered in the course of this work, the party in the fall may cross back to the east side of the mountains by one of them; or, if not, it will return by way of its outgoing route and be picked up about the middle of September at Trading Bay by a boat sent out through the courtesy of the Alaska Railroad. The geographic results of this expedition should be of great interest, as the surveys will traverse many hundred miles of hitherto unexplored country that has long remained a blank area on maps.

North of Tanana River adjacent to the international boundary and extending westward for more than a hundred miles is a triangular tract of country that lies south of the Fortymile placer district. A reconnaissance topographic map of this tract was made a number of years ago, but the geology was not mapped. In this tract a geologic party in charge of J. B. Mertie, jr., and two camp assistants, with a small pack train, was to make geologic surveys during the season of 1928. A serious injury to one of the members of the party necessitated return to Eagle in order to send the man to the hospital. As the party was too short-handed to tackle the job without additional assistance and as in that remote region it might be impossible to obtain a packer without too much delay, the original plans were suspended and alternative plans suggested. At the time that this report is submitted selection between these various plans had not been made, but whatever the choice, it will involve carrying on some geologic work in the general tract between Yukon and Tanana Rivers. As is true with respect to most of Alaska, there is no trouble in finding problems that are worth while undertaking; the trouble lies in selecting the one which can best be done under existing conditions.

The only field work of a general character that is to be conducted by a member of the staff with headquarters in Washington during the season of 1928 is 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 recently been visited by members of the Geological Survey. In the course of this work it is proposed to visit such of the Geological Survey parties and local offices as can be reached without too much delay, so as to be in close personal touch with the problems of each. This work will be done by the chief Alaskan geologist, who left Washington the last of June.

On July 1, 1925, certain of the work related to mining on the national domain that was formerly performed by the Bureau of Mines was transferred to the Geological Survey, and that part which related to Alaska was assigned jointly to the conservation and Alaskan branches. This arrangement worked satisfactorily until changes in the wording of the appropriation act for the work of the conservation branch made it desirable that work transferred from the Bureau of Mines relating to mineral leasing in Alaska should be differentiated from all work of a general investigative character in that Territory, by being paid for from separate appropriations. Therefore, in the appropriation act for 1928–29 the amount allotted for the strictly leasing work is still retained but the item for the other work, amounting to $4,500, has been added to the item for the investigation of the mineral resources of Alaska. Therefore, henceforth some of the work done by the local offices of the Geological Survey in Alaska will be comparable with and included with work now done under this general authorization. Inasmuch, however, as the fitting of this work into the general scheme must be worked out gradually and as the general work performed by the Alaskan office of the Geological Survey is more fully discussed in a later section of this report, further discussion here or prediction as to the details of its work in relation to future investigations of mineral resources may be omitted. The administration of both the leasing and the mineral resources work conducted through the Alaskan office will continue to be in local charge of B. D. Stewart, and every effort will be made to give better and greater service to the mining industry through the change in fiscal responsibility.

EXPENDITURES

The funds available for the regular work by the Geological Survey on Alaskan mineral resources during part of the fiscal year 1927–28 were appropriated in the Interior Department appropriation acts for both the years 1927-28 and 1928-29. For the season of 1927 there was also available, until June 30, 1927, any unexpended balances from the appropriation for 1926–27. The amount appropriated in the act for 1926-27 was $50,000; in the act for 1927-28, $60,000; and in the act for 1928–29, $64,500. 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 appropriations have been properly accounted for, but the mere bookkeeping statement, as has already been pointed out, does not give any clear picture of the real conduct of the work. In spite of this difficulty of presenting a simple statement of the expenditures, the following generalized analysis of the actual expenditures from the appropriation for 1927–28, distributed among a number of major heads, may be of service:

Expenditures from funds appropriated for investigation of mineral resources in Alaska for the fiscal year 1927–28

Projects for season of 1927	$16,180
Projects for season of 1928	7,560
Administrative salaries from July 1, 1927, to June 30, 1928	3,250
All other professional and scientific salaries, July 1, 1927, to June 30, 1928	24,933
All other clerical and drafting salaries	5,888
Office maintenance and expenses	1,511
Bureau of the Budget reserve	678
	60,000

In the first two items in the foregoing table no charges are included for salaries of any of the permanent employees of the branch, as these are all 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 included in these first two items, for practically every expenditure of the branch relates directly or indirectly to these projects. Thus the scientific and professional force is maintained solely to carry out these projects; the clerical and drafting force is maintained solely to help in preparing the reports and maps and in attending to the innumerable details connected with the business of properly conducting the projects; and all the office supplies and equipment purchased are really incidental to the task of carrying through the projects.

The expenditures for the projects of 1927, amounting to $16,180, included $6,323 for geologic and general investigations and $9,857 for topographic work, including the compilation of maps from aerial photographs. These figures are based on the assumption that in combined geologic and topographic parties the expense is divided equally between the two types of work. A similar analysis of the allotments for the season of 1928 from the funds for the fiscal year 1927-28, amounting to $7,560, shows $4,360 allotted to geologic surveys and $3,200 to topographic surveys.

The following tables prepared on a seasonal basis will make the true relation of the work to sources of funds more apparent:

Approximate cost and distribution of work by geographic divisions for the season 1927

Region or work	Appropriation for 1926-27		Appropriation for 1927-28		Total
	Expenses	Salaries	Expenses	Salaries	
Southeastern Alaska			$6, 190	[a] $3, 332	$9, 522
Copper River	$575	$575	1, 790	2, 300	5, 240
Alaska Range	1, 800	1, 445	4, 782	6, 633	14, 660
Yukon	4, 250	2, 510	2, 551	4, 140	13, 451
General	190		867	1, 350	2, 407
Mineral resources				[b] 2, 133	2, 133
Office work on former projects				4, 043	4, 043
	6, 815	4, 530	16, 180	23, 931	51, 456

[a] Includes $1,000 of drafting salaries.
[b] Includes $1,683 for clerical salaries.

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

Region or work	Appropriation for 1927-28		Appropriation for 1928-29		Total
	Expenses	Salaries	Expenses	[a] Salaries	
Southeastern Alaska [b]	$1,900	$765	$4,700	$3,067	$10,432
Copper River	360	765	2,440	3,067	6,632
Alaska Range	2,600	1,445	5,800	6,230	16,075
Yukon-Tanana region	2,400	700	2,600	2,450	8,150
General			1,500	1,900	3,400
Mineral resources				[c] 1,750	1,750
Alaska district office					[d] 4,500
Office work on former projects				3,218	3,218
	7,560	3,675	17,040	21,682	54,457

[a] Exclusive of changes in rates of pay that will be made through operation of the Welch bill.
[b] Exclusive of $2,150 transfer from Forest Service for special work ($750, 1927-28; $1,400, 1928-29).
[c] Includes $1,300 for clerical services.
[d] Not separately apportioned for expenses and salaries but larger part for salaries and excluded except in last column.

The item of $3,250 for administrative salaries, shown in the table on page 80, includes only those salaries that are directly related to the administration of the work of the branch as a whole and does not include administration such as each party chief is called on to perform with regard to the unit under his charge. The amount expended for administration is exceedingly low, because much of the time of the principal administrative officer is spent on specific technical and related projects, which therefore bear their prpportional share of the charge for salary. Although this practice undoubtedly makes the cost of administration low, it is not regarded as good, because it leads to the loss of real directive handling of many matters. With the present personnel of the Alaskan branch, made up as it is of men long familiar with the work and well qualified to solve many of the problems as they arise, the loss is not so apparent, but it is believed to be no less real.

The item of expenditures for clerical and drafting salaries covers part of the salary of the chief clerk, Miss L. M. Graves, and all of the salaries of a junior clerk and a draftsman. Part of the pay of the chief clerk is included in the item for administration, as during much of the field season she is in charge of the office. Three-quarters of the time of the junior clerk is devoted to the computation of the statistics of the production of minerals and work related thereto. During the year several clerks have handled this work; the present incumbent is Miss L. H. Stone. The drafting work of the branch is done by J. B. Torbert. The clerical personnel is entirely too small to handle the large volume of work expeditiously and thoroughly, but it has been cut down to the lowest limits so as to provide funds for the important field projects. The cut was first made to meet what was believed to be temporary curtailment of appropriations for the branch as a whole, but as subsequently there has not been a return to the former rate of appropriation, it is probably not wise to hold this clerical force much longer at its present small size.

Only about 2½ per cent of the entire appropriation for Alaskan work was spent for items that are included in the table as office maintenance and expenses. This item does not cover purchases of supplies and equipment for the specific field projects, as those expenses are included in the allotments for the individual projects. It does, however, include the general repair of all instruments or the purchase of such instruments and material to be used in the field as are not directly assigned to an individual project. The repair and purchase of instruments and related supplies was the largest item of expense included under office maintenance and expenses and for the fiscal year 1927–28 amounted to slightly more than $590. The next largest item is for photographic and related work in developing and printing the many photographs taken in the field and making the necessary copies of field sheets and other cartographic data used in compiling the maps prepared in the branch for publication. Other items that are included under this head are telegrams; general office supplies, principally stationery used in the field; 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 editorial inspection of maps and other cartographic data submitted for publication; and such other expenses as do not relate solely to a specific project.

LEASING WORK

As already noted, the leasing work in Alaska in 1927–28 was conducted from an allotment of $14,500 made from a separate item in the appropriation for the Geological Survey. In order that the policies and practices that have been developed for handling the much larger volume of similar work in the States should be maintained so far as they are applicable or should be appropriately modified to meet Alaskan conditions, and in order to utilize the existing agency that is charged with the administration of other Alaskan affairs for the Geological Survey, the general conduct of the leasing work in Alaska is shared between the conservation branch and the Alaskan branch. For the conduct of the field work local offices are maintained at Juneau and Anchorage, Alaska, in charge of B. D. Stewart, supervising mining engineer, with a staff of two other engineers, J. J. Corey and J. G. Shepard, together with the necessary clerical assistance.

The Territorial government of Alaska cooperates in certain of the work conducted under this allotment to the extent of furnishing office facilities and clerical services at Juneau and supplying funds for such travel expenses as are performed in the interests of the Territory. This arrangement appears to be especially fortunate, for it eliminates much duplication that would be necessary if the Federal and Territorial Governments each maintained separate organizations to conduct the work desired by them, much of which is identical in character.

The primary purpose of these local offices in Alaska is to supervise the operations under the coal and oil leases issued by the Government. Nearly all the coal mining and much of the oil drilling in Alaska is done on public lands, held temporarily by private individuals or companies under leases or permits. The interest of the Government in these lands requires that the developments shall be supervised so as to insure that proper methods of extracting the minerals are employed, to prevent undue waste, and that the lives, health, and welfare of those employed in the work are properly safeguarded. The coal-mining developments are carefully supervised, and wherever possible assistance is given to the operators by outlining and putting into effect economical and safe development and mining programs. Special attention is given to the installation and maintenance of safe and efficient hoisting and tramming equipment; to mine ventilation; to the reduction of fire, explosion, and blasting hazards; and to the providing of adequate pillars in advance of all mining operations. During the current year there was one fatality in connection with coal mining—the second to occur during a period of six years. There was one accident which resulted in permanent, partial disability and four serious and four slight accidents that together caused the injured employees a total loss of time of 147 days. This record is exceedingly good, as on the average 95 men were employed throughout the year in coal mining and approximately 32,000 man-shifts were worked.

The care and maintenance of the coal properties and equipment that the Government owns at Eska, Chickaloon, Sutton, and Coal Creek devolves upon the members of this unit. All these properties are now idle, but the Eska mine and camp are kept in condition for immediate reopening in case an emergency should arise that might jeopardize the coal supply for the Alaska Railroad.

During the season of 1927 it was also practicable for the engineers attached to the Alaska local offices to conduct general investigations and be of assistance to miners in many of the districts of southeastern Alaska and in the country adjacent to the Alaska Railroad. Special mention may be made of the work of this kind done at Taku River, Windham Bay, Chichagof Island, Hyder, and Chickamin River, in southeastern Alaska, and at Willow Creek, in the vicinity of the Alaska Railroad.

Their familiarity with mining matters throughout many parts of the Territory and their availability for consultation enabled Mr. Stewart and his staff to give much valuable information and advice to many of the Federal and Territorial agencies in Alaska, including the Alaska Railroad, the Forest Service, the governor, and members of the Territorial legislature, and also to many individual operators and prospectors. The Alaska offices also act as local distributing offices for publications of the Geological Survey and assist in furnishing the main office at Washington with information on many phases of the mineral industry.

During 1927–28 the following was the approximate distribution of funds expended by this office:

Administrative salaries	$3,200
Other technical salaries	8,000
Clerical salaries	1,500
Field and office expenses	1,800
	14,500

Much of the time of the administrative officer in Alaska is given to field work and other duties not regarded as strictly administrative in character, so that only a proportional part of his salary is charged as a direct administrative expense and the rest is included in the item "Other technical salaries."

As has been indicated above, some of the activities of the members of the Alaskan branch who have been paid from appropriations for the leasing work can not strictly be considered as closely related to that work. To remove any possible difficulties that might arise from this condition, it was decided to carry the two different kinds of work in separate appropriations. In the appropriation act for 1928–29 $4,500 was added to the appropriation for the investigation of mineral resources of Alaska, to cover work of this type, and the appropriation for leasing work was reduced by a similar amount. Henceforth, therefore, the two kinds of work will be accounted for separately, and for the fiscal year 1928-29 the amount allotted to the strictly leasing work will be $10,000. No decided change is contemplated in the future handling of either phase of the work. The result of the separation of funds should be not only to get on a strictly accurate basis but also to give greater flexibility in the use of the funds appropriated for the general investigative work and place more definitely the responsibility for planning the use of those funds, so that they may be used to best advantage by removing duplication and causing closer coordination between all the units that have a share in fostering the mineral industry of the Territory.

THE CHANDALAR-SHEENJEK DISTRICT, ALASKA

By J. B. MERTIE, Jr.

INTRODUCTION

The Chandalar-Sheenjek district, as described in this report, consists of an irregular area of about 6,000 square miles that lies between parallels 66° 28′ and 69° north latitude and meridians 143° 25′ and 147° 35′ west longitude. This area includes mainly the valleys of the Sheenjek River and the East Fork of the Chandalar River from their headwaters in the Brooks Range southward to their debouchures into the Yukon Flats. The index map (fig. 1) shows the position of this area in northern Alaska. Only traverses were made by the writer south of latitude 66° 48′, but the limits of the map have been extended southward to Fort Yukon and Beaver, in order to show the geographic relation of these settlements to the mapped area.

The geologic information given in this report is based principally on field work done by the writer in 1926 and 1927. The topographic map was begun by J. O. Kilmartin in 1926, in the Sheenjek Valley, but 85 per cent of the mapping was done by Gerald FitzGerald during the season of 1927. No surveys earlier than 1926 had been made in the greater part of what is here considered the Chandalar-Sheenjek district, but several geologic reports and topographic maps of contiguous areas that have a direct bearing upon the results outlined in this report are listed below in chronologic order:

Schrader, F. C., Preliminary report on a reconnaissance along the Chandalar and Koyukuk Rivers, Alaska, in 1899: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 441–486, 1900.

Kindle, E. M., Geologic reconnaissance of the Porcupine Valley, Alaska: Geol. Soc. America Bull., vol. 19, pp. 315–338, 1908.

Maddren, A. G., Geologic investigations along the Canada-Alaska boundary: U. S. Geol. Survey Bull. 520, pp. 296–314, 1912.

Maddren, A. G., The Koyukuk-Chandalar region, Alaska: U. S. Geol. Survey Bull. 532, 1913.

Leffingwell, E. de K., The Canning River region, northern Alaska: U. S. Geol. Survey Prof. Paper 109, 1919.

Mertie, J. B., jr., Geology and gold placers of the Chandalar district, Alaska: U. S. Geol. Survey Bull. 773, pp. 215–263, 1925.

On June 6, 1926, the writer, accompanied by J. O. Kilmartin, topographer, and Earl Hunter and Ray Russell, camp helpers, left Fort Yukon in two Peterborough canoes equipped with outboard motors and proceeded up the Porcupine River to the Sheenjek River and thence up that stream. Geologic and topographic mapping was

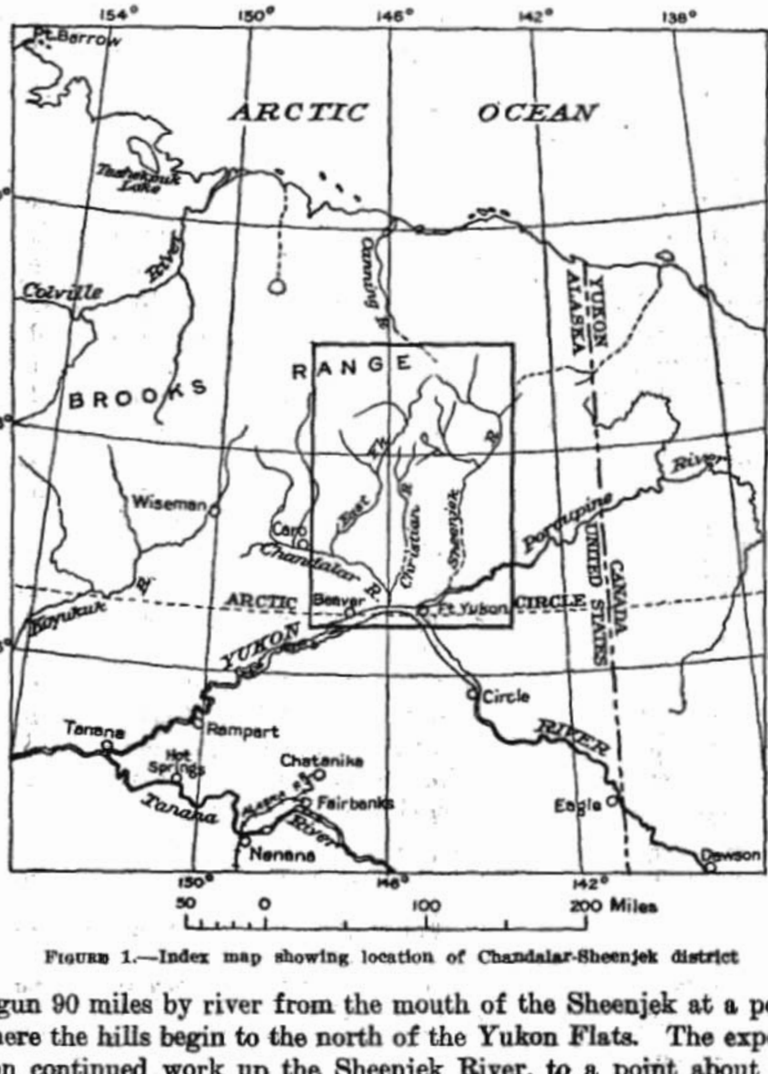

FIGURE 1.—Index map showing location of Chandalar-Sheenjek district

begun 90 miles by river from the mouth of the Sheenjek at a point where the hills begin to the north of the Yukon Flats. The expedition continued work up the Sheenjek River, to a point about 160 miles by river above the mouth, where, on account of injuries sustained by Russell and Kilmartin, the work was discontinued, and the party returned to Fort Yukon in the later part of July. As a result of this work, a topographic map and a preliminary geologic report were prepared and published.[1]

As the Geological Survey desired to continue this work, another expedition was outfitted in 1927 but with a different organization. The personnel, as in 1926, consisted of four men, but the expedition was divided into two units of two men each, one of which was to enter the country during the late winter, in order to establish a base camp in the Brooks Range and to lay out caches of supplies for the work of the ensuing summer. Accordingly Gerald FitzGerald, topographic engineer, left Seattle February 26, 1927, and proceeded to Fairbanks. He was joined at Nenana by Fred E. Clark. On March 13 FitzGerald and Clark left Fairbanks by dog team and proceeded by way of Circle to Fort Yukon, where they arrived after seven days' travel. The expedition was outfitted at Fort Yukon. It had originally been planned that the winter party would freight a summer's outfit of supplies and one Peterborough canoe northward into the Brooks Range, but it was found at Fort Yukon that it would be impossible to transport a canoe into the mountains over the narrow toboggan trail used by the natives, which was the only route of entry. Arrangements were then made with natives at Fort Yukon for freighting a part of the supplies of the expedition northward, and about a week afterward eight dog teams, manned by natives and loaded with 2,200 pounds of supplies for the expedition and necessary dog feed, left Fort Yukon and moved this freight northwestward to Caribou House, a distance of 107 miles by trail. On March 30 FitzGerald and Clark also left Fort Yukon with two dog teams and 800 pounds of additional supplies, and on April 4 they arrived at Caribou House. From this point FitzGerald and Clark moved the entire 3,000 pounds of supplies northward to Arctic Village by relaying, and by April 19 the entire outfit was safely landed at Arctic Village, 150 miles by trail from Fort Yukon. This freighting was accomplished in winter, under most trying conditions, for the party was traveling rapidly, with a minimum of camping and personal equipment. Much of the ultimate success of the expedition must be attributed to the successful completion of this winter work.

After arrival at Arctic Village Clark and two natives, with three dog teams, departed on April 25 and moved 1,500 pounds of supplies northeastward into the upper valley of the Sheenjek River, where they made two caches, and returned to Arctic Village by May 4. In the meanwhile FitzGerald continued with the topographic mapping, which he had begun April 4 at Caribou House, and made five

[1] Mertie, J. B., jr., Preliminary report on the Sheenjek River district, Alaska: U. S. Geol. Survey Bull. 797, pp. 99–123, 1928.

side trips by dog team out from Arctic Village. On one of these trips, on which he started May 10, accompanied by Clark, he placed another cache of provisions up the East Fork of the Chandalar River, about 15 miles above Arctic Village. On May 27 the spring break-up occurred on the East Fork at Arctic Village, and thereafter for some time travel by any means was impracticable. Between June 10 and July 15, however, the topographic mapping was continued on three side trips from Arctic Village, dogs being used for the transportation of supplies.

In the meanwhile the writer had arrived at Fort Yukon, and on June 9, accompanied by C. A. Wheeler, in a canoe equipped with an outboard motor, he proceeded down the Yukon to the upper mouth of the Chandalar River and thence up that stream. Progress up the lower part of the Chandalar River, for the first 25 miles, was easy and rapid, but from that point westward progress became slower and more difficult, for the river was then at its highest stage and was therefore swift and full of driftwood and was carrying a large volume of water spread out into numerous overflow channels. Finally the current became too swift to ascend with a motor, and as many of the gravel bars were covered with water continuous lining of the canoe was also impracticable. The party was therefore obliged to stop at several places and wait for falling water, thus losing 15 days, so that the mouth of the East Fork of the Chandalar River was not reached until July 2. Up to this point considerable use had been made of the outboard motor, but in continuing up the East Fork of the Chandalar River most of the progress was made by lining the canoe along gravel bars, the motor being used mostly in making bad crossings and in ascending stretches of the river where no gravel bars were exposed on either side.

On July 9 the party arrived at a point about 3 miles above Lush Creek and 135 miles by river from Fort Yukon but was unable temporarily to go farther because of an injury of the ankle received by the writer. Wheeler then proceeded upstream on foot and made connection July 14 with FitzGerald at Arctic Village. On July 15 FitzGerald and a native came downstream in a canvas canoe and joined the writer at Lush Creek; and the night of July 16 the three men started back to Arctic Village, back packing the necessary equipment for the summer's work, and arrived there in two and a half days. This return trip of 60 miles was made along the ridge that lies between the East Fork of the Chandalar River and the Christian River and enabled the writer to see the rock formations along this part of the route.

On July 19 the united party, consisting of FitzGerald, Clark, Wheeler, and the writer, started northeastward for the upper

Sheenjek River. Six dogs accompanied the party, packing about 150 pounds, and the remainder of the camp and personal equipment and instruments were packed on the backs of the four men, with an average load of 65 pounds to the man. The route followed was eastward from Arctic Village by way of Old John Lake to Johnnie Frank's cabin on the Koness River, thence northeastward to the caches on the Sheenjek, thence westward up the valley of Old Woman Creek and over into the upper valley of the East Fork of the Chandalar River, and thence southward by the East Fork cache to Arctic Village. This trip, which covered a distance of about 200 miles, was made in four weeks and resulted in the topographic and geologic mapping of all of the Koness Valley and the headwaters of the Sheenjek River and the East Fork of the Chandalar River.

On August 20 the party started down the East Fork in two skin boats, obtained from the natives at Arctic Village, and on August 28 it arrived at Lush Creek, where the Peterborough canoe and the canvas canoe had been stored. It proceeded downstream the following day, three men in the Peterborough canoe and one in the canvas canoe, and arrived at the mouth of the East Fork September 5. During this trip downstream the East Fork was mapped on both sides of the valley, from Arctic Village to its mouth, but early snows in the later part of August materially impeded the progress of work in the lower stretches of the river. On September 9 the expedition arrived at Beaver, on the Yukon, and on September 11 FitzGerald and the writer started upstream in the Peterborough canoe for Fort Yukon, where they arrived, ending the season, on September 13.

The members of this expedition are much indebted to numerous people in interior Alaska for hospitality and cordial cooperation. Particularly should be mentioned Mr. Jack Donald, agent for the Northern Commercial Co. at Fort Yukon, and Dr. and Mrs. Grafton Burke, also of Fort Yukon. Mr. L. J. Palmer, of the United States Biological Survey, at Fairbanks, also helped materially by the loan of a sled for the winter trip from Fairbanks to Fort Yukon.

GEOGRAPHY

DRAINAGE

The Chandalar-Sheenjek district (pl. 1) is drained by the East Fork of the Chandalar River and by the Sheenjek and Christian Rivers. The Christian River empties into the main Chandalar River, which drains into the Yukon. The Sheenjek River empties into the Porcupine River, another tributary of the Yukon. Hence all the streams of this region are a part of the Yukon River system and drain the south slopes of the Brooks Range.

The Yukon River from Circle to Fort Hamlin splits into numerous channels and spreads out over a wide flood plain known as the Yukon Flats. From Circle the Yukon flows northwestward for an air-line distance of about 75 miles and then turns southwestward and flows 125 miles farther through these flats. Within this 200-mile stretch all the streams tributary to the Yukon likewise flow through flats in their lower courses. This great flood plain of the Yukon, together with its continuation up the lower courses of the tributary streams, includes an area of about 7,500 square miles, and at Fort Yukon its width from north to south is at least 70 miles.

The Porcupine River, the largest tributary of the Yukon within the flats, enters the Yukon just below Fort Yukon, at the point where the course of the main river veers southwestward. The Porcupine itself flows southwestward, and the Yukon Valley below Fort Yukon appears therefore to be rather a continuation of the Porcupine Valley than of the Yukon Valley above Fort Yukon. The main part of the Porcupine River enters the Yukon several miles below Fort Yukon, but a navigable slough of the Porcupine joins the Yukon about a mile or two below Fort Yukon, and this slough is the route usually taken by small boats in entering the river. The Porcupine flows in its lower course through the Yukon Flats and within that stretch is joined from the southeast by the Black and Little Black Rivers and from the north by the Sheenjek River, which is locally called the Salmon River. These tributary streams also flow through flats in their lower courses.

The Porcupine River, from its mouth upstream for 125 miles, though probably only half that distance in an air line, flows through the flats in large meanders, splitting, particularly at times of high water, into numerous channels and sloughs. The banks, as seen along the outer sides of the meanders, are composed of silt and peat, with here and there bodies of ground ice, and are often undercut by the river current, producing overhanging masses of peat and vegetation, which by caving fall into the river and produce snags and sweepers. These higher banks are usually bordered by timber, mainly spruce. The inner sides of the meanders are generally low sand or gravel bars, and for some distance back from these the flats are covered mainly with willows and alders. At ordinary stages of water the lower Porcupine is a rather sluggish stream, with a current of 2 to 3 miles an hour, but during stages of high water it is considerably swifter, approximating at places a 5-mile current. The current at the mouth of the Porcupine is determined mainly by the stage of water in the Yukon, being particularly sluggish if the Porcupine is at low stage while the Yukon is in flood and rather swift if these conditions are reversed.

The Sheenjek River flows in its lower course through flats of the same character as those above described, and the conditions along the river in this stretch are much the same as those on the Porcupine, except that the Sheenjek is a smaller stream and therefore flows in meanders of smaller amplitude, though no less tortuously, than the Porcupine. Other differences are that the river banks along the Sheenjek are lower than on the Porcupine, and in its lower course fewer and smaller gravel bars are present. In fact, when the Sheenjek is in flood, no gravel bars are visible from the mouth upstream for 60 miles by river, although many such bars are visible in the lower river at low water. Like the Porcupine, the Sheenjek River shows great variation in stream velocity, dependent on the stage of water. At low water the lower Sheenjek is distinctly sluggish, but in flood the current is fairly strong, and at some places a motor boat with considerable power is required for traveling upstream against the current. In general, however, the lower Sheenjek presents no difficulty to motor-boat navigation, except at very high water, when the presence of driftwood, concealed snags, and occasional whirlpools necessitates greater care.

Few riffles occur in the lower Sheenjek River, but these swifter and shallower places become progressively more numerous upstream, so that at ordinary stages of water the upper limit of navigation for a power boat is Carroll's cabin, about 75 miles by river from the mouth. At high water a well-powered motor boat of shallow draft can go 20 miles farther upstream, to Christian's cabin, but within this 20-mile stretch the heavily loaded canoes of the Geological Survey party of 1926, which were propelled by outboard motors, were unable at many places to travel upstream except by lining them along the gravel bars.

In going up the Sheenjek the first sight of hills is obtained about 72 miles by river from the mouth. Here, at the end of a short eastward course, the traveler turns abruptly northward and sees a low wooded ridge that lies east of Christian's cabin. From this point upstream to the hills the river, although still within the flats, changes to a swifter stream, with fewer cut banks and numerous gravel bars on both sides. At Christian's cabin the river swings eastward and approaches closely to the wooded hill above mentioned, which may then be seen to be a low spur, projecting 10 miles or more southward from the main hills. From this place for another 15 miles upstream from Christian's cabin to the hills the river remains essentially a swift braided stream, flowing through flats.

From the southern edge of the hills upstream to the forks of the Sheenjek and for some distance up the west or main fork this river continues to be a swift braided stream, and although more confined than in the flats and straighter in its general course, it splits repeatedly into two or more channels and has numerous high-water overflow sloughs. The walls of the valley, however, are well defined, and the valley floor is a well-wooded flat, characterized by oxbows, lakes, swamps, and muskeg. At one point, about 10 miles in an air line below the mouth of the Koness River, the valley is constricted to a width of less than half a mile, but above this point it widens again to an average width of 2 miles. At the forks of the Sheenjek River, 185 miles by river from the mouth, the course of the main valley turns abruptly westward and then veers northward again to the headwaters.

All the streams that drain southward from the eastern part of the Brooks Range within the Chandalar-Sheenjek region are characterized in their upper courses by a stretch of relatively sluggish water that is followed downstream by rapids. The Sheenjek River is no exception to this rule, and the main river, 10 miles above the forks, changes to a sluggish meandering stream and continues thus for 20 miles upstream. Within this stretch the river is confined largely to a single channel and flows through a wide lake-dotted valley floor with banks of sand and silt. Between this sluggish water and the mouth of the East Fork are rapids, the river flowing swiftly through numerous riffles characterized by large boulders. Upstream from this sluggish stretch of water the river is a typical swift mountain stream, and the gradient steepens to its head.

The only large tributary of the Sheenjek River below the forks is the Koness River, which enters from the west side of the valley about midway between the northern edge of the flats and the forks. The Koness River, though not a large stream at ordinary stages of water, drains a large and diversified area west and northwest of its mouth. In its lower course, where it cuts through the hills to join the Sheenjek, the river flows through a narrow canyon-like valley but is nevertheless a meandering stream bordered by sand and gravel bars, much like the Sheenjek. Farther upstream it splits into a number of tributaries, which flow for the most part in wide, open valleys bordered by rolling hills. One of these tributaries heads to the west in Old John Lake, which lies in a wide valley leading to the East Fork of the Chandalar River. The tributaries from the north head mainly against Monument and Old Woman Creeks, tributaries of the Sheenjek.

The East Fork of the Sheenjek River has not been mapped but is said by prospectors to head about 20 miles northeast of the forks and to be cut off from the Arctic divide by an upper tributary of the Coleen River. A low divide exists between the head of the East Fork of the Sheenjek River and the Coleen River, and an even lower pass is said to separate the head of the East Fork from the main Sheenjek. About 8 or 9 miles below the forks a small tributary of the Sheenjek River, known as Monument Creek, comes in from the southwest, and a little upstream from Table Mountain a larger stream, known as Old Woman Creek, enters the Sheenjek River from the northwest. All the larger tributaries of the Sheenjek River except the East Fork enter from the west, thus rendering the Sheenjek drainage system markedly asymmetric. Along the main river below the forks, for example, it is less than 10 miles in places to the Sheenjek-Coleen watershed, but the East Fork of the Chandalar River, which is the next large stream to the west that flows parallel to the Sheenjek, lies 50 miles distant. Another noteworthy feature of the Sheenjek drainage system is the marked tendency of a number of the tributaries that enter from the west to flow northeastward in approaching the main valley, thus creating a condition resembling "backhand drainage." This feature is believed to be due mainly to the controlling effect of the rock structure.

The East Fork of the Chandalar River and the main Chandalar River below the mouth of the East Fork form the other main drainage system of this area. The Chandalar River enters the Yukon in several channels, which together with the outlets of the Porcupine create a maze of islands along the north side of the Yukon for 50 miles or more below Fort Yukon. The main mouth of the Chandalar is about 40 miles by river below Fort Yukon, but two other good-sized outlets exist farther upstream, and through the upper one, 20 miles below Fork Yukon, the expedition of 1927 entered the Chandalar. Between the upper and lower mouths sloughs lead off to the Yukon, but most of these could be entered only at a very high stage of water. The expedition of 1927 came out of the Chandalar into the Yukon by way of the lower mouth.

The Christian River enters the Chandalar about 25 miles by river above the upper mouth. In this stretch the Chandalar is very sluggish at low water, but in flood stages it has a current of 2 to 3 miles an hour. Above the Christian River for 20 miles the river is swifter and split into numerous channels, through which, even at low water, it is not easy for a stranger to follow the main channel. From this point upstream to the East Fork, a distance of 25 miles, the river is a swift stream but is less split up than farther downstream. The current in the Chandalar River, from the Christian River to the East Fork, runs from 3 to 5 miles an hour at high water, and under these conditions the stream is hard to navigate. Like those of the Sheenjek, the sand bars of the lower river are covered at high water, the river flowing between cut banks, but this zone extends only 20 miles up the Chandalar, as compared with 60 miles up the Sheenjek. Above the Christian River sand and gravel bars are exposed at all stages of water, and the river meanders swiftly along, with timbered cut banks of sand and silt on the outer sides of the turns and gravel bars on the insides, which farther back from the river are covered with willows and alders. The natives have no difficulty in navigating the river in motor boats up to Chandalar Village, 45 miles from the upper mouth, at any stage of water, and at high water a well-powered shallow-draft boat could probably go on upstream beyond the mouth of the East Fork, perhaps to the mouth of the Middle Fork. Small shallow-draft steamboats in fact did at one time go up on high water to a point midway between the East and Middle Forks, but loaded canoes of considerable draft with outboard motors can not navigate successfully the 70 miles to the East Fork at high water, because the stream is too swift, and at low water the shallow channels will cause trouble.

Throughout the 70 miles from the East Fork to its mouth the Chandalar flows through the Yukon Flats, a featureless plain devoid of relief. Its current, as well as that of the other streams in the flats, including also the Yukon River, shows clearly that this flood plain is by no means " flat " but has a strong tilt, the main Yukon flood plain sloping strongly southwestward and the flood plains of the tributary streams sloping even more perceptibly toward the Yukon. In traveling up the Chandalar distant hills to the north are first seen a short distance above the Christian River, and at Chandalar Village one channel of the river swings to the north side of its valley and impinges against a gravel bluff about 35 feet high, which is the southward edge of an alluvial bench that rises northward to the hills. Just below the mouth of the East Fork the river swings in to the south side of the valley, against a hard-rock bluff. From the appearance of the two streams at their confluence, the East Fork carries nearly as much water as the main Chandalar above the confluence.

The East Fork of the Chandalar River is a larger river than the Sheenjek, both in drainage area and in amount of water carried, although the Sheenjek, which rises as far north and flows for so many miles through the Yukon Flats to the Porcupine, is perhaps a somewhat longer stream. The air-line length of the East Fork is about 150 miles, but the length by river may be as much as 300 miles. The general course is relatively straight and bears about S. 30° W.; in this respect it is dissimilar to that of the Sheenjek River. The East Fork of the Chandalar may in general be divided into four zones. In the first zone, which extends from the mouth upstream to the Wind River, an air-line distance of 60 miles, the river is much like the Sheenjek, from the northern margins of the flats up to the forks. It flows with a fairly swift current over an alluvium-filled valley floor from 1 to 5 miles wide, in one channel for much of this distance but at numerous places braided into several channels.

The stream gravel is rather coarse everywhere, and at places, particularly where the river cuts into the gravel benches on both sides, the gravel is very coarse and contains numerous large boulders. On account of the large amount of water that flows at flood stage in the spring, it is difficult to line canoes upstream through these braided channels, owing to the necessity for making numerous crossings in the swift current from island to island. Where the river flows in one channel, upstream travel is in general good, and in such places an outboard can be used to advantage. In the lower 10 miles of this stretch the valley walls close in and the stream flows through a narrow gorge over a bed of very coarse gravel and large boulders. The current in this 10 miles, however, is no swifter than above, and as the stream is confined to one channel the boating either upstream or downstream is better than above the gorge. At one place just below the gorge, where the river starts out across the valley floor of the main Chandalar, the stream cuts bedrock and makes rapids for about 100 yards, but these are not especially difficult in downstream travel if care is exercised, and in going upstream, especially at high water, one can line around this stretch through another channel.

In the second zone from the Wind River upstream for 17 miles to a point a few miles above Crow Nest Creek the river has numerous rapids where it flows swiftly over coarse gravel and boulders, and this portion constitutes the worst stretch on the river for boating. It corresponds to the similar stretch on the Sheenjek River between Table Mountain and the forks and may be described as the zone in which the valley gradient is suddenly steepened. This feature resembles superficially the effect produced by a recent lowering of the base-level of a stream, the rapids corresponding to that zone of headward steepening where adjustment between an old and a new base-level is in progress. The location of these rapids on the North, Middle, and East Forks of the Chandalar and on the Sheenjek, however, corresponds with the southern limit of morainal material and is probably determined mainly by the preexisting conditions of glaciation.

Above these rapids stretches the third zone, in which the East Fork for nearly 40 miles in an air line is a sluggish meandering stream, with sand bars and banks of sand and silt. At places where the river has cut laterally into morainal material, gravel and boulders have slumped down to the water level, producing gravel bars, but such places are not characteristic of this part of the river as a whole. The 20-mile stretch on the Sheenjek River above Table

Mountain is strictly analogous to this 40-mile stretch on the East Fork of the Chandalar. In this zone of sluggish water the valley floor of the East Fork is from 5 to 10 miles wide and is a timber-covered lake-dotted flat. Oxbow lakes are well developed, and changes in the drainage channels of some of the tributary streams are also clearly evident.

The fourth zone lies above the sluggish part, extending to the head of the river. Here the river is again a typical mountain stream, with a steadily rising gradient to the Arctic watershed. This stretch of the river is perhaps 50 miles long, as compared with about half that distance for the similar stretch on the Sheenjek. One of the striking features of this upper zone on the East Fork is the presence of a number of bodies of aufeis. One of the largest of these deposits of ice occurs at the lower end of this upper stretch, just above the place where the river ceases to be a sluggish meandering stream. Another notable deposit is developed on the Junjik River, likewise just above the meandering zone of the river. One at a similar site is also known on the upper Sheenjek River, about 30 miles above Old Woman Creek. These ice sheets lie usually in the headwater stream courses, where the streams are split to form a braided network of channels; but it is not clear whether the site of such braided channels has determined the position of the ice, or whether the ice by its formation has caused the braiding of the stream channels. These bodies of ice, which may be 10 feet or more thick and several miles in length, remain usually until late in summer and during a cold season may persist in part throughout the summer.

The East Fork of the Chandalar River, like the Sheenjek River, is markedly asymmetric in its drainage system. The three largest tributaries, named in order upstream, are the Wind River, Crow Nest Creek, and the Junjik River, all of which enter from the west side. The Wind and Junjik Rivers are said by natives to head against one another in a low divide about 30 miles west of the main river. Below the Wind River, however, a tributary of the Middle Fork of the Chandalar River heads within 10 miles of the East Fork. Along the east side of the East Fork no large tributaries enter the river, and the watershed that separates the East Fork from the Christian and Koness Rivers and from the upper part of the Sheenjek River lies everywhere 10 miles or less distant.

The Christian River, the only other stream of any size draining this district, lies between the East Fork of the Chandalar River and the Sheenjek River but is quite different in character from either of those streams. It heads against the Koness River on the north and is therefore cut off from the high mountains of the Arctic watershed and also lies for the most part south of the glaciated portion of this area. From the point where it enters the Chandalar upstream to Christian Village it is said by natives to be little more than a sluggish slough, impeded by log jams, so that it is not suitable for navigation by small boats. Above Christian Village the valley is constricted for some distance into a narrow gorge, but above this gorge the head-water tributaries flare out into wide, open valleys cut in rolling hills.

RELIEF

The Chandalar and Sheenjek Valleys and the intervening territory may naturally be divided into three well-marked physiographic provinces, which from south to north are the Yukon Flats, the piedmont province, and the alpine province. The Christian River, however, flows only through the piedmont province and the Yukon Flats.

The Yukon Flats, through which all three of the above-mentioned streams flow in their lower courses, form a densely timbered alluvial plain, relatively devoid of relief and traversed, especially at high water, by innumerable sloughs of the Yukon and Porcupine Rivers and their tributaries. These flats, which characterize the Yukon River from Circle to Fort Hamlin, extend up the Porcupine River almost to the mouth of the Coleen River and therefore extend also up all the lower tributaries of the Porcupine, including the Black and Little Black Rivers as well as the Sheenjek. These flats in the Chandalar-Sheenjek district have a pronounced slope southward and southwestward, as shown by the gradients of the streams traversing them, and also by the altitude at the northeast and southwest limits of the flats within the Chandalar-Sheenjek district. Thus from the northern margin of the flats on the Sheenjek River southward to Fort Yukon the average gradient of the flats is about 11 feet to the mile. It does not of course follow that the streams in this area have any such average gradient, for many of them follow indirect and winding courses, but this figure does give an approximate idea of the slope of this alluvial plain and shows that it is a " flat " only in the apparent sense of having no prominent topographic landmarks.

The northern border of the Yukon Flats extends from the mouth of the East Fork of the Chandalar River about N. 70° E. toward the Sheenjek and Coleen Rivers. From this line northward for 50 to 70 miles lies a country of rolling hills, which merge northward into the higher mountains of the Brooks Range. This intermediate zone, here called the piedmont province, is of course more sharply defined from the Yukon Flats than from the alpine province to the north, from which it is distinguished in general by lower relief, more gradual slopes, and an absence or smaller degree of glacial erosion. This piedmont province reaches from the mouth of the

East Fork of the Chandalar River upstream to the south side of the group of high mountains west of Arctic Village and from this point extends east-northeastward, passing south of Titus Mountain, at the head of Tritt Creek, and south of Index and Table Mountains, in the upper Sheenjek Valley. Within this stretch the regional relief differs considerably but averages close to 2,000 feet, although the maximum relief is perhaps as much as 4,000 feet. Thus at the mouth of the East Fork of the Chandalar the altitude of the valley bottom is about 800 feet above sea level, and the ridges on each side rise to general altitudes of 2,000 to 3,000 feet, though the highest points attain 4,000 feet. At the upper end of this province on the East Fork, however, the valley floor has an altitude of about 2,000 feet, and the neighboring hills rise to altitudes of 3,000 to 4,000 feet, with higher mountains attaining nearly 5,000 feet. Similarly on the Sheenjek River the valley floor in the piedmont province rises from 1,400 feet at the southern limit to 2,000 feet at the northern limit, and the average crest lines of the ridges rise correspondingly from 3,000 feet to 3,800 feet, though the highest points on the ridges rise perhaps to 4,600 feet. Thus it appears that a surface joining the average crest lines in this piedmont province approximates in form a plane that slopes southwestward from the south front of the Brooks Range to the Yukon Flats and is incised by two trunk valleys that have a fall of similar magnitude.

Certain variations in this general picture should, however, be pointed out. Just as the valleys of the East Fork of the Chandalar and Sheenjek Rivers are asymmetric in their areal limits, so the boundary ridges are likewise noticeably asymmetric in the vertical sense. Thus the ridge along the east side of the Sheenjek River, which forms the watershed between that stream and the Coleen River, is on the average lower than the bounding watershed on the west side of the Sheenjek, and similarly the watershed between the East Fork of the Chandalar and the Christian Rivers is lower than the watershed that lies west of the East Fork. The Christian River, on the other hand, does not flow in a trunk valley and is fairly symmetrical areally. These facts bring to light the anomalous condition that although the average slope of the summits of the crest lines in the piedmont province is southwestward, this old erosional surface, if it is one, is modified by reversals of this slope to a southeasterly direction along the two trunk valleys, thus giving rise to an asymmetrically fluted surface.

Within this piedmont province certain tracts rise conspicuously above the average level of the crest. One of the more prominent of these is Helmet Mountain, which has an altitude of nearly 4,000 feet, about 6 miles northwest of the constricted part of Sheenjek

Valley. The top of Helmet Mountain is a sharp protuberance of igneous rock below which the slopes down to the lower ridge level are rounded, thus simulating the form of a German helmet. Shoulder Mountain, about 6 miles north of the mouth of the Koness River, is another outstanding mountain 4,200 feet high but is flat and mesa-like on top. A third mountain, known as Smoke Mountain, which has an altitude of 5,000 feet, stands west of the East Fork of the Chandalar River, between Crow Nest and Smoke Creeks, and still another mountain, flat on top like Shoulder Mountain, lies 9 miles southwest of Smoke Mountain and rises to an altitude of more than 4,400 feet. Farther down the East Fork, where the river cuts through a gorge into the main Chandalar Valley, a group of hills stands out in relief above the regional crest, and although the maximum altitude of these hills is not as great by 1,000 feet as that of Smoke Mountain, the relative relief is perhaps even greater. One other prominent landmark in this piedmont province should be mentioned, although it lies east of the area here treated. This feature is a symmetrically conical mountain, about 5,000 feet high, which stands east of the Coleen River and is known locally as Spike Mountain. This peak, which stands well south of the front of the alpine province amid much lower hills, is one of the highest mountains in the piedmont province and is therefore visible for many miles in all directions. On account of its striking character and visibility it should make a valuable reference point for tying together adjoining surveys in this general region. Spike Mountain was sighted by FitzGerald and the writer from Index Mountain, a distance between 80 and 100 miles.

The benches of the East Fork of the Chandalar and the Sheenjek River constitute a feature particularly characteristic of the piedmont province and worthy of separate mention. In going up the main Chandalar Valley a prominent terrace may be seen as soon as the hills are visible. This terrace extends upstream from a point about opposite the place where the Christian River issues into the flats. At this point the terrace appears to stand about 600 feet above the valley floor of the Chandalar River, but it becomes progressively lower upstream and is lost to view in the hills just below the mouth of the East Fork. The difference in slope between this terrace and the present river gradient of the Chandalar suggests the presence of an old lake in this valley or at least of an ancient stream with a gradient materially less than that of the present river. Also, at Chandalar Village, as previously stated, one slough of the river cuts into the north wall of its valley, truncating a bench composed of coarse gravel, about 30 or 35 feet high, which continues upstream and appears to be more nearly conformable in gradient with the present stream. Just at the mouth of the East Fork a low gravel bench, about 20 feet above the valley floor, is well developed on the north side of the main Chandalar, and this may in fact be the upstream continuation of the gravel bench at Chandalar Village. In the lower gorge of the East Fork no prominent terraces were noted, but just above the gorge, where the valley widens out, a well-marked bench about 300 feet high occurs on both sides of the valley. Where the East Fork cuts against this bench it is seen to be composed mainly of gravel, though in a few places it is mainly bedrock, with probably a veneer of gravel. This bench continues upstream to a place within a few miles of the Wind River, at more or less this same altitude above the valley floor, and at one or two places in this stretch the river cuts bedrock.

From the upper limit of this bench upstream to Ottertail Creek the East Fork rises 600 feet or more and therefore rises to the top of this bench, which from this point upstream corresponds roughly to the present valley floor. The tributary streams in this stretch also have a system of benches, as exemplified by the gravel deposits that lie between the lower courses of Smoke Creek and the Wind River. In this tract there are several well-marked gravel benches and some minor ones, which rise in all about 600 feet in the 6 miles from the East Fork to the hard-rock hills to the west. Upstream from Ottertail Creek terraces are noticeable at places but appear for the most part to be older terraces, well above the river level. Thus in the hills along the west side of the valley, opposite Arctic Village, four such terraces were noted, and similarly on the east side of Nichenthraw Mountain four rock terraces were seen, of which the next to the highest, about 800 feet above the valley floor, is very well developed.

On the Sheenjek River, where that stream debouches into the flats, a bench 300 feet high is well developed along the west side of the valley, and about 8½ miles in an air line above Christian's cabin the Sheenjek impinges against the west wall of the valley, cutting into this bench and exposing at this point perhaps 50 feet of gravel. This bench continues upstream with diminishing width for several miles to the constricted part of the Sheenjek Valley. Upstream from this point another bench appears, and although this seems to be cut in rock, it doubtless is related genetically to the gravel bench of similar height farther downstream. In addition two higher rock-cut terraces, one at an altitude of about 2,600 to 2,800 feet and the other at about 3,400 feet, are also present in the upper valley. The lower of these features is probably an old river terrace, but the higher one may be due to planating processes that are peculiar to sub-Arctic regions. Similar high benches are also seen on the upper slopes of the group of hills near the mouth of the East Fork.

North of the piedmont province and extending to the Arctic divide and beyond rise the high and rugged mountains that constitute the Brooks Range in this longitude. This area is the alpine province of the Chandalar-Sheenjek district. The expedition of 1927 penetrated 20 miles northward into the alpine province, both on the East Fork of the Chandalar and on the Sheenjek, and about one-sixth of the accompanying map portrays its topography. This mountainous region rises for the most part above timber line and has been extensively glaciated in past times, although in the parts visited no indications of present glaciation exist. This past glaciation has resulted in a typically glacial form of topography, including U-shaped main valleys, truncated spurs, smooth ridge tops, hanging valleys, and roches moutonnées in the southern part and cirques and generally ragged crest lines due to headward glacial sapping in the northern part.

The floors of the trunk valleys in the alpine province lie at altitudes above 2,000 feet, and the tributary valleys are correspondingly higher. The mountain tops range from 4,000 to 8,000 feet in altitude, and some of the peaks along the Arctic divide may even reach an altitude of 9,000 feet. Hence the maximum relief in this part of the district is 6,000 feet or more, and the average relief ranges from 2,000 to 5,000 feet. Many prominent mountains exist in this province, but only a few, particularly those which form prominent landmarks along the southern margin, have been named. Table Mountain, on the Sheenjek, Titus Mountain, at the head of Tritt Creek, and Nichenthraw Mountain, between the East Fork of the Chandalar River and the Junjik River, are some of these. A prominent mountain 16 miles southwest of Table Mountain rises to an altitude of 5,600 feet. This mountain was called Index Mountain by the members of the expedition. In the area 4 miles northwest of Nichenthraw Mountain stands a peak about 5,600 feet high, which was named Yasuda Mountain after Frank Yasuda, who about 30 years ago crossed the Brooks Range from the Arctic side and came down the creek west of this mountain. Another high mountain, 12 miles northwest of Arctic Village, which has an altitude of 6,200 feet, was named Misty Mountain, because of the usual covering of clouds upon it.

CLIMATE

The Chandalar-Sheenjek district has the typical sub-Arctic climate of northern Alaska, consisting of short, fairly warm summers and long, cold winters. The only available climatic records near this district are those made at Fort Yukon, on the Yukon Flats, and manifestly these can not be applied to the piedmont and alpine provinces farther north. Nevertheless these records are of interest in that they apply to part of the area here considered, and it is possible to extrapolate from them to obtain an approximate idea of the climatic conditions in the rest of the area.

At Fort Yukon the records of the United States Weather Bureau indicate an average total precipitation between 7 and 8 inches a year, with an average snowfall of 45 inches. This precipitation is fairly well distributed throughout the year, although a somewhat greater proportion of it appears to occur in the late spring and early summer. September, so far as present records show, appears to have a smaller mean precipitation than any other month. The summer days, particularly in June, July, and early August, are long and moderately warm, and about 45 to 50 days may be expected during the summer when the maximum daily temperature will be 70° or higher, although temperatures as high as 100° have been recorded in late June and early July. The minimum daily temperature may be expected to drop below freezing any time within the nine months from September to May, and freezing weather has been recorded exceptionally even during the three summer months. On the average, however, the daily temperature may be expected to fall below the freezing point during 245 days in the year and below zero during 155 days in the year. The extreme minimum of 70° below zero has been recorded in winter. The Yukon River at Fort Yukon usually freezes over about the last of October, and the ice in the river breaks and begins to move downstream about the middle of May.

In the piedmont and alpine provinces north of Fort Yukon climatic conditions are believed to be essentially similar to those at Fort Yukon, except in the following respects. Maximum summer temperatures are probably lower. It is doubtful if the minimum winter temperatures are much lower than at Fort Yukon, but the winter is longer and the summer shorter, and correlatively the mountain streams freeze earlier in the fall and open later in the spring. The East Fork of the Chandalar, for example, broke at Arctic Village on May 27, 1927, which is about two weeks later than the usual time of the spring break-up on the Yukon at Fort Yukon. No quantitative data on precipitation in the piedmont and alpine provinces are available, but with little doubt the precipitation, both rain and snow, is greater than at Fort Yukon. Still farther north, however, on the north slopes of the Brooks Range, the precipitation probably decreases toward the Arctic Ocean; for most of the rains come up the Yukon Valley from the southwest, and the Brooks Range interposes a barrier that prevents these storm clouds from dropping their moisture on the Arctic slopes. The Arctic Ocean, on the other hand, appears to be too cold to act as a source of moisture-laden winds.

ANIMALS AND PLANTS

The larger game animals of the country are moose, caribou, mountain sheep, and bear. Moose are fairly plentiful, particularly in the swampy lake-dotted stretches of the East Fork of the Chandalar and the Sheenjek River, near the south front of the Brooks Range. Individual caribou and small herds of them were seen and are fairly plentiful, though no very large herds like those in the Yukon-Tanana region roam in this country. Mountain sheep appear to be scarce. Both the black and brown grizzly bear live in this region, and some of the latter attain great size. The smaller mammals, many of which are valuable for their fur, include wolf, wolverine, coyote, fox, lynx, mink, beaver, rabbit, muskrat, ground squirrel, and porcupine. The native game birds of the country are ptarmigan and grouse, but their numbers appear to vary greatly from year to year, both being scarce during the seasons of 1926 and 1927. Numerous varieties of migrating birds, however, visit this country in summer, ducks and geese being then plentiful on the lakes and sluggish sloughs. The streams are well stocked with fish, particularly grayling or Arctic trout and lake trout. Pickerel and whitefish also inhabit these waters. Salmon run up the Porcupine and its tributaries in summer but not in the same degree as on the Yukon.

Spruce is the principal timber in the valley of the Sheenjek; the trees range in size from some 2 feet in diameter in the lower valley to the typical scrubby spruce of the upper wooded slopes. Several varieties of poplar also are common. Birch grows usually in the interior on well-drained lands, commonly hill slopes, but much of the timbered areas of the East Fork of the Chandalar and the Sheenjek River is boggy bottom land, so that birch is rather uncommon. The best birch on the East Fork of the Chandalar River was seen on the gravel benches on the west side, between Crow Nest Creek and the Wind River. Birch is also found in the lower part of the Koness River and on the Sheenjek River. Birch is highly prized by the natives, being used by them for snowshoes and as frames for their skin boats. Willows and alders grow in profusion in the swampy bottom lands, usually as high underbrush. Buck brush, or dwarfed black birch, occurs in this region as a low underbrush but not so plentifully as south of the Yukon. Timber line ranges from 2,000 to 2,500 feet, depending upon local conditions, but in the valleys of the larger streams timber may follow up a main valley to an altitude of 3,000 feet. Figure 2 shows the distribution of timber in the Chandalar-Sheenjek district.

Many varieties of flowering plants mature in this region during the summer. Small but fairly representative collections of the early maturing plants were made by the writer in 1926 and 1927 and sub-

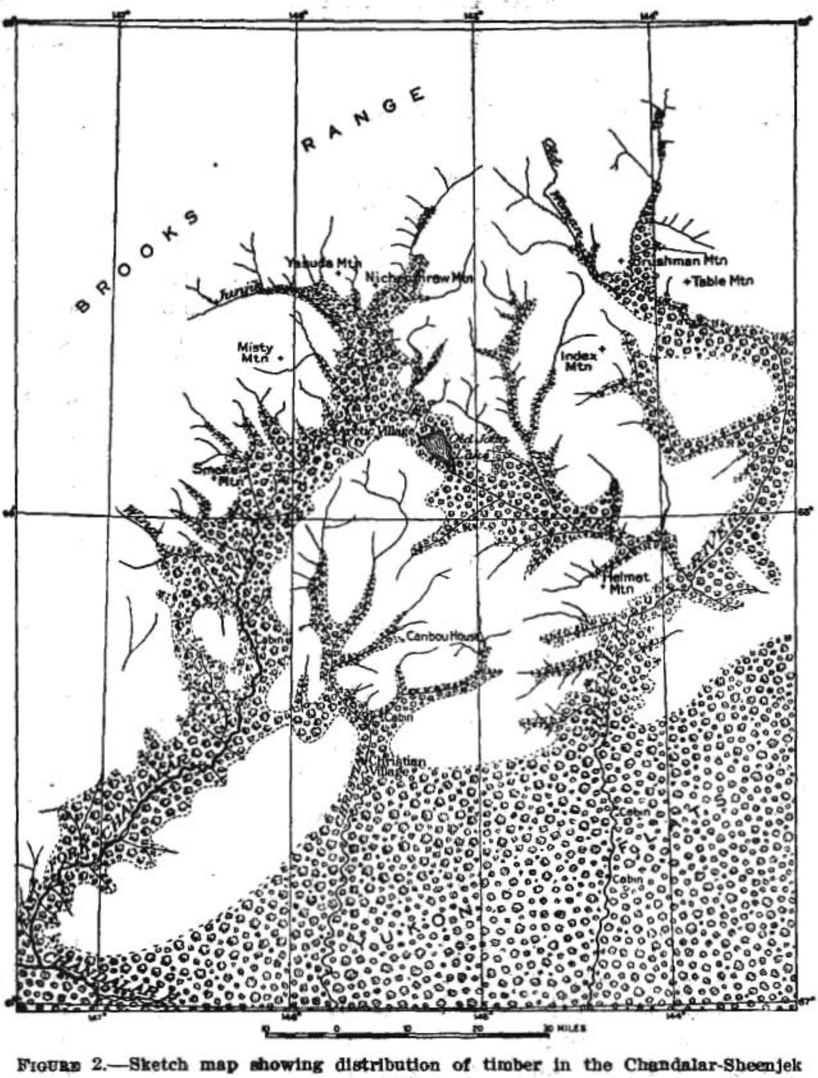

FIGURE 2.—Sketch map showing distribution of timber in the Chandalar-Sheenjek district

mitted to the Smithsonian Institution for identification. This flora, as determined by Dr. Paul C. Standley, is listed below:

Poaceae (grass family):
- Torresia odorata (Linné) Hitchcock. Sweet grass.

Cyperaceae (sedge family):
- Eriophorum callitrix Chamisso. Cotton grass.

Liliaceae (lily family):
- Allium sibiricum Linné. Wild onion.
- Tofieldia palustris Hudson. Scottish asphodel.
- Zygadenus elegans Pursh. Poison camas.

Orchidaceae (orchid family):
- Cypripedium guttatum Swartz. Lady's-slipper.
- Cypripedium passerinum Richardson.
- Habenaria obtusata (Pursh) Richardson.

Salicaceae (willow family):
- Salix sp. Willow.

Polygonaceae (buckwheat family):
- Polygonum bistorta Linné. Knotweed.

Silenaceae (pink family):
- Arenaria capillaris Poiret. Sandwort.
- Arenaria macrocarpa Pursh.
- Cerastium maximum Linné. Mouse-ear chickweed.
- Dianthus repens Patrin.
- Silene acaulis Linné. Carpet pink.
- Silene repens Patrin.
- Stellaria longipes Goldie. Chickweed.

Ranunculaceae (buttercup family):
- Aconitum delphinifolium De Candolle. Monkshood.
- Anemone multiceps (Greene) Wight.
- Caltha palustris var. arctica (R. Brown) Huth. Marsh marigold.

Papaveraceae (poppy family):
- Papaver nudicaule Linné. Arctic poppy.

Brassicaceae (mustard family):
- Cheirinia cheiranthoides (Linné). Link. Wild wallflower.
- Lesquerella arctica (Wormskiold) Watson. Bladder pod.
- Sisymbrium humile Ledebour. Water cress.

Parnassiaceae (Parnassia family):
- Parnassia kotzebuei Chamisso. Grass of Parnassus.

Saxifragaceae (saxifrage family):
- Saxifraga bronchialis Linné. Saxifrage.
- Saxifraga tricuspidata Rottboell. Saxifrage.

Rosaceae (rose family):
- Dryas drummondii Hooker. Yellow dryad.
- Dryas integrifolia Vahl. Dryad.
- Dryas octopetala Linné.
- Potentilla fructicosa Linné. Shrubby cinquefoil.
- Potentilla nivea Linné.
- Potentilla pennsylvanica Linné.
- Potentilla villosa Pallas.
- Rosa acicularis Linné. Wild rose.
- Rubus arcticus Linné.
- Spirea steveni (Schneider) Rydberg. Meadow sweet.

Fabaceae (bean family):
- Astragalus alpinus Linné. Loco weed.
- Astragalus gormani Wight.
- Astragalus sp.
- Hedysarum americanum (Michaux) Britton.
- Hedysarum mackenzii Richardson.
- Lupinus arcticus Watson. Lupine.
- Oxytropis campestris (Linné) De Candolle.
- Oxytropis nigrescens (Pallas) Fischer.

Onagraceae (evening primrose family):
- Epilobium angustifolium Linné. Fireweed.
- Epilobium latifolium Linné.

Apiaceae (parsley family):
- Conioselinum gmelini (Chamisso and Schlechtendal) Coulter and Rose. Hemlock parsley.

Ammiaceae (carrot family):
- Bupleurum americanum Coulter and Rose.

Cornaceae (dogwood family):
- Cornus stolonifera Michaux. Red osier dogwood.

Pyrolaceae (Pyrola family):
- Pyrola grandiflora Radius. Wintergreen.
- Pyrola minor Linné.
- Pyrola secunda Linné.

Ericaceae (heath family):
- Arctostaphylos uva-ursi (Linné) Sprengel. Bearberry.
- Ledum decumbens (Aiton) Loddiges. Labrador tea.
- Ledum groenlandicum Oeder.
- Rhododendron lapponicum Linné.

Vacciniaceae (blueberry family):
- Vaccinium vitis-idaea Linné. Bilberry.

Primulaceae (primrose family):
- Androsace chamaejasme Wulfen.

Polemoniaceae (Jacob's ladder family):
- Phlox hoodii Richardson.
- Phlox sibirica Linné.
- Polemonium humile Willdenow. Jacob's ladder.
- Polemonium pulcherrimum Hooker.

Boraginaceae (borage family):
- Eritrichum aretioides (Chamisso) De Candolle.
- Mertensia alaskana Britton. Bluebells.

Scrophulariaceae (figwort family):
- Castilleja tristis Wight. Indian paintbrush.
- Castilleja tristis var. pubens Wight.
- Pedicularis labradorica Panzer. Lousewort.
- Pedicularis sudetica Willdenow.
- Pentstemon gormani Greene. Beard tongue.

Rubiaceae (madder family):
- Galium boreale Linné. Bedstraw.

Caprifoliaceae (honeysuckle family):
- Linnaea borealis Linné. Twinflower.
- Viburnum pauciflorum Pylaie. High-bush cranberry.

Valerianaceae (valerian family):
- Valeriana capitata Pallas. Valerian.

Campanulaceae (harebell family):
- Campanula lasiocarpa Chamisso. Harebell.
- Campanula uniflora Linné.

Asteraceae (aster family):
- Achillea borealis Bongard. Yarrow.
- Arnica alpina (Linné) Olin.
- Arnica nutans Rydberg.
- Aster sibiricus Linné.
- Crepis nana Richardson.

Asteraceae (aster family)—Continued.
 Erigeron caespitosus Nuttall. Fleabane.
 Erigeron hyperboreus Greene.
 Erigeron uniflorus Linné?
 Senecio atropurpureus (Ledebour) Greenman. Groundsel.
 Senecio lugens Richardson.
 Taraxacum ceratophorum (Ledebour) De Candolle. Dandelion.

SETTLEMENTS

Fort Yukon, at the confluence of the Porcupine and Yukon Rivers, and Beaver, about 80 miles by river downstream from Fort Yukon, are the only white settlements in this region. Fort Yukon, the point of entry for the Porcupine Valley, is the center of the fur industry of the upper Yukon, and its population is therefore to some extent nomadic, the trappers being alternately in and out of town. The stable white population consists perhaps of 40 to 50 people, augmented periodically by trappers and prospectors. The United States Signal Corps maintains a radio station at Fort Yukon. One of the local points of interest at Fort Yukon is the Hudson Stuck Memorial Hospital, where the native people of this district are cared for in sickness and are taught the rudiments of sanitation and hygiene, as well as the fundamentals of Christianity. This is the only well-equipped hospital in this region and is therefore also a great benefit to the white people along the upper Yukon.

Beaver is another trading post and trapping center on the Yukon. The population of Beaver, like that of Fort Yukon, is variable but usually consists of a few white men and several native families. Beaver is also the point of entry into the Chandalar mining district, 125 miles to the northwest.

Several native settlements exist in this district, of which the largest is the one at Fort Yukon, where 200 or more natives live. The next largest settlement is at Arctic Village, about midway between the Junjik River and Ottertail Creek, on the East Fork of the Chandalar, where there are about 75 natives. Christian Village, another settlement of perhaps 20 natives, is just below the constricted part of the Christian River valley, where the river discharges into the Yukon flats. Chandalar Village, on the Chandalar about 45 miles by river from its upper mouth, is another native settlement. All these natives are of Indian stock. The native families at Beaver, however, are mainly Eskimos and their descendants, who migrated across the Brooks Range from the Arctic side with Frank Yasuda about 30 years ago.

The only road in this district is a wagon road 75 miles long, from Beaver to Caro, on the Chandalar, over which supplies for the Chandalar mining districts are freighted. A number of winter trails are used by the natives and trappers, however, one of the more frequented of which is the trail from Fort Yukon to Arctic Village by way of Christian Village. The distance from Fort Yukon to Christian Village is 75 miles and to Arctic Village 150 miles.

The Yukon River is the arterial highway of this region. In summer passengers, mail, and freight are carried on the Yukon by a steamboat operated by the American-Yukon Navigation Co., and in winter a regular mail service is maintained by dog teams from Fairbanks to Circle and thence up the Yukon to Eagle and downstream to Fort Yukon and Beaver.

GEOLOGY

OUTLINE

The sedimentary rocks of the Chandalar-Sheenjek district are mainly of Paleozoic age. Six sedimentary formations are shown on the accompanying geologic map (pl. 2), ranging in age from pre-Silurian to Carboniferous. Igneous rocks also are present but are confined mainly to Sheenjek Valley, where they occur as intrusive bodies in the late Devonian or early Mississippian sediments. Tertiary lavas are represented in the southwest corner of the mapped area.

The oldest sedimentary rocks are a group of schists of early Paleozoic and possibly in part of pre-Paleozoic age. These schists are overlain by the Skajit limestone, of Silurian age, and this in turn is followed by a group of rocks that are believed to belong in the Devonian system. Three younger formations are also mapped, of which the lower one is here considered to be of Upper Devonian or early Mississippian age. The intermediate formation is regarded as lower Mississippian. The youngest of these three formations is the Lisburne limestone, of upper Mississippian age. Triassic rocks are known also to exist to the northwest and northeast but have not been recognized as such in this district. To the west Cretaceous rocks also are known to exist south of the Brooks Range, and such rocks may indeed be present in the unmapped country in the south-central part of this area, especially near the Christian River.

SEDIMENTARY ROCKS

EARLY PALEOZOIC AND POSSIBLY OLDER ROCKS

Distribution.—Undifferentiated early Paleozoic rocks crop out along the East Fork of the Chandalar River from the mouth upstream for 50 miles in an air line and continue thence upstream along the west side to Ottertail Creek as a narrow fringe adjoining the Skajit limestone. At Ottertail Creek a local doming brings to the surface an equidimensional area of 30 to 40 square miles, and this dome marks the northern extent of these rocks.

These rocks continue westward at about the same latitude into the valley of the Middle Fork of the Chandalar River and still farther westward into the North Fork, where they have been described and mapped by the writer.[2] To the east, in the Chandalar-Sheenjek district, these undifferentiated Paleozoic rocks appear to be covered by younger rocks, for they are exposed nowhere on the Sheenjek River. Undifferentiated metamorphic rocks north of the Chandalar-Sheenjek district, however, on the north slopes of the Brooks Range, have been described and mapped by Leffingwell[3] under the name Neruokpuk schist. It is therefore probable that all the younger rocks in the Chandalar-Sheenjek district are underlain at depth by these older Paleozoic rocks.

Lithology and structure.—Very few observations of these rocks were made in the lower valley of the East Fork of the Chandalar, because few exposures occur in the valley walls and the tops of the hills in late August were deeply buried by snow. The few data available, however, show that this group is composed mainly of mica schist, quartz-mica schist, and phyllite, the last in places graphitic. Also a few specimens show the presence of more quartzose rocks, approaching quartzite schist and quartzite in character, mainly in the hills near the Chandalar River, at the south side of this belt of rocks. No crystalline limestone was seen, but from the character of those rocks farther west thin bands of this rock may occur. Old vein quartz was also seen, kneaded into the mica schist and phyllite and appearing therefore mainly as thin laminae and flattened lenses along the cleavage planes.

On top of the hill between the lower valley of Lush Creek and the East Fork an interesting sheared conglomerate crops out. This conglomerate is sheared to such an extraordinary degree that its originally fragmental character is scarcely evident in hand specimens. The component pebbles, which seem to be chert and quartz, are from half an inch to 3 inches in length, perhaps one-third to one-half as wide, and from one-sixteenth to one-fourth inch in thickness and are therefore prolate spheroidal in shape but extremely flattened in one dimension. The long axes lie parallel to the dip of the cleavage. Together with the conglomerate at this locality occur long stringers of slate, chert, and vein quartz, as thin as the pebbles above described, showing that these rocks have been disrupted and drawn out into elongated slivers. The cleavage is usually fairly regular, approximating a plane surface, but in places it is wavy and somewhat crenu-

[2] Mertie, J. B., jr., Geology and gold placers of the Chandalar district: U. S. Geol. Survey Bull. 773, pp. 225–228, 1925.

[3] Leffingwell, E. de K., The Canning River region, northern Alaska: U. S. Geol. Survey Prof. Paper 109, pp. 103–105, 1919.

lated. Ordinarily the occurrence of conglomeratic phases of these metamorphic rocks near the northern border of the group might have some stratigraphic significance, but in rocks so greatly metamorphosed their present geographic position probably means little or nothing with reference to stratigraphic interpretation. The nearest approach to limestone in this group of rocks was seen in the center of the dome, on the ridge southwest of Ottertail Creek. The rocks on this ridge are mainly calcareous mica schist, composed essentially of muscovite and calcite, with some more argillaceous types of mica schist.

Sheared greenstone is intermingled with the schist along the ridge east of the mouth of the East Fork of the Chandalar River, and sheared igneous rocks that may originally have been dioritic occur at places in the lower canyon of the East Fork. Hence igneous rocks of intermediate and basic character appear to constitute a part, though a minor part, of this group of rocks, but no information is at hand for interpreting their original mode of occurrence. In general, however, such igneous rocks appear to occur mainly along the southern margin of this group of undifferentiated rocks, thus suggesting that they are very ancient.

No original bedding planes were recognized, and the available stratigraphic data are too meager to permit the tracing of any distinct lithologic horizons areally. Hence the stratigraphic succession of beds is quite unknown. The cleavage, which is the only structure visible, strikes from N. 60° W. to west and dips mainly north at angles of 15° to 25°, although at places it dips south. At the center of the Ottertail Creek dome the cleavage is nearly horizontal and dips very slightly, but this is evidently a minor structure and has little regional significance. It appears probable, from the few data available, that these rocks have been deformed in several stages and have at some time been acted upon by intense lateral pressure applied either from the north, which thus produced the northward-dipping cleavage, or from the reverse direction, which produced conjugate cleavage, of which the northward-dipping cleavage in this area is a part.

Age and correlation.—No fossil evidence is available for assigning these rocks to any part of the geologic column. However, both here and to the west they lie south of the Skajit limestone, which is of Silurian age, and as this limestone appears to dip in general northward and is regionally less metamorphosed, these schistose rocks underlie it stratigraphically. No absolute data are available either to prove or to disprove an unconformity at the base of the Skajit limestone, but the variable nature of the schist along the southern margin of the limestone makes it probable that such an unconformity does in fact exist. Hence it seems best to regard these schists as totally pre-Silurian, rather than possibly Silurian in their upper beds. Similarly the lower age limit is indefinite, but the sequence as a whole resembles more closely the altered Paleozoic rocks of the Yukon-Tanana region than the definitely pre-Cambrian rocks which underlie them. On the other hand, the occurrence of quartzitic rocks in this group, along its southern margin, suggests a downward gradation into pre-Cambrian rocks. In general, therefore, this group of undifferentiated schistose rocks is regarded as mainly of early Paleozoic age, with the possibility of an admixture of pre-Cambrian rocks along the southern margin of the belt.

SILURIAN ROCKS

SKAJIT LIMESTONE

Distribution.—The Skajit limestone crops out along the west side of the East Fork of the Chandalar River from a point about opposite the head of Lush Creek northward at least for 80 miles and continues on in the same direction into the Brooks Range. Just above Nichenthraw Mountain this limestone crosses to the east side of the valley, but its areal extent north and northeast of that point is undetermined. About 35 miles north of Nichenthraw Mountain Leffingwell[4] has mapped a great mass of limestone, which on the basis of fossils found at the west end of the Franklin Mountains and farther down the Canning River he regarded as essentially Carboniferous. Undoubtedly a large part of this limestone is of Carboniferous age, a fact which is further corroborated by the presence of similar limestones at the head of the Sheenjek River, striking off northwestward, in the direction of the head of the Canning River. But another part of the limestone mapped by Leffingwell, particularly the limestone at the crest of the Brooks Range, north of Nichenthraw Mountain, is almost certainly the Skajit limestone, of Silurian age. Evidently two limestone formations, of greatly different age, lie in contact with one another or in close proximity along the crest and north slopes of the Brooks Range.

Lithology and structure.—This formation consists of crystalline and semicrystalline limestone and includes possibly dolomitic beds. In the Chandalar-Sheenjek district the Skajit limestone was seen mostly from a distance and appeared to be white or light gray but mottled in places by red and brown iron stains. The general appearance is also affected considerably by the degree of metamorphism to which the limestone has been subjected, and the general absence of any dark-gray or bluish colors in this district leads to the belief that

[4] Leffingwell, E. de K., op. cit., pp. 108–112.

the limestone has been much deformed and is probably much recrystallized. Commonly the Skajit limestone occurs as heavy beds of massive limestone, much fractured in places and commonly seamed by veins of calcite and less commonly quartz. It therefore differs markedly from the Carboniferous limestone on the Sheenjek River, which is thin bedded and very cherty.

The only structural observations available on the Skajit limestone in the Chandalar-Sheenjek district are those dealing with the attitude of the bedding planes of the limestone at and near the contact with the underlying schist. From the Wind River to Crow Nest Creek long-distance observations show clearly that the limestone beds dip steeply westward and northwestward. Also on Ottertail Creek, where cross structure has created a doming of both the schist and the limestone, the limestone dips away from the schist on the north, west, and southwest sides of the dome. These observations suffice to prove that the Skajit limestone lies stratigraphically above the schist, and as previously stated it is probable that an unconformity separates these two groups of rocks.

The regional structure of the Skajit limestone in this district is somewhat mystifying when compared with its regional structure and trend to the west. This Silurian limestone has been shown in previous publications [5] to extend almost continuously across northern Alaska, from Kotzebue Sound on the west to the Middle Fork of the Chandalar River on the east, and it was believed from that point to swing southeastward to the Porcupine Valley, where a similar limestone of Silurian age is known. Here, on the East Fork of the Chandalar River, however, it appears to veer sharply northward toward the crest of the Brooks Range, and to judge from Leffingwell's work in the valleys east of the Canning River it is not likely to continue eastward along the north side of the Brooks Range. On the other hand, the explorations on the Sheenjek River and information obtained from prospectors relative to the Coleen River indicate that this limestone does not continue eastward along the south side of the Brooks Range. Moreover, it does not appear to plunge under younger formations to the east, for the limestone is bounded by schist on the south in the valley of the East Fork and on the north along the Canning River. This areal distribution of these two groups of rocks suggests the presence of a large northeastward-trending synclinorium, whereby the limestone comes to the surface and ends. With the information at present available this hypothesis is strongly indicated.

[5] Mertie, J. B., jr., Geology and gold places of the Chandalar district, Alaska: U. S. Geol. Survey Bull. 773, pp. 229–283, 1925. Smith, P. S., and Mertie, J. B., jr., Geology and mineral resources of northwestern Alaska: U. S. Geol. Survey Bull. 815 [in preparation].

Manifestly, if such a synclinorium is present, this area is a most unfavorable one in which to attempt any measurement of the thickness of the formation, and as a matter of fact the route of the expedition of 1927 did not lead sufficiently close to this formation to collect any such data, even had the structural conditions been more propitious. Hence all that may be said regarding thickness is to repeat the previous estimate made by the writer, which was based on observations made in the valley of the North Fork of the Chandalar. From those data the stratigraphic thickness was judged to be on the order of 6,000 feet.

Age and correlation.—No determinable fossils were collected from this limestone during the season of 1927, but it is known to be continuous with the Silurian limestone of the Middle and North Forks of the Chandalar River, which in turn continues westward to join the Skajit limestone on the John River. Excellent fossils were collected from the upper part of this limestone by the writer [6] on the North Fork of the Chandalar River in 1923, consisting mainly of a thick-shelled species of *Conchidium*, which was referred by Edwin Kirk, of the U. S. Geological Survey, to the upper Silurian. This of course does not prove that all of this great mass of limestone is of upper Silurian age. In fact, other data suggest that it may include beds of earlier Silurian horizons. But in any event this limestone is certainly of Silurian age and is believed by the writer to be mainly of upper and middle Silurian age.

The name Skajit was not applied to the Silurian limestone on the Middle and North Forks of the Chandalar River when that area was mapped by the writer, owing mainly to the uncertain status of the formational nomenclature at that time, but the correlation of this Silurian limestone with the Skajit formation was made. Recently the old term Skajit formation has been changed to Skajit limestone, by Smith and Mertie,[7] and the term Skajit limestone, now applicable to the limestone here discussed, has been adopted in this report.

DEVONIAN (?) ROCKS

Distribution.—Rocks believed to be mainly of Devonian age are shown on the accompanying geologic map along the east side of the East Fork of the Chandalar River, beginning about 5 miles above Lush Creek and extending north-northeastward to Old John Lake, with two outlying masses on the west side of the valley, one just below the Wind River and the other in the hills west of Arctic

[6] Mertie, J. B., jr., Geology and gold placers of the Chandalar district: U. S. Geol. Survey Bull. 773, p. 232, 1925.

[7] Smith, P. S., and Mertie, J. B., jr., Geology and mineral resources of northwestern Alaska: U. S. Geol. Survey Bull. 815 [in preparation].

Village. The recognition of these rocks and their cartographic delineation as a separate mappable unit are based largely on their lithology, and their areal representation is therefore of necessity somewhat diagrammatic.

Lithology and structure.—Along the low ridge that forms the watershed between the Christian River and the East Fork of the Chandalar River these rocks are exposed as surface rubble and consist mainly of quartzitic sandstone. These are fine-grained light-gray to dark-gray rocks, the component grains of which are chert and quartz, with certain other constituents that on oxidation produce reddish-brown iron-stained bedding planes and similarly colored rusty spots within the rock itself as seen on a fresh fracture. The original grains are clearly evident with a hand lens, but some of the specimens show incipient recrystallization, which produces a somewhat quartzitic texture. Naturally, these harder rocks form the ridges, and the softer members of the group are probably localized mainly in the valleys. Thus along the west wall of the East Fork, just below the mouth of Crow Nest Creek, rocks of the same group are exposed and are seen to consist of thin-bedded sandstone and slate, in beds of variable thickness that repeatedly alternate within short distances. These thin-bedded sandstones are essentially similar to those exposed on the ridge to the east, except that they are more quartzose and if anything more quartzitic. The slates are thin cleaving and dark gray to black. Both the sandstone and slate show ripple marking, and the slate shows minute muddy concretionary forms of irregular outline on the bedding planes. Thin seams of quartz are also prevalent at places as fillings along planes of fracture transverse to the bedding. These rocks strike about due northeast and dip about 70° SE., and the cleavage of the slaty rocks is clearly parallel to the bedding. This attitude of the beds, if it represents their regional structure, indicates that they overlie the schist and the Skajit limestone, which lie along the valley wall to the west.

Along the ridge southeast of Arctic Village and southwest of Old John Lake, where these beds are fairly well exposed, they consist of quartzitic sandstone, similar to that described above, in beds from 4 to 18 inches thick interbedded in the fissile dark-gray to black slate, in part sandy, and some fissile red argillaceous slate. The heavier of these sandstone beds are dark gray but weather to a very light gray. All these beds in this locality strike fairly regularly north to N. 10° E. and dip 30°–40° E.

Similarly, in the hills west of Arctic Village, quartzitic sandstone and shaly beds were seen, the sandstone in beds from 4 to 18 inches thick, which weather out on the steep slopes of the valley wall as great flat slabs. This quartzitic sandstone differs from the conglomeratic quartzite described below in that it is not conglomeratic, is softer and thinner bedded, and has considerable mica, which does not seem to be of secondary origin. The strike of these rocks, however, is N. 60°–80° W., and they differ in this regard from the rocks described above.

The recorded structural observations tend to show that this group of rocks not only overlies the schist and the Skajit limestone but also is separated from the underlying formations by a structural unconformity. Undoubtedly these rocks are much folded, and insufficient work has yet been done to evaluate this folding and other structural features, so that no estimate of thickness is warranted. A considerable thickness, however, perhaps several thousand feet, is indicated by the fact that the areal extent of the outcrops across the strike is at least 10 miles.

Age and correlation.—The rocks of this group are unquestionably post-Silurian, but as fossils have not been found in them, no precise geologic age may be assigned. Lithologically they resemble both the Devonian rocks of the Brooks Range and the Lower Cretaceous rocks of the Yukon Valley. The actual contact between these rocks and the Upper Devonian or early Mississippian rocks to the northeast has not been carefully studied, and insufficient structural data are available along this contact line to state definitely which of the two groups is the older. Their position in the geologic column must therefore be decided on regional geologic data of less specific nature.

On the North Fork of the Chandalar River a conspicuous group of rocks, containing in their lower horizons Middle Devonian fossils were found by the writer [8] overlying and closely adjoining the Skajit limestone, and these rocks appeared to continue eastward in the direction of the Middle and East Forks of the Chandalar River. West of the Chandalar Valley the Devonian sequence, containing in its upper part Upper Devonian fossils, has been mapped by Smith and Mertie [9] in the valley of the Killik River and shown by them to continue westward to Cape Lisburne. It is evident, therefore, that the Devonian is represented by a well-developed sequence of rocks in northern Alaska and may be expected to occur in the Chandalar-Sheenjek region. The rocks of this region, here designated Devonian (?), resemble greatly the Devonian rocks of the North Fork of the Chandalar River and of the Killik River, both in their lithology and in the character and degree of their deformation. Hence strong presumptive evidence exists for their assignment to the Devonian.

The Lower Cretaceous rocks of northern Alaska, on the other hand, have not been found to extend east of the Mosquito Fork of the

[8] Mertie, J. B., jr., Geology and gold placers of the Chandalar district, Alaska: U. S. Geol. Survey Bull. 773, pp. 233–235, 1925.

[9] Smith, P. S., and Mertie, J. B., jr., Geology and mineral resources of northwestern Alaska: U. S. Geol. Survey Bull. 815 [in preparation].

Koyukuk River, although the main Chandalar Valley, toward which they trend, has been mapped geologically both by Schrader and by the writer. Lower Cretaceous rocks, however, are known to the east of the Chandalar-Sheenjek region, in Canadian territory, and also to the southeast, between Circle and Eagle; but both these areas are more than 150 miles distant and appear to represent sedimentation in an arm of the Cretaceous sea that did not communicate directly with the Koyukuk area. The existing evidence, therefore, does not favor the assignment of these rocks to the Mesozoic, although the possible Mesozoic age of part of them is by no means disproved.

Two other groups of rocks, as later described in this report, are believed to lie between these rocks and the Lisburne limestone, and this condition favors their assignment to the early Devonian rather than to the late Devonian. As a matter of fact, however, no Lower Devonian rocks are known to exist anywhere in Alaska, and with this fact in mind the rocks here described are believed to represent either Middle or Upper Devonian horizons, or parts of both.

CARBONIFEROUS SYSTEM

MISSISSIPPIAN SERIES

GENERAL FEATURES

Two formations that are believed to be of Mississippian age and another that is assigned to the Upper Devonian or Mississippian have been shown on the geologic map (pl. 2). The uppermost of these three, known as the Lisburne limestone, is definitely of upper Mississippian age. The two lower ones, in which fossils have not been found, are quite enigmatic in their structural and stratigraphic relations to one another and to the Lisburne limestone, and their assignment to the Mississippian has been made mainly on the basis of their lithology, compared to better-known sections elsewhere. So doubtful, in fact, is the stratigraphic sequence of these two formations that it might have been better to map them collectively as a single group of rocks, as was done with a similar stratigraphic sequence by Smith and the writer [10] farther west in the Brooks Range. The lithology of these two formations, however, is sufficiently dissimilar to make it seem best to differentiate them, even if the boundaries given are only approximate, with the hope that such differentiation will serve as a starting point for any subsequent geologic studies in this and adjoining areas.

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[10] Smith, P. S., and Mertie, J. B., jr., op. cit.

LOWER MISSISSIPPIAN ROCKS

Distribution.—The two lower formations are a quartzite-conglomerate-slate formation and a chert-slate formation. The chert-slate formation is here considered to be either of Upper Devonian or early Mississippian age. It is typically developed on the Sheenjek River, from Outlook Point northward for at least 55 miles, to the mouth of Monument Creek and also in the hills south and southwest of Old Woman Creek. The quartzite-conglomerate-slate formation occurs at Table Mountain, whence it continues northwestward up the northeast side of Old Woman Creek, thence veers southwestward, and extends for 30 miles to Nichenthraw Mountain, on the East Fork of the Chandalar. From Table Mountain this formation also extends southwestward for at least 30 miles to Johnnie Frank's cabin, on the Koness River.

Lithology.—The Sheenjek River may be considered the type locality of the chert-slate formation. The low ridge known as Outlook Point, east of Christian's cabin, is the southernmost exposure of this formation, and there the country rock consists of a massive light-gray chert, cut by numerous dikes of gabbro and diabase. One of the distinguishing characteristics of this formation on the Sheenjek River is the large amount of basic igneous rock associated with it. This mixture of chert, shaly slate, and basic igneous rock continues on up the Sheenjek River and appears to be the only formation represented up to Monument Creek. Helmet Mountain, one of the prominent landmarks of the Sheenjek Valley, is composed of a fine-grained gabbro, but the ridge southeast of Helmet Mountain is composed of light to dark gray chert that weathers white on the surface owing to the development of a thin veneer of opaloid material. This type of weathered surface is characteristic of chert rubble on the tops of ridges in the piedmont province, where the chert has been particularly affected by residual decomposition. Shoulder Mountain, farther up the west side of the Sheenjek, is likewise composed of basic igneous rocks, surrounded on the lower slopes by chert with some interbedded sandstone and argillite. On the west side of the Sheenjek Valley 10 miles above the Koness River the spurs are likewise composed essentially of chert, but near the top of the spur between the Sheenjek River and Monument Creek some thin bands of limestone and calcified chert were also seen. This material is worthy of special description. In the beds where replacement has occurred the boundary line between the chert limestone follows bedding planes in some places, but in others the contact forms an intricate pattern in no way related to bedding. Some of the contacts appear sharp and clean-cut and others indefinite, but in thin sections of this material even the sharp contacts are seen to be only relatively so, being bordered on one side by completely calcified material and on the other by a zone showing incipient calcification of the chert.

Additional evidence of the operation of secondary processes at this locality is found in the numerous euhedral crystals of limonite, pseudomorphic after pyrite, that are scattered about on the surface of the ground. Along the east side of the Sheenjek Valley 13 miles above the Koness River the spurs consist of chert and diabase, but near the crest of the Coleen-Sheenjek watershed a recrystallized chert was found which resembled superficially a gneissoid rock but was determined to be a fine-grained quartzite, replaced to a considerable extent by calcite. Naturally, because of their superior resistance to erosion, the chert and associated basic igneous rocks form most of the ridges and prominent spurs in the lower Sheenjek Valley. This formation, however, is believed to contain a considerable amount of shale and slate. About 20 miles above Christian's cabin, for example, fissile chocolate-colored shaly slate occurs along the west wall of the valley just at the edge of the valley floor, and similar rocks are believed to be extensively developed in the valleys elsewhere.

The area south and southeast of Old Woman Creek, which is mapped as part of the chert-shale formation, is at the southern edge of the alpine province and yields good exposures of these rocks. The southward-facing spurs between the forks of Old Woman Creek, for example, are bare, particularly toward their tops, and the country rock is an intimate mixture of chert, slate, and shale. The chert is gray and black and in part banded, and the slate and shale are largely thin-cleaving brown varieties, though in part green or red. Still farther west, along the contact between the chert-slate and the quartzite-conglomerate-slate formations, the chert and slate are about evenly divided in quantity, and there, at or near the top of the chert-slate formation, is a thin but conspicuous and apparently persistent bed of red slate that is traceable by its brick-red outcrops for at least 3 miles along the strike.

Only at one locality, however, in this northern area of the chert-slate formation were basic igneous intrusives seen in this sedimentary formation. At this locality, on the hill about 5 miles southwest of the mouth of Old Woman Creek, occurs a peculiar assemblage of rocks, consisting of light-gray and greenish chert, black, red, and green slate, thin-bedded sandstone, basalt, and beds of the quartzite and conglomerate typical of the overlying formation. The proximity of the quartzite-conglomerate-slate formation to the south doubtless accounts for the presence of these two types of rocks.

The quartzite-conglomerate-slate formation, as the designation implies, consists mainly of rocks of these three types, but quartzite and conglomerate constitute the prominent and specially diagnostic parts of the sequence. The quartzite is mainly of two kinds, of which the more common is a dark-gray rock composed of rounded grains of chert and quartz that show a certain amount of recrystallization, although in general the rounded outlines of the original grains are still preserved. The less common type is a light-gray quartzitic sandstone, nearly free of chert grains. The darker variety, by an increase in the proportion of chert and an increase in the size of the constituent grains, grades into a conglomeratic rock at several places, the most common variety of which consists of angular, subangular, and rounded grains of vitreous white vein quartz and light-gray and black chert in a matrix which is partly chert and partly quartz. Some of these rocks are essentially chert conglomerate—that is, mainly angular chert pebbles in a chert matrix. Generally, however, both chert and vein quartz constitute the pebbles, and the matrix is quartzitic. When such rocks have dark angular grains of chert and quartz in a lighter-colored quartzose matrix, they resemble superficially granitic rocks and have been mistaken for such by prospectors in this region. Generally the pebbles are not larger than half an inch in diameter, but at some localities, as for example on the mountain 7 miles southwest of Table Mountain, pebbles several inches in size were seen.

The cherty matrix of some of these conglomerates appears to resemble the chert conglomerate at the base of a chert formation in the Livengood district of the Yukon-Tanana region, described by the writer,[11] but the occurrence of quartz in many specimens, both in the pebbles and in the matrix, constitutes a distinguishing feature not seen in the rock of the Livengood district. Moreover, this formation appears to overlie rather than underlie a chert formation, therein differing again from the chert conglomerate at Livengood.

The slate associated with this quartzite and conglomerate is a black variety, almost phyllitic in places, and occurs in numerous bands through the formation, thus separating the more massive rocks into a number of zones. Good exposures occur on top of the mountain east of Nichenthraw Mountain, on the upper part of the East Fork of the Chandalar. Several bands of the slate crop out along the west face of this mountain, interbedded with the quartzite, and an outlying hill of quartzite to the southwest, which forms a roche moutonnée in the valley of the East Fork, is evidently separated from the main valley wall by such a band of slate, which has been gouged out by the old glacier that moved down the valley. The particularly noticeable shearing in this black slate is probably due to the fact that such beds that lie between the massive quartzite and

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[11] Mertie, J. B., jr., The gold placers of the Tolovana district: U. S. Geol. Survey Bull. 662, pp. 239–242, 1918.

conglomerate have acted as planes of slipping in the folding of this formation.

Structure.—The chert formation in the piedmont portion of the Sheenjek Valley is not well exposed on the lower slopes of the spurs, and many of the tops are composed of basic igneous rocks. Hence few structural observations are available in this part of the valley. Also, because these rocks are rather incompetent and therefore much deformed, the few scattered observations of strike and dip can have little value in interpreting the larger structural features. So far as the dominant strike or trend of the rocks is concerned, the direction of drainage channels and ridge tops probably gives more real information than the detailed structural observations. As will be seen from Plates 1 and 2, many of the tributaries of the Sheenjek within the piedmont province trend about N. 70° E., and the few available results of observations on the structure of the chert and the directions of elongation of the bodies of intrusive rocks do not depart greatly from that direction. Hence it is inferred that the regional trend of the chert-slate formation in the piedmont province is about N. 70° E. The direction of the prevailing dip can be inferred even less surely than the strike. In fact, the few scattered observations may be said to be practically worthless for affording an understanding of the broader features. The regional geology, however, indicates that younger rocks crop out to the north in the Sheenjek Valley and that older rocks crop out to the south on the East Fork of the Chandalar River. Hence the general dip of the chert-slate formation in this part of the Sheenjek Valley is considered to be northward. Little is known of the type of folding that characterizes these rocks, but the great distance across their strike suggests that there is much duplication of beds at the surface. Furthermore, the net effect of the folding must be such that a low regional dip is produced, even if these beds occur in a basin that lies unconformably upon older rocks. Otherwise, younger rocks should show as unfolded strata or older rocks would be exposed by erosion, unless an inordinately great thickness is assumed for this formation. The few available observations suggest a multiplicity of intricate folds of small amplitude, which duplicate certain beds many times at the surface.

At the northern locality of the chert-slate formation, south and southwest of Old Woman Creek, these rocks strike about N. 60° E. and give rise to a characteristically hummocky landscape, the chert layers forming elongated hummocks and hogbacks on the sides of larger hills. Along the south flanks of the quartzite-conglomerate-slate formation that lies to the north the rocks of the chert-slate formation appear to dip rather constantly southeastward. This structure is puzzling, because it suggests that the chert-slate formation overlies the quartzite-conglomerate-slate formation.

Little is known of the structure of the quartzite-conglomerate-slate formation, particularly as regards its structural relation to the chert-slate formation. At Brushman Mountain the quartzite appears to strike N. 60° E. and dips about 30° NW., and northward this structure seems to remain fairly constant, thus plunging this formation under the Lisburne limestone. Opposite Nichenthraw Mountain, on the East Fork of the Chandalar River, however, the rocks of the quartzite-conglomerate-slate formation strike about N. 50° E. and dip 45° SE. It is fairly certain that these rocks underlie the Lisburne limestone, but obviously much doubt exists whether they overlie or underlie the chert-slate formation.

Age and correlation.—The quartzite-conglomerate-slate formation is a peculiarly distinctive lithologic unit which has been recognized elsewhere in northern Alaska and is fairly well placed stratigraphically. The equivalent of this formation was first observed by Schrader [12] on the headwaters of the Anaktuvuk River and described under the name Stuver "series" and was believed by him to be pre-Devonian in age. Subsequently, in 1923, the writer [13] found many boulders of these quartzitic conglomerates among the stream gravel in the headwaters of the North and Middle Forks of the Chandalar River in such a geologic environment that they were believed to overlie the known Middle Devonian rocks of that area. These rocks were again seen by the writer [14] in 1924 on the Killik River just south of the Lisburne limestone, in a geologic sequence of rocks that seemed to be progressively younger in going from south to north. These data sufficed for a new age assignment for these rocks, and along the Killik River they were grouped with the black shales of the Noatak formation, of Mississippian age, with which they seemed to belong stratigraphically. This evidence, coupled with their apparent position below the Lisburne limestone on the headwaters of the Sheenjek River, is the basis for their assignment in this report to the lower Mississippian.

The age of the chert-slate formation, however, is less definite. Rocks comparable with this formation also were first recognized by Schrader [15] along the North and West Forks of the Chandalar River and described by him under the name West Fork "series." No fossils were found in place in this "series" by Schrader, but he picked up some fossiliferous black flint in the gravel of the Chanda-

[12] Schrader, F. C., A reconnaissance in northern Alaska: U. S. Geol. Survey Prof. Paper 20, pp. 60–62, 1904.

[13] Mertie, J. B., jr., Geology and gold placers of the Chandalar district: U. S. Geol. Survey Bull. 773, p. 236, 1925.

[14] Smith, P. S., and Mertie, J. B., jr., op. cit.

[15] Schrader, F. C., Preliminary report on a reconnaissance along the Chandalar and Koyukuk Rivers, Alaska, in 1899: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 475–476, 1900.

lar River, which he believed was derived from this group of rocks. A list of the fossils contained in these flint pebbles was first published in 1925,[16] and on the basis of these fossils, which included two species of *Syringopora*, *Acervularia*, a cyathophylloid coral, and *Spirifer disjunctus?*, and following the correlation of G. H. Girty, the writer referred the West Fork "series" to the Upper Devonian or Mississippian. The position of the West Fork "series" far south of the alpine province in the Chandalar Valley, where the Devonian and Mississippian rocks are typically developed, was very puzzling at that time, even as it is in the lower Sheenjek Valley, but the writer nevertheless correlated the West Fork "series" with the chert-conglomerate rocks equivalent to the Stuver "series," which at the longitude of the North Fork of the Chandalar River lie apparently at the crest of the Brooks Range. It now seems likely that this correlation was erroneous, but the data in hand still seem to justify the reference of the West Fork "series" to the Upper Devonian or Mississippian, though probably underlying the Stuver "series." It also seems probable that rocks comparable with the West Fork "series" crop out intermittently along the south flanks of the Brooks Range from the North and West Forks of the Chandalar River eastward at least as far as the Sheenjek Valley. Under these conditions, and with no contradictory data at hand, it seems necessary to regard the chert-slate formation of the lower Sheenjek Valley, which is probably the equivalent of the West Fork "series," as Upper Devonian or Mississippian. As regards a choice between the assignments of Upper Devonian and Mississippian, the writer, influenced by the Carboniferous aspect of these corals and the questionable specific determination of the *Spirifer* and also by the known presence of a lower Mississippian chert formation along the Yukon, has been inclined to regard the West Fork "series" and the chert-slate formation of the Sheenjek Valley as a part of the Carboniferous rather than the Devonian system, but this is only an unproved opinion.

On the other hand, if the fossiliferous flints collected as float by Schrader came from some undetermined horizon and not from the West Fork "series," this whole framework of correlation fails. The geologic explorations of recent years in central and northern Alaska have proved the existence of extensive chert formations other than the lower Mississippian chert of the Yukon-Tanana region. One such formation of Triassic age in northwestern Alaska has been described by Smith and the writer,[17] and another of Middle Devonian age

[16] Mertie, J. B. jr., Geology and gold placers of the Chandalar district: U. S. Geol. Survey Bull. 773, p. 237, 1925.

[17] Smith, P. S., and Mertie, J. B., jr., op. cit.

along the Yukon has recently been described by the writer.[18] Therefore, in the absence of fossil evidence a reasonable doubt is cast upon the assignment of the chert-slate formation of the Sheenjek Valley to the late Devonian or early Mississippian. The Upper Triassic chert-shale formation of northwestern Alaska, in particular, is a significant alternative for correlation. Against such a correlation, however, must be cited the fact that the nearest Upper Triassic formations to the Sheenjek Valley are the Shublik formation of the Canning River region, described by Leffingwell,[19] and the Upper Triassic rocks along the international boundary, north of the Porcupine, described by Maddren[20]; and both of these Upper Triassic formations are described as limestone, shale, and sandstone, with no mention whatever of any cherty rocks in the sequence. For lack of any better data the writer therefore correlates the chert-slate formation of the Sheenjek Valley with the basal Mississippian rocks or with the upper part of the Upper Devonian sequence.

UPPER MISSISSIPPIAN ROCKS

LISBURNE LIMESTONE

Distribution.—The Lisburne limestone is found in the Chandalar-Sheenjek district only in the upper Sheenjek Valley, where it crops out in a band from 10 to 15 miles wide that trends perhaps N. 60° W. The easternmost point at which this limestone was seen is on the spur between the forks of the Sheenjek River. From the main Sheenjek River it continues westward into the East Fork of the Chandalar River and on in the same general direction across the crest of the Brooks Range into the valley of the Canning River.

Lithology.—The lithology of the Lisburne limestone is fairly well known from comparative studies farther west, and hence the formation is readily recognized even where fossils are scarce. On the upper Sheenjek it was possible to examine this formation at only one locality. The writer spent one day in the limestone hills on the east side of the river, opposite the camp at the mouth of Old Woman Creek, and the following lithologic data may apply more particularly to the basal part, which was examined in the course of that work, than to the formation as a whole. The limestone in these hills appears from a distance to be rather well bedded, for the lines of stratification are strongly marked on the hillsides. On close inspection this stratification is seen to mark the boundaries of innumerable alternating beds of limestone and chert, the limestone light in

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[18] Mertie, J. B., jr., Geology of the Eagle-Circle district, Alaska: U. S. Geol. Survey Bull. 816 [in preparation].

[19] Leffingwell, E. de K., op. cit., pp. 115–118.

[20] Maddren, A. G., Geologic investigations along the Canada-Alaska boundary: U. S. Geol. Survey Bull. 520, pp. 312–313, 1912.

color, owing to weathering, and the chert mainly dark, and thus the section has an appearance similar to that of the outcroppings at Calico Bluff. Chert appears to constitute perhaps as much as 50 per cent of the rock, particularly in the hills close to Table Mountain, which represent the basal part of the formation. Farther up the Sheenjek the rocks appear more massive and less laminated and probably contain a much smaller proportion of chert. In addition to the interbedded and interlaminated chert the limestone beds themselves contain much chert, which occurs in indescribably complex shapes and patterns. At one place it simulates a fault breccia; at others the chert patches are rounded, in all sizes from minute fragments up to areas several feet in diameter; again, the chert appears to be zonally grown; and finally, it occurs in colloidal laminae so intricate in shape that they resemble the crenulated layers in a highly contorted schist, although obviously the bedding planes are fairly regular. Most of this chert is black, though a very little light-gray chert was also seen. The limestone is typically a dark-gray to black, finely crystalline variety, though in places coarsely crystalline, and emits a fetid odor where freshly broken. Thin seams of pyrite in places cross the bedding of the limestone. Little or no white crystalline limestone or anything suggesting dolomite was seen, though such limestone is probably present farther up the Sheenjek Valley. A little black slaty shale in beds from an inch to a foot in thickness was also seen in this lower part of the formation. Both the chert and the limestone contain innumerable crinoid stems, but fossil shells are not so numerous at the locality visited.

Structure.—Observations of strike and dip show that the formation is much folded, though apparently not closely appressed. Just northwest of Table Mountain the trend of the limestone appears to be N. 20° W. for a considerable distance, but in the limestone belt as a whole, the regional trend seems to be nearly N. 60° W. Continuous dip slopes, which extend over long distances, together with the regular bedding on the hillsides, indicate that the folding is relatively open, and the great width of the limestone belt suggests much duplication of beds at the surface. Numerous reversals in dip were noted, but the regional dip is presumed to be northward. The northern limit of the limestone on the Sheenjek River was seen and mapped from a distance of 20 miles, but insufficient structural data regarding the whole formation are available with which to make any estimate of the stratigraphic thickness. Obviously, however, the thickness is comparable with that of the Silurian limestone, which was stated to be approximately 6,000 feet.

Age and correlation.—Only a few of the crinoid stems of this formation were collected, because they were not regarded as sufficiently diagnostic to warrant their transportation back to Arctic Village. One imperfect shell and a crinoid head, however, were collected from the base of the Lisburne limestone hills on the east side of the upper Sheenjek Valley, about 4 miles N. 70° W. of the north end of Table Mountain. G. H. Girty, of the United States Geological Survey, makes the following identifications and statement:

27AMt25. Crinoid columnals.
27AMt28. Megistocrinus sp.
27AMt29. Spirifer sp.

The *Spirifer* is an imperfect pedicle valve that has a broad, shallow, and apparently unplicated sinus and numerous lateral plications. Superficially it is marked by delicate but sharp radial striae. Among Carboniferous Spirifers I know of none that possesses this combination of characters, for though some have similar fine superficial striae, they have a plicated fold and sinus, such as *S. logani* and *S. grimesi*. In the Silurian and Devonian, however, a considerable number of Spirifers occur that have these characters. Edwin Kirk, of the United States Geological Survey, to whom these specimens have also been referred, is of the opinion that this fauna is not Devonian, and I can not say that it is not Carboniferous. The character of the matrix certainly suggests the Calico Bluff formation, and the stratigraphic and lithologic evidence presented by Mr. Mertie obviously suggests a Carboniferous age. The most probable geologic age, therefore, is Mississippian. I might add, however, that *Megistocrinus* is not known above the lower Mississippian, and if the Calico Bluff formation is upper Mississippian, as I have thought it to be, the horizon of this collection is not Calico Bluff.

In general, however, the age of the Lisburne limestone is well known, being substantiated by large collections of fossils made farther west in the Brooks Range. The writer [21] has recently assembled all the known faunas of the Lisburne limestone from the Brooks Range, west of the John and Anaktuvuk Rivers, into a list that embraces about 100 genera and perhaps twice as many species. Nearly all these fossils have been determined at different times in the last 25 years by Mr. Girty, and as a result of this work the age is definitely known to be upper Mississippian. The fossils from the upper Sheenjek Valley, however, appear to be of lower Mississippian age, and this determination introduces a serious difficulty in correlation. If it should develop that these fossils were collected from the uppermost beds of the rocks that directly underlie the Lisburne limestone, rather than from the base of the Lisburne limestone itself, the difficulty still persists, because Smith and the writer have shown that the Lisburne limestone to the west is underlain by a pre-Lisburne Mississippian sequence that includes in its upper horizons rocks of upper Mississippian age. In the absence of any known or surmised discontinuity of sedimentation between the Lisburne limestone and the pre-Lisburne Mississippian rocks, the paleontologic determina-

[21] Smith, P. S., and Mertie, J. B., jr., op. cit.

tions of Messrs. Kirk and Girty indicate that a marked lithologic change takes place along the strike of the Mississippian sequence from west to east, whereby all the upper Mississippian rocks become of calcareous character and as such a part of the Lisburne limestone, while the pre-Lisburne Mississippian rocks become essentially of lower Mississippian age. This inference constitutes a good reason why the term "Noatak formation," as defined at present, should not be extended east of the John River into the region here described.

The nearest point to the Sheenjek Valley where the Lisburne limestone has been recognized is to the northwest, along the north slopes of the Brooks Range, where it has been described and mapped by Leffingwell.[22] Upper Mississippian rocks about 40 miles to the northeast, in the upper valley of Old Crow River, and in the Firth River Valley, have also been described by Maddren,[23] though he did not at that time apply to them the specific designation Lisburne limestone. This formation, so well known in the western part of the Brooks Range, therefore apparently extends for about 600 miles across northern Alaska, from Cape Lisburne to the international boundary, and is recognized geologically as one of the notable horizon markers of the range.

Along the Porcupine River are rocks that contain the upper Mississippian fauna just above the lower ramparts and also farther upstream, just above the mouth of the Coleen River, and have been described by Kindle.[24] Along the Yukon below Eagle the same fauna is also found in the well-known Calico Bluff formation. Both the Yukon and Porcupine occurrences of this upper Mississippian fauna, however, are in rocks that are essentially thin-bedded limestone and shale and include no massive limestone or chert. These rocks are thus a materially different lithologic unit but are correlated paleontologically with the Lisburne limestone.

QUATERNARY DEPOSITS

GENERAL FEATURES

The Quaternary deposits may conveniently be divided into two general types, the separation being made primarily on the basis of age and secondarily on the character of the deposits. The older or Pleistocene deposits originated mainly from glacial erosion during the glacial epoch and from the partial reworking of glacial débris by the streams that issued from the southern terminals of the glaciers. These older deposits, therefore, consist in part

[22] Leffingwell, E. de K., op. cit., pp. 108–113.
[23] Maddren, A. G., op. cit. pp. 310–312.
[24] Kindle, E. M., Geologic reconnaissance of the Porcupine Valley, Alaska: Geol. Soc. America Bull., vol. 19, pp. 330–333, 1907.

of true glacial deposits, or till, and in part of reworked glacial débris, commonly known as outwash deposits. The later unconsolidated deposits consist of sand, gravel, and silt, which have been derived in part from the postglacial weathering and stream transportation of the hard-rock formations and in part from the reworking and transportation of the older Quaternary deposits. The work in the Chandalar-Sheenjek district has not been sufficiently detailed to warrant the separate delineation of these two types of unconsolidated deposits, and therefore on the accompanying map (pl. 2) they have been grouped together as a unit and designated Quaternary deposits.

PLEISTOCENE GLACIATION AND DEPOSITS

The term Pleistocene epoch is commonly used as more or less synonymous with the term "Glacial period," though it is recognized that the glacial epoch in Alaska probably began earlier and certainly continued later than in the northern United States. Parts of southern Alaska, for example, which are still begirt by ice, may be regarded as still within a glacial epoch. The initiation of glacial conditions requires an annual snowfall greater than the annual dissipation by melting of snow and ice. After extensive ice fields have once formed, however, glaciation will persist indefinitely if a balance exists between the annual accumulation and dissipation of ice and will persist for a great length of time even if the annual accumulation is slightly less than the annual dissipation. The conditions that make glaciation possible are either a cold climate, or a heavy snowfall, or both. Parts of central and northern Alaska have a mean annual temperature that is adequate, at the present day, to give rise to glaciation. Nevertheless, these areas are at present essentially unglaciated, and central Alaska remained for the most part unglaciated throughout the Pleistocene epoch. It is therefore probable that changes in precipitation have been a notable factor in the glaciation of northern Alaska, which began early in the Pleistocene and continued throughout that epoch and probably for a considerable length of time in the Recent epoch. The Brooks Range, although extensively glaciated during this period of maximum accumulation of snow and ice, is now almost free of perennial ice, but the effects of the extensive glaciation are still clearly visible.

When a glacial climate has been established, snow accumulates from year to year and the lower parts of the snow banks gradually congeal to ice. When the weight of superincumbent snow and ice becomes too great the ice begins to flow slowly down into the valleys, commonly extending miles beyond the main site of accumulation. This ice movement, which measures usually but a few feet a year, produces a type of erosion quite different from stream erosion. It is primarily a scouring action, accompanied by sapping on the main crest lines. The valleys and ridges are scoured smooth, while the main divides just above the flowing ice are converted into ragged crest lines. The ice-borne débris is carried down into the lower valleys and there deposited, picked up again by glacial streams that issue from the ends of the glaciers, and redistributed to a greater or lesser extent farther down the valleys. The original glacial débris is characterized by a complete lack of assortment, boulders and cobbles of all sizes being mingled indiscriminately with finer débris and clay. The rock débris is unrounded, and many of the cobbles are scoured on one or more sides to produce flat or faceted surfaces. Such material is called till. The partly reworked material, or outwash, preserves to some extent its original form and character, but by prolonged stream action it gradually develops into normal stream sand and gravel.

At the time of maximum glaciation in northern Alaska the Brooks Range was probably almost entirely covered by ice, which extended both northward and southward down the river valleys for miles and formed at their lower ends individual valley glaciers. This glaciation was essentially alpine in character, although the glaciers in the upper valleys extended high up into the intervalley watershed regions. Thus along the west side of the valley of the East Fork, near Nichenthraw Mountain, huge erratic boulders were seen up to an altitude of 4,800 feet, or 2,000 feet above the valley floor, thus indicating the presence there at one time of a body of ice that had a minimum thickness of 2,000 feet. Nichenthraw Mountain, with a glacial cirque at about the same altitude, offers corroborative evidence of this fact. The Sheenjek Glacier, however, was smaller, having a minimum thickness, at the mouth of Old Woman Creek, of only about 1,400 feet. The glaciers of both the East Fork of the Chandalar and the Sheenjek appear to have thinned rapidly as they emerged from the alpine into the piedmont province. The glacial deposits that remain indicate that the southern limit of the glacier of the East Fork of the Chandalar was somewhere between the Wind River and Lush Creek, about 35 miles below Nichenthraw Mountain; and the Sheenjek Glacier ended at or a short distance below the confluence of the East Fork of the Sheenjek. During the time of maximum glaciation one large distributary of the glacier of the East Fork of the Chandalar was diverted southeastward from a point opposite the mouth of the Junjik River into the wide depression that is now occupied by Old John Lake and the upper Koness drainage. The long ridge that lies between Old John Lake and the East Fork, however, although overridden by ice at the time of maximum glaciation, must have served as an effective barrier as the glaciers began to recede, leaving a great body of stagnant ice in this depression. A similar distributary from the Sheenjek Glacier is believed to have been diverted southward into the upper valley of Monument Creek, to be similarly cut off as the main Sheenjek Glacier receded.

The upper valleys of the East Fork of the Chandalar and the Sheenjek River have the characteristic U-shaped outlines that are produced by glacial erosion. Also, the spurs that extend from the main ridges down into these valleys, especially in the alpine province, have been truncated and oversteepened by glacial action. The smaller tributary valleys, which were not eroded by ice as actively as the main valleys, were left, after the retreat of the ice, as hanging valleys and now have a steep gradient and rapids in their lower parts. The creek that enters the East Fork of the Chandalar east of Nichenthraw Mountain is a good example of a small U-shaped hanging valley, in the lower end of which postglacial stream action has incised a precipitous V-shaped gorge. Beautiful examples of glaciated spurs, elongated in the direction of the main valley by the scouring action of the ice and separated or nearly separated from the main valley walls, are also prominent. Such outlying spurs, or roches moutonnées, are especially prominent in the valley of the East Fork of the Chandalar River upstream from Arctic Village.

Morainal deposits left by the glaciers are now found in the valley of the East Fork of the Chandalar River from Nichenthraw Mountain downstream nearly to Lush Creek and on the Sheenjek River from a point 15 miles above Old Woman Creek down to the forks. These deposits, incidentally, correspond in situation with the sluggish, meandering portions of these two streams and evidently have played a notable part in postglacial stream history. Within these stretches are wide valley floors, with a typical kettle-hole topography and with many lakes in the undrained depressions. Old lake levels, which are still preserved, show that many large lakes were present in the morainal zone after the ice retreated. Thus, at Old John Lake three well-defined benches remain—one at 8 feet above the present lake, a second at 20 feet, and a third at 50 feet. The main stream courses also were sluggish, as at present, and therefore the morainal deposits along the main rivers, as on the East Fork of the Chandalar and the Sheenjek River, are for the most part covered by sand and silt of postglacial fluviatile and lacustrine origin. Only in the lower parts of the morainal deposits, where the rapids occur, is the glacial débris well exposed in the gravel bluffs. The gravel in the bluffs farther downstream, though originally of glacial origin, has been reworked to a considerable degree and is really outwash rather than till.

The dumping of glacial débris in the main valleys evidently created new base-levels for the headwater tributaries, and postglacial stream history is mainly concerned with the readjustment of the drainage channels to these new base-levels. Thus on the East Fork of the Chandalar two zones occur where such adjustments of gradient are in progress. The lower East Fork, from the main Chandalar up to the Wind River, has the normal gradient of a mountain stream. The rapids that extend from this point upstream for 30 miles represent a zone of readjustment to the lower drainage, and this zone of rapids will gradually migrate upstream through the morainal deposits until a uniformly rising stream gradient is established. The other zone of adjustment is at the upper end of the morainal deposits, where the headwater stream abruptly loses its gradient and debouches upon a nearly level valley floor. The headwater stream is depositing a veneer of stream gravel upon the morainal deposits, temporarily raising its lower base-level and at the same time actively eroding upstream to bring the headwater drainage into adjustment with the lower gradient. Hence it may be said that two new base-levels are being established on the East Fork—an upper one, which is relatively temporary, and a lower one, with which the entire East Fork will ultimately be brought into adjustment. Exactly the same process is taking place on the Sheenjek River.

So far as the character of the till and outwash deposits are concerned little need be said. Both types consist of silt, sand, gravel, and boulders and differ from one another mainly in the degree of assortment of the component material and in the degree of rounding which the coarser débris has undergone. The till is largely unsorted, boulders and gravel of all sizes being mixed indiscriminately with sand and clay. The outwash deposits consist of rounded to subangular detritus, according to the amount of transportation, and the gravel and boulder beds are fairly well separated from the finer sediments. Some of the glacial boulders now exposed in the valley of the East Fork, among the outwash deposits, are 5 or 6 feet in diameter, such coarse material being specially plentiful in the lower gorge and also farther upstream where the river has undercut high banks of outwash gravel.

The maximum thickness of the till is hard to estimate, because the East Fork of the Chandalar River does not cut to bedrock at the lower end of the morainal deposits, where the till is best exposed in the bluffs. Farther downstream, however, the river does at places cut bedrock alongside of gravel benches 300 feet high, thus indicating a minimum thickness of that order for the outwash deposits. In the lower end of the morainal zone, however, the glaciers may have gouged downward into the hard-rock valley floor, thus materially lowering the old hard-rock gradient. As the gravel benches in this zone are as high as those farther downstream, the total thickness of till may be considerably in excess of 300 feet in the center of the valley.

RECENT DEPOSITS

The Recent deposits consist of the sand, gravel, silt, carbonaceous deposits, and hillside rubble that form the flood plains and contiguous débris in the present valleys. Such deposits may be classified into three general types, which differ from one another in their physiographic history as well as in their lithologic character. These are (1) the detrital deposits that constitute the alluvial fillings in the present valley floors; (2) the sand, silt, and carbonaceous deposits that constitute the filling in the Yukon Flats and also the detrital veneer over the morainal material farther upstream; and (3) the hillside rubble, or eluvial deposits, that form a covering on the slopes of present valleys.

The deposits of class 1 consist mainly of coarse sand and gravel and subordinately of fine sand and silt and are found along all the swift watercourses of this region. In a mountainous region like the Chandalar-Sheenjek district such deposits should normally be made up of sand and gravel. However, as the main streams are handling reworked glacial débris, in addition to normal stream gravel, this recent alluvium contains in places more or less fine sand, silt, and clay, as well as abnormally large boulders. Such composite débris forms thick alluvial deposits in the lower valleys.

The finer detrital material and carbonaceous deposits of class 2 are found mainly in the Yukon Flats and are probably both fluviatile and lacustrine in origin. A general description of these flats has already been given. The final chapter in their origin has not yet been written, and it is doubtful if a thoroughly satisfactory explanation of this great alluvium-filled depression of the Yukon can be formulated until a reliable topographic map of the flats and the bordering hills has been drawn and detailed geologic studies have been made. Yet, whatever the final explanation may be, it is evident that the encircling hills at Fort Hamlin, at the lower end of the "flats," were the site of a bulwark that controlled for a long period the base-level of the upper Yukon. In the absence of any reliable data that would prove their mode of origin, it is commonly inferred that the Fort Hamlin hills and the Yukon Valley above Fort Hamlin have been involved in differential uplift or depression, whereby the natural grade of the bedrock floor of the Yukon has been changed, so that at Fort Hamlin and for an undetermined distance upstream the bedrock grade of the Yukon is upstream. This condition has produced a great dumping of river deposits above Fort Hamlin, and the long-continued operation of this process has extended such alluvial deposits up into all the streams tributary to the Yukon to points where their naturally high headwater gradients have brought their valley floors above this great alluvial plain.

In the main Chandalar Valley the critical point is some distance above the mouth of the Christian River, where the river changes to a swift braided stream that flows over a flood plain with a fairly strong gradient. The upper stretch of 40 miles, although within the Yukon Flats from the Christian River to the hills, contains alluvial material more characteristic of the mountain gradients. From the Christian River downstream the Chandalar flows as a sluggish stream over a flood plain of appreciably lower slope, and because the river meanders tortuously in this stretch the gradient per stream-mile is still further reduced. Consequently little stream gravel is seen on the river bars below the Christian River, the alluvium being mostly sand and silt. The presence at places of high alluvial banks, which appear to be above the highest stage to which the streams now reach, indicates, however, that the downward movement of sediments, even in the lower valley, exceeds the yearly alluviation by overflow and that the flats as a whole are in process of destruction rather than construction.

The similar critical point on the Sheenjek River is just above Carroll's cabin, likewise in the Yukon Flats, 20 miles from the nearest hills at Outlook Point. The presence of sand and silt in the lower valley is therefore to be expected. The black carbonaceous sediments, seen in many of the river banks in the lower river, also are explicable in terms of present conditions. The numerous log jams and snag flats of the present stream show how carbonaceous material can accumulate in the river mud, and the heavy layers of moss in the forest and brush, back from the river, afford a major source for the peaty deposits seen in the silt.

Similar deposits of fine sand and silt also occur as a veneer over the morainal deposits, both on the East Fork of the Chandalar River and on the Sheenjek River, and such deposits are essentially similar to those seen in the Yukon Flats. One noticeable difference, however, is the lack of snags and log jams and the paucity of carbonaceous material in these upstream deposits of sand and silt, due mainly, of course, to the fact that in these upper stretches timber is smaller and more sparsely distributed. Eluvial deposits are present everywhere on the gentle lower hill slopes in the piedmont province and must constitute a large part of the surficial detritus. For the most part, however, they are covered by heavy layers of vegetal material. Much of the ground back from the main waterways is perpetually frozen, so that solifluxion, nivation, and similar processes must play a significant part in the genesis and movement of such material.

IGNEOUS ROCKS

CHARACTER AND DISTRIBUTION

Igneous rocks are singularly scarce in the Chandalar-Sheenjek district and are confined mostly to the piedmont province of Sheenjek Valley and the main Chandalar Valley. Such rocks may be divided into three general groups, as follows:

1. Greenstone and metadiorite, which form an integral part of the pre-Silurian sequence of metamorphic rocks. A few such rocks were noted, mostly as rubble, in the lower valley of the East Fork of the Chandalar River. The occurrence and general character of such rocks have been mentioned in the description of the early Paleozoic or older rocks, and no separate description will be given.

2. The basic intrusive rocks of Sheenjek Valley, of Carboniferous or Mesozoic age, which are most numerous in the areas occupied by the chert-slate formation.

3. Basaltic lava flows and associated intrusive rocks, of Tertiary age, which are found in the main Chandalar Valley.

CARBONIFEROUS OR MESOZOIC INTRUSIVE ROCKS

Distribution.—The Carboniferous or Mesozoic intrusive rocks, as previously stated, are found mainly in association with the rocks of the chert-slate formation and occur chiefly in the piedmont province of the Sheenjek River, where this formation is typically developed. It would be superfluous to mention all the many localities in the Sheenjek Valley where such intrusive rocks were seen, for almost everywhere they appear to be represented in the chert-slate sequence. On the other hand, no areas of intrusive rocks were observed large enough to warrant their separate delineation. The chert-slate formation and its included igneous rocks are therefore shown on the geologic map as a single pattern. Shoulder Mountain and the summit of Helmet Mountain are two of the more prominent localities of these intrusive rocks.

Petrologic character.—These intrusive rocks are all basic but may in general be classified into four types—gabbro, quartz gabbro, diabase, and basalt. The gabbro, diabase, and basalt are normal rock types and require no particular description. They consist essentially of plagioclase, which has an average composition about that of labradorite, augite, and iron oxides, with more or less accessory apatite. In some of these rocks the pyroxene or plagioclase or both are altered to a degree sufficient to justify the appellation greenstone. In others the component minerals are little altered. The three types mentioned differ from one another mainly in their granularity and texture.

A more specialized type, designated quartz gabbro, is distributed along with the other intrusive rocks at several localities in the valley but occurs typically at Shoulder Mountain. This rock is typically granular but is in places rather exceptionally coarse grained. It consists essentially of plagioclase, quartz, augite, and iron oxides, with accessory apatite, together with secondary minerals, such as sericite, chlorite, biotite, basaltic hornblende, and iron hydroxides. The feldspar is zonally grown, with centers of labradorite and rims of oligoclase. Another striking feature is the presence of peculiar latticed intergrowths of magnetite and biotite. The general idea derived from a microscopic examination of these quartz gabbros is that they have been extensively altered by hydrothermal processes at a late stage of their formation, to which may be attributed the formation of the sericite, biotite, and hornblende and possibly a certain degree of the albitization.

Age.—The age of these intrusive rocks is not exactly known. They clearly intrude the rocks of the chert-slate formation, but the age of that formation also is somewhat in doubt. If, as suggested in this paper, the chert-slate formation is of late Devonian or early Mississippian age, these intrusive rocks can not well be older than Mississippian. On the other hand, these rocks have developed to a greater or less degree a pronounced greenstone habit, in which they differ markedly from the Tertiary volcanic rocks described below. They are therefore believed to have originated prior to the Tertiary period. So far as the evidence in the Sheenjek Valley is concerned, the age of these basic intrusive rocks must therefore be given as Carboniferous or Mesozoic.

If the chert-slate formation is in reality of Mississippian age, these intrusive rocks might well be correlated with the volcanic rocks along the Yukon which constitute the Rampart group, and with the similar intrusive rocks, described by the writer,[25] in the chert formation at Livengood, in the Yukon-Tanana region. Intrusive and extrusive types of basic volcanic rock were widespread during Mississippian time, in both central and southern Alaska, and this correlation seems very suggestive. On the other hand, if the chert-slate formation should be proved to be of Upper Triassic age, it would then seem necessary to correlate these intrusive rocks with the Jurassic volcanism. As against this correlation, however, it must be remembered that the Jurassic volcanism produced also a great variety of granitic and related rocks, none of which appear to be represented in the Sheenjek Valley, nor, in fact, anywhere in the Chandalar-Sheenjek region.

[25] Mertie, J. B., jr., The gold placers of the Tolovana district: U. S. Geol. Survey Bull. 662, p. 243, 1918.

TERTIARY VOLCANIC ROCKS

Distribution.—Basaltic lavas crop out along the south side of the Chandalar River just opposite the mouth of the East Fork, making prominent red bluffs. This is the only occurrence of these rocks within the area covered by this report, but similar rocks, both extrusive and intrusive, are found farther upstream on the north side of the Chandalar River and continue on up the West Fork of the Chandalar. The general distribution of these rocks is therefore about east and west.

Petrologic character.—The lavas opposite the mouth of the East Fork of the Chandalar River are olivine basalts. These rocks, though in places somewhat porphyritic, are for the most part fine grained and nonporphyritic, with a fabric ranging from intersertal to partly glassy. The groundmass consists mainly of labradorite, augite, olivine, and magnetite, with a small amount of apatite. The glassy specimens contain from 5 to 40 per cent of a reddish-brown glass. Where the rock is porphyritic the phenocrysts comprise labradorite and olivine and less commonly also augite. The feldspars and pyroxene in these rocks are quite fresh and unaltered in appearance, and even the olivine is very little serpentinized.

Age.—The age of these lavas is not definitely known. Farther up the Chandalar occur both extrusive and intrusive basalts that are believed to have originated at the same time as the lavas at the mouth of the East Fork. The intrusive phases of these volcanic rocks have been observed by the writer in places where they cut the Mesozoic granodiorite that lies along the south side of the Chandalar River. Hence it is likely that these volcanic rocks originated late in the Mesozoic or in the Tertiary. The fresh, unaltered condition of the lavas at the mouth of the East Fork is a strong indication of their Tertiary age.

ECONOMIC GEOLOGY

Igneous rocks are relatively scarce in the Chandalar-Sheenjek district, and granitic rocks, which commonly are the source of most of the metalliferous deposits in central and northern Alaska, have nowhere been seen. Nevertheless, only a small portion of the 6,000 square miles of this district has been examined in any detail, and the possibility still exists that granitic rocks with attendant mineral deposits may be found.

Metalliferous lodes in this region could hardly be commercially valuable at the present time, because the region is very remote from centers of supply and is devoid of modern transportation facilities. The airplane holds forth the greatest promise of transportation if metalliferous deposits should be discovered and developed here. Such transportation, however, is costly, and only lodes of the bonanza type could possibly be developed under present conditions. Placer deposits, however, require a minimum of equipment and yield quick returns, and the discovery and mining of such deposits offer the only prospect of any metalliferous mining activity in this region in the near future.

The alpine province and the more northerly part of the piedmont province, where the surficial features have been affected by glaciation, constitute the least hopeful area for prospecting for gold placers, because glacial erosion tends to dissipate rather than to concentrate the metals. Moreover, if gold placers existed in this region prior to the glacial epoch, the ensuing glaciation very likely has eroded and scattered such deposits. Finally, it is a striking fact that most of the richer gold placers in interior Alaska have been found in areas of relatively low altitude and relief, where long-continued denudation and uninterrupted alluviation have operated to develop more or less continuous pay streaks. These conditions do not exist in the alpine province of the Chandalar-Sheenjek district, and although gold placers may occur anywhere if the contributing lode material is of sufficiently high grade and sufficiently extensive, the odds against such optimum conditions are great.

So far as the surficial features of the piedmont province are concerned, the conditions for the accumulation of placers are favorable provided the necessary lode deposits are present from which such placers may be concentrated. Granitic rocks and definite evidences of gold mineralization have not been observed by the writer, but the piedmont part of this region requires much more careful inspection before it may be stated that such mineralization has not occurred. To the west workable gold placers are found on the North Fork of the Chandalar River, and to the east gold is found at places on the bars of the Coleen River. The East Fork of the Chandalar River and the Sheenjek River are practically unprospected as yet, and no inherently good reasons exist against the possible occurrence of mineral deposits in this region.

Another interesting mineral deposit of possible value in this region is oil shale. A sample from the Christian River about 75 miles northwest of Fort Yukon, which was submitted to the Geological Survey in 1926, was found to contain a phenomenally high percentage of shale oil. This sample was distilled and examined by E. T. Erickson, of the Geological Survey, and his report is given herewith:

A distillation test made by the Bureau of Mines oil-shale distillation method [30] gave 122 gallons of crude oil per ton. Rate of distillation maintained during the period of active distillation, 0.5 cubic centimeter of distillate per minute. Specific gravity of the crude distillate, 0.864 $\frac{15°C.}{15°C.}$ Setting point of the crude oil, 11° C.

When first distilled, the crude oil was strongly green, a color unlike the amber or dark-brownish colors usually exhibited by crude shale oils. The color of the crude oil, however, darkened considerably upon prolonged contact with air, and the change was accompanied by the separation of a dark substance. The green color, together with the unusually high yield of the crude oil, suggested that the sample might be related to some form of residual petroleum, for the heavier lubricating fractions of certain petroleums are characterized by a similar color. Extraction tests made with chloroform and benzene directly on the sample and also on the sample previously treated with hydrofluoric acid gave no evidence to confirm this suggestion, yielding but slight quantities of soluble material. Hydrocarbon material directly related to petroleum would likely exhibit solubility in these solvents. The slight solubility noted, together with the ash determination of 33.15 per cent, may be considered to classify the sample as oil shale.

The setting point is the temperature at which solidification of the oil occurs, probably through the separation of wax and other hydrocarbon substances. The setting point noted is considerably lower than that given by typical Colorado and Scottish shale oils.

The green color noted may have some significance as to the commercial value of the crude oil for lubricants and may also be of scientific interest in regard to the geologic origin of the colored hydrocarbons of petroleum, as their occurrence in the crude shale oil involves a distillation process.

The locality where this oil shale occurs has not been visited by any geologist, and the character and age of the containing rocks have therefore not been ascertained. Deposits of coal are also reported from the valley of the Christian River, and this fact, together with the occurrence in the same area of oil shale, suggests that Mesozoic rocks may be present in that valley.

[30] Karrick, L. C., A convenient and reliable retort for assaying oil shales for oil yield: U. S. Bur. Mines Repts. No. 2229, 1921.

THE MOUNT SPURR 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 side of Cook Inlet, in latitude 60° 50′ to 61° 30′ north, longitude 151° to 153° 20′ west. Mount Spurr, a prominent snow-clad peak of 11,000 feet altitude that is plainly visible from Cook Inlet, lies almost centrally in the region. As can be seen from the coast, the region to the west consists of a piedmont belt, beyond which lies a rugged snow-capped range, with great glaciers extending down the valleys to the mountain front. Heretofore this region, except for a part of the piedmont belt, has been almost entirely unexplored, yet existing knowledge of surrounding areas indicated that within it lay the headwaters of several large rivers, including streams that drain eastward to Cook Inlet, southward to Lake Clark and Bristol Bay, westward to the Kuskokwim and Bering Sea by way of the Stony River and the South Fork of the Kuskokwim, and northward through the Skwentna River to the Susitna. Inquiries which have been made for many years of prospectors, trappers, and hunters had failed to bring to light any information about the mountainous portion of this region, though vague accounts from the natives indicated that there was some sort of difficult route by which it was possible to go on foot well back into the mountains somewhere west of Tyonek.

PREVIOUS SURVEYS

Although the Russian fur traders had pushed eastward along the Alaska Peninsula as far as Kodiak Island by 1762, they had made no permanent settlements on the American continent at that time. The earliest accurate information about this part of Alaska was that obtained by the British navigator Capt. James Cook, who in May, 1778, discovered the inlet that bears his name and soon afterward sailed northward up it as far as Point Possession, charting its shores as he proceeded. A second British expedition, in charge of George

Vancouver, returned to the inlet in 1794 and completed the charting of its upper end, including Turnagain and Knik Arms.

From 1794 until the transfer of Alaska from Russia to the United States, in 1867, the Russians had gradually extended their trading posts to this part of Alaska but apparently carried on no systematic surveys. The Russian charts of that time add little to the surveys of Cook and Vancouver, except that they show in a general way the courses of the Susitna and Matanuska Rivers.

From 1867 until the discovery of gold in the upper Cook Inlet region, in 1894, there was a general apathy concerning this part of Alaska, and though in the next four years there was a large influx of prospectors and miners into the Cook Inlet region, most of them left no written record of their explorations.

The discovery of bonanza gold placer deposits in the Klondike was the stimulus that brought about a tardy recognition of the value of this frontier territory, and appropriations were made by the Federal Government for systematic surveys. Among the agencies chosen to do this work was the United States Geological Survey, which in 1898 had members on several expeditions that radiated west, north, and east from the head of Cook Inlet. Two of these expeditions ascended the Matanuska and Susitna Rivers, respectively, but the one that had most bearing on the region here under discussion was that in charge of J. E. Spurr[1] and W. S. Post, who ascended the Susitna, Yentna, and Skwentna Rivers to the mouth of Portage Creek, proceeded up that creek to a high pass across the Alaska Range, and thence descended the Kuskokwim to its mouth, returned by canoe eastward to the Alaska Peninsula, and terminated their exploration at Katmai Village. Thus on this trip they traveled entirely around the region here described. As a result of this extraordinary trip they obtained geographic and geologic information concerning a large area, including a section directly across the Alaska Range.

The next expedition to procure definite topographic and geologic information in this general region was that conducted by Alfred H. Brooks[2] in 1902. The Brooks party landed at Tyonek and proceeded by pack train northward to the Skwentna River and thence westward across the Alaska Range at Rainy Pass, from which their course lay northward along the face of the range. The expedition yielded an astonishing fund of information about a great area that had previously been unexplored, but it left untouched the great mountainous region south of the Skwentna.

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

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

Later explorations of the Geological Survey that reduced the unmapped area of that part of the Alaska Range that lies south of the Skwentna were made by G. C. Martin [3] on the shore of Cook Inlet between Tuxedni and Iniskin Bays in 1903 and 1904; by Martin, Katz, Witherspoon, and Giffin in the Iliamna-Lake Clark region in 1909; by P. S. Smith [4] and R. H. Sargent in their expedition from Lake Clark to the Kuskokwim in 1914; and with more detailed mapping by F. H. Moffit [5] and associates on the coast of Cook Inlet in 1921.

All these expeditions procured invaluable geologic and geographic data from the areas that they traversed, but there still remained a great region of about 15,000 square miles, roughly outlined by Spurr's route along the Skwentna River on the north, by Snug Harbor, the Iniskin-Chinitna Peninsula, and Cook Inlet on the southeast and east, by Lakes Clark and Iliamna on the south, and by the Kuskokwim-Mulchatna lowland on the west, that was entirely unmapped and virtually unexplored. Plans had been under consideration for many years by the Geological Survey to enter this region, but lack of funds forced the postponement of these projects. In 1926, however, a party in charge of the writer [6] ascended the Skwentna River to its head and mapped a considerable area on the north edge of this region.

PRESENT INVESTIGATION

The expedition of 1927, here described, was planned for the purpose of still further reducing the unexplored portion of this part of the Alaska Range and of studying its geology, in order to determine its mineral resources. In spite of the extended inquiries that had been made, no information was available as to the easiest route of approach to the mountainous area or as to the possibility of taking pack horses from Cook Inlet westward to and beyond the face of the forbidding mountain range that could be seen from the coast. There were vague reports that many years ago the natives were accustomed to cross the mountains to the head of the Skwentna to hunt caribou, but the route that they traveled was not known. The only clue as to the location of a route into the range was the break in the mountain front just south of Mount Spurr, which could be seen from a distance and which offered the only possible entry into the mountains, the other valleys all being occupied by vigorous glaciers.

[3] Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region, Alaska: U. S. Geol. Survey Bull. 485, 138 pp., 1912.

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

[5] Moffit, F. H., The Iniskin-Chinitna Peninsula and Snug Harbor district, Alaska: U. S. Geol. Survey Bull. 789, 71 pp., 1927.

[6] Capps, S. R., The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 67–98, 1929.

There was also considerable doubt as to whether horses could be taken from the shore of Cook Inlet westward to the mountains, for the coastal belt, from 15 to 35 miles wide, was known to contain large marshy areas and to have great areas of dense alder thickets through which trail must be chopped tediously and laboriously.

A careful consideration of all the information available indicated that the most promising line of attack was to land on the west side of Cook Inlet a few miles south of the native village of Tyonek and to proceed thence westward to the mountain front just south of Mount Spurr, with the hope that at that place a possible route would be found westward into the mountains. Accordingly the party was organized at Anchorage during the first week of June, 1927. The writer was in charge and was responsible for the geologic mapping. R. H. Sargent, topographic engineer, was to carry on the topographic surveys, assisted by Ray C. Russell, recorder. C. C. Tousley and G. W. Pearson were employed as packers, and Edgar Brooker as cook. An excellent pack train of 15 horses was leased from W. N. Beach, of New York. By the courtesy of Noel W. Smith, general manager, a gasoline launch and a large open scow were chartered from the Alaska Railroad, and every possible facility was provided for the transfer of the party to its point of debarkation and for its return in the same way to Anchorage at the end of the field season. The writer wishes here to acknowledge his deep obligation to the members of the party for faithful services performed throughout a difficult journey; to Mr. Noel W. Smith for his hearty cooperation with the facilities of the Alaska Railroad; and to Mr. and Mrs. E. L. Everett and Mr. R. H. Koch for their unfailing hospitality at their fishing site near Nicolai Creek.

On June 10 the party of 6 men, with 15 horses and supplies and provisions for 100 days, sailed from Anchorage and landed that same day on the open beach of Trading Bay, about 2 miles northeast of the mouth of Nicolai Creek and 65 miles southwest of Anchorage. The point chosen for departure from the beach proved most fortunate, for there a piedmont slope rises gradually from the shore toward the mountains, offering comparatively solid footing for horses, whereas immediately to the southwest is a great marshy lowland drained by Nicolai Creek and the Chakachatna and McArthur Rivers, and this lowland is utterly impassable for horses in the summer. The first 12 to 15 miles of the journey toward the mountains lay along a ridge at an altitude of only 200 to 300 feet above sea level, through spruce, birch, and hemlock timber and around the edges of irregular marshes. Considerable trail cutting was necessary, but forward progress of about 5 miles a day could be made. Still farther west the height of the ridge increased, and as timber line was approached, at an altitude of about 1,200 feet, the country became more open and afforded excellent travel through grassy meadows and along mossy ridges.

At a point about 18 miles by trail from the beach the ridge followed rises to an altitude of 1,700 feet and swings somewhat to the north. It therefore became necessary, in order to ascend the large valley to the south of Mount Spurr, to drop down into the brushy lowlands. There for many miles the expedition encountered dense alder thickets that required laborious trail cutting before horses could be taken through them. In places the efforts of the entire party could open less than a mile of trail in a day. The route followed led southwestward toward a large river that could be seen to emerge from an extensive valley that cuts the mountains on the south flank of Mount Spurr. When this river, the Chakachatna, as it was known to the natives, was reached it was found to be a roaring torrent, far too deep and swift to be crossed with horses, and bordered on the north for several miles by rock cliffs several hundred feet high, against the foot of which it flowed. It was therefore necessary to return to the high bench north of the river and cut trail for several miles through dense alders to a point above these rock bluffs. That accomplished, it was found possible to ascend the valley on the north bank of the river, though cut bluffs and thick brush still required much trail building and cutting.

Upon ascending the Chakachatna Valley about 15 miles into the mountains, at a distance of 35 miles from the beach, a glacier was encountered that descended from the southwest slope of Mount Spurr and pushed entirely across the valley of the Chakachatna, completely blockading the valley and impounding a superb lake, Chakachamna Lake. For its lower 3 miles this glacier is generally covered by coarse morainal material from a few feet to several feet thick, though in many places the ice shows through. The edges of the moraine are heavily clothed with large alder brush, and smaller alders have found a footing over the more stable portions of the moraine-covered ice. This glacier offers no serious obstacle to passage on foot, but the cutting and grading of a trail passable for pack horses across it required the equivalent of 20 days' work for one man.

Chakachamna Lake is about 23 miles long and lies in a deep glacial valley whose walls rise so abruptly from the water's edge that it has no beach upon which travel is possible except at the mouths of tributary streams, where small deltas have been built out into the lake. Travel with horses along the lake was obviously impossible, but a route was found around the northeast corner of the lake into the valley of the Nagishlamina River, a stream that flows southeastward into the lake. Up this valley the party proceeded, but only with difficulty, for the brush is heavy and the flat of the stream so strewn with great boulders that it was barely possible to take horses through. By dint of much trail cutting and some grading a route was opened to a point 6 miles above the lake, where a second glacier from the northeast blockaded the valley, and several days of trail work was necessary to cross it. About 4 miles farther to the northwest a third glacier crossed the valley, but this was passed with less delay. Above this third glacier a broad, open valley leads to the low pass into the head of the Skwentna, and here travel was easy. From the head of the Nagishlamina the party crossed a high but easy pass, at an altitude of 3,700 feet, into the basin of the Chilligan River, and thence southwestward across another easy pass to the Igitna, where the lateness of the season forced the party to turn back. So far as could be seen, no unusual difficulties other than considerable brush would be encountered in traversing the valleys of the streams that flow into Chakachamna Lake from the northwest, west, and southwest.

The return trip to the coast, over the trail already established, offered no difficulties other than some very soft going, for much of the route traveled earlier in the season was over ground that was still frozen a short distance below the surface, and by the end of the summer this ground had thawed, so that the trail, especially in some stretches that were cut through alder thickets, was so soft as to be barely passable even with lightly loaded horses. The launch and scow that had been arranged for in the spring arrived at Trading Bay on September 13, the date agreed upon, and the expedition arrived at Anchorage on the morning of September 14. After the return to Washington the thin sections of the rock specimens collected were examined by J. B. Mertie, jr., who has made the petrographic determinations mentioned in the discussion of the rock formations.

The area mapped during the expedition is shown on Plate 8.

GEOGRAPHY

DRAINAGE

Reference has already been made to some of the major drainage features of the region. Until the expedition of 1927 the only geographic features of this part of Alaska that were correctly shown on existing maps were the coast line of Cook Inlet; the mouths of the McArthur River and Nicolai Creek, which had been accurately located by the Coast and Geodetic Survey; and Mount Spurr, the position and altitude of which had been pretty well determined by the Brooks expedition in 1902 and later by the Coast and Geodetic

Survey. Some unofficial maps had been published on which a number of rivers and lakes were shown, but these were drawn from imagination and had little or no relation to the facts. Actual surveys had been made only of the lower mile or two of Nicolai Creek and the McArthur River. From the coast the view up the great lowland from which the McArthur River emerges shows the snout of a great glacier that pushes northeastward to the mountain front, and it was presumed that this glacier was the principal source of the river. It was determined, however, that another large stream, the Chakachatna, drains a large basin in the heart of the range and emerges from a valley just south of Mount Spurr to join the McArthur River only a few miles from the coast. Although the part of the McArthur River above the Chakachatna was not seen at close range, it is almost certain, from the size of the drainage basins of the two streams, that the Chakachatna supplies more water to the McArthur River than the glacier at the head of that stream. For the lower 25 miles of its course the Chakachatna flows through a marshy lowland at a comparatively low gradient and probably with a current of only moderate swiftness. Within the mountains it has a fall from 1,170 feet at its source in Chakachamna Lake to 400 feet at the western edge of the lowland and is a roaring torrent that through considerable distances has a current estimated at 15 miles an hour. The Chakachatna receives a number of tributaries from the north, all of which carry the drainage from the glaciers that radiate from Mount Spurr, and a few short tributaries of moderate size from the south, all of which head in glaciers in the granite mountains south of the river.

Chakachamna Lake, in which Chakachatna River has its source, lies in a great east-west glacial valley, the headward portion of which is damned by Barrier Glacier, a vigorous ice stream that descends the southwest slope of Mount Spurr. To ascend the Chakachatna Valley along the north side of the river to the lake (the south side being impassable for horses), it is necessary to cross the moraine-covered portion of Barrier Glacier, and this can be accomplished with little difficulty on foot, though for horse travel much trail building is necessary. The lake is a superb body of water, 23 miles long and on the average 2 miles wide, inclosed on all sides by steep, rugged, and lofty mountains that rise precipitously from the shores. The members of the expedition saw the lake from its lower end and from a number of points north and northwest of it. At a point 15 miles above its lower end the lake is constricted by a large ice tongue, Shamrock Glacier, that flows into it from the south. Above Shamrock Glacier there is another area of lake, but its exact shape and whether or not it is continuous with the lower lake could not be positively determined. Several glaciers from tributary valleys descend into the lake, or almost to it, and nearly every valley of the surrounding mountains contains a glacier at its head. The water of Chakachamna Lake is slightly turbid in summer, for all the streams that flow into it are glacial streams. The steep cliffs that form the shores of the lake on its north and south sides render land travel along the lake difficult or impossible, though by boat all points on the lake could be reached with ease.

The only tributaries of the lake visited by the expedition were those that enter it from the north. The easternmost of these streams, the Nagishlamina, which joins the lake near its northeast end, was ascended to its source. This river is a large turbulent stream during the summer, too swift and deep in its lower course to be fordable with horses, and carries such coarse boulders that the bars are difficult to traverse with pack animals. At a point 6 miles above the lake this valley is blockaded by Pothole Glacier, which descends from the range north of Mount Spurr and has built a great moraine across the stream valley. This glacier forms an obstacle to travel along the valley, which, though not so difficult to pass as Barrier Glacier, nevertheless required the equivalent of 8 or 10 days' work for one man to build a passable trail across it. About 4 miles farther upstream a similar glacial obstruction is encountered, but this can be largely avoided by crossing the river to its northwest side and skirting the edge of the glacier. Beyond Harpoon Glacier, the second glacier in the Nagishlamina Valley, travel is easy through a wide-floored glacial trough up to the broad pass that separates this drainage basin from the head of the Skwentna River. The extreme headward tributary of the Nagishlamina from the west may be followed without difficulty to a pass at an altitude of 3,600 feet that leads into the valley of the Chilligan River, 13 miles above the point where that stream flows into Chakachamna Lake.

The Chilligan River is the longest of the northern tributaries of Chakachamna Lake. It heads in the high mountains in which lies the divide between the Skwentna and the South Fork of the Kuskokwim, flows eastward and then southeastward, and empties into the lake 15 miles above its lower end. Its total length is about 35 miles. The Igitna River lies southwest of the Chilligan River, receives a number of eastward-flowing tributaries from the main crest of the Alaska Range, and empties into the upper lake, or the upper part of Chakachamna Lake.

There are many other tributaries of Chakachamna Lake from the west and south, but these were not visited. Most of them are known to be short and to head in the glaciers that lie in the heads of practically all the valleys.

Two other streams that deserve mention are the Straight River, which heads in a vigorous glacier on the east flank of Mount Spurr and flows into the lowland to join the Chakachatna 20 miles above its mouth, and Nicolai Creek, which flows along the north edge of a swampy flat and receives drainage from the flat itself and from tributaries that drain the rolling ridge north of the flat. Nicolai Creek is a clear stream and empties into Cook Inlet 11 miles northeast of the mouth of the McArthur River.

RELIEF

As already stated, the Mount Spurr region may be divided into two distinct provinces—a coastal belt, of low or moderate relief, and a mountainous belt. The coastal belt may be subdivided into the swampy flat, of low relief, that extends from Nicolai Creek southward to and beyond the McArthur River, and the rolling ridge north of Nicolai Creek. This ridge, which starts at the beach of Cook Inlet in a bluff about 150 feet high, gradually increases in altitude as the mountains are approached and reaches 3,000 feet at the point where it passes into the mountains proper. Its surface has been modeled by glacial scour to rolling, gentle slopes, with some stream-developed terraces along its south edge and a few steep, intricately eroded gulches, where southward-flowing streams with steep gradients have cut through the veneer of glacial materials and into the underlying Eocene sediments.

The mountain province includes all of the area here considered that lies west of the coastal belt. These mountains rise steeply from the coastal belt to the highest peaks in this part of the range. Mount Spurr has an altitude of 11,000 feet, and other points in the range to the north of Mount Spurr are almost as high. This ridge, though lofty and heavily charged with glacial ice, maintains a high average altitude, and no individual peaks stand up conspicuously above their fellows. Vigorous glaciers flow eastward from it to the lowland and supply the greater part of the water to the Beluga and Straight Rivers, and southward and westward flowing glaciers drain to the Chakachatna both directly and by way of Chakachamna Lake and the Nagishlamina River. Still other westward-flowing glaciers from this same mountain ridge supply waters to the head of the Skwentna.

West of the high ridge on which Mount Spurr stands is a wide area of rugged mountains and glacial valleys comprising the headward portion of the Chakachatna Basin. Many mountains reach altitudes of 7,000 to 9,000 feet, and especially in those areas of granitic rocks the ridges and peaks are ragged and steep and form scenic features of impressive grandeur. The valleys, however, show the scouring effects of the glaciers that formerly occupied them and are fairly wide and of moderate gradients, so that travel through them is not difficult, except as it may be impeded by heavy brush.

CLIMATE

No observations on the climate of this region are available except for the period in 1927 during which the Geological Survey party was in the field. That year between June 11 and September 13 there was some rain on more than 70 days at the points where the party happened to be, but the summer of 1927 was unusually rainy throughout the Cook Inlet region, and the area near Mount Spurr probably also received more than an average amount of precipitation. To judge from the general position of this region with respect to the ocean, the prevailing winds, and the topography, it is likely that the average summer is mild, with a considerable number of cloudy or rainy days on the face of the mountains toward Cook Inlet, but that precipitation is less as the crest of the range is approached, and that within the mountain province the winters are severe with moderate snowfall, the quantity of snow increasing from the crest of the range toward Cook Inlet. In short, the yearly climate is probably not far different from that of the other mountain areas that border Cook Inlet. The attitude of the brush on the Cook Inlet piedmont area indicates a fairly heavy snowfall, whereas within the mountains the indications point to less heavy snows in the winter.

VEGETATION

The piedmont and coastal plain province of this region is characterized by a fairly continuous stand of spruce, birch, and some hemlock and cottonwood below an altitude of 1,200 to 1,500 feet in those areas that are not too wet to permit the growth of forest trees. The great lowland along the courses of the McArthur and Chakachatna Rivers and Nicolai Creek is generally marshy and supports timber only in narrow strips bordering the streams or scrubby trees in a few areas that are relatively well drained. The remainder of the lowland is clothed only with brush and marsh plants. The rolling piedmont ridge that stretches from the coast to the mountains north of the marshy lowland is generally forested up to an altitude of 1,200 feet, though there are many marshy openings that have no trees and are covered with moss and low brush. Within the timber there is generally brushy undergrowth, including alders and high-bush cranberry, which makes travel somewhat arduous, and near timber line the alders flourish in places in dense stands through which it is necessary to chop trail continuously in order to make a way for horses. In general it may be stated that the largest trees grow on the best-drained ground. Spruce trees 2½ feet in diameter were seen, and birch trees 12 to 18 inches in diameter are common in places. The writer noted the presence of some hemlock of fair size. This tree grows abundantly on Kenai Peninsula and around Turnagain

Arm but is absent farther north, and this is the first time he has seen hemlock on the west side of Cook Inlet. Within the mountains timber is found only along the valley bottoms and lower slopes. Timber, which is limited to altitudes of 1,500 feet or less in the piedmont area, is found up to 2,300 feet in the mountain valleys, though by no means all of the surface below that altitude is forested. Alders, which may be burned green, grow to altitudes of 2,000 to 2,600 feet, and large willows occur considerably higher. Willows large enough for tent poles were found in favorable places up to altitudes of 3,000 feet or more. The areas in which timber occurs are shown on Plate 4.

Grass for horses can generally be procured throughout the region, though there are some areas in dense alders or in the timber where none is obtainable. Large areas of luxuriant redtop grass are found on the rolling ridge between Mount Spurr and the beach and just above timber line, and that region should be capable of supporting much livestock during the summer.

Within the mountains patches of grass sufficient for a moderate number of animals for a few days may be found here and there, but there are many places where forage is scant. In open valleys above timber line, such as the broad valley near the pass between the head of the Nagishlamina and the Skwentna, there is fine forage, including redtop, bunch grass, and other vegetation, but within the timbered areas of the Chilligan and Igitna Rivers grass is scarce. As a whole, however, this region is well supplied with forage for pack animals, and if some consideration is given to the choice of camping places with the matter of forage in mind, horses will do well in the country from early June until late in September.

GAME

Within the piedmont area between Cook Inlet and the face of the mountains the only large wild animals that are at all abundant are bears. Black bears are abundant within the timbered and brushy areas, and they are particularly bold in molesting any provisions that are not protected by being placed in a high, bear-proof cache. At and above the upper limit of timber and brush grizzly bears are common, but they seem more fearful of the presence of man than the black bears. In the mountainous part of the region, also, bears are numerous, and 65 of them were seen during the summer, about equally divided in numbers between blacks and grizzlies. It is doubtful if most of these bears had ever before seen a human being, and though they seemed little concerned by the presence of the party, they showed no inclination to attack it. On many occasions bears came into camp and attempted to carry off provisions, so that constant watchfulness was necessary. The same care was required to protect food supplies from the wolverines, which were surprisingly numerous throughout the region. Eighteen of these animals were seen during the summer, and wolverine tracks were everywhere.

Several beaver colonies were observed in the piedmont area, both on the high ridge north of Nicolai Creek and in the lowland tributary to the Chakachatna. Several families of land otters were seen, and there were less abundant signs of fox and mink.

Above Chakachamna Lake the tributary valleys from the northwest are occupied by caribou and moose in moderate numbers, and some fairly recent sheep sign was seen, though no sheep were actually observed. In the country above the foot of the lake there was much less evidence of the presence of fur-bearing animals other than wolverines than in the piedmont area east of the rugged mountains.

Among the small game animals the rabbits, in places so abundant in Alaska, were seen only in moderate numbers, and ptarmigan, though present within the higher mountains, were not plentiful.

This region can not be considered a good country for the fisherman. A few of the small, clear streams contain Dolly Varden trout of small size. No grayling were seen. A very few salmon run up the Chakachatna, possibly as far as the lake, but the run is very small and of no commercial value.

ROUTES OF TRAVEL

The approach to the Mount Spurr region is made by water, as the region is bordered on the southeast by the west shore of Cook Inlet. The only settlement on this part of the inlet is the native village of Tyonek, about 40 miles west of Anchorage. No regular boat service is maintained to Tyonek or to any other point in the Mount Spurr region, though small boats ply between Cook Inlet points at irregular intervals. During the summer, when the salmon are running, however, boats from Anchorage call at the fish traps every day or two to collect the fish, and transportation can be obtained on these boats.

The expedition landed on the open beach of Trading Bay, 3 miles northeast of the mouth of Nicolai Creek, at a cabin owned by Koch & Everett, who operate fish traps there, and discharged horses and equipment from a scow directly onto the beach. Such a procedure would be possible only in calm weather, for the shore there is unprotected from easterly or southerly winds. During stormy weather a pilot thoroughly familiar with these waters might manage to enter the mouth of Nicolai Creek at high tide and thus obtain shelter, but otherwise there are no protected waters hereabout.

Once ashore, there are no well-established routes of travel inland, although it is possible to follow the beach except at extreme high tide. It is said that there is an old but scarcely discernible Indian trail leading from Tyonek back to the mountains, but no evidences of such a trail were seen by the expedition, and its route and destination are not known to the writer. The older natives report that 30 years ago members of this tribe were accustomed to make hunting expeditions into the mountains northwest of Chakachamna Lake, and they doubtless had some feasible route of travel, but since that time they have given up these expeditions, and as the younger generation knows nothing of the back country, their hunting and trapping is confined to a rather narrow area in the piedmont belt.

With the exception of a few trappers who maintain trap lines within the piedmont area, the country back from the beach is entirely uninhabited. These trappers take supplies to their headquarters either by small boat during the season of open water or by dog sled over the marshy lowlands after the streams are frozen in the fall. They have established no summer trails from the beach. In the expedition here described, therefore, the party had no semblance of trail to follow except where game trails could be utilized, and it was necessary to establish a trail as the party proceeded. The general route followed has already been described (pp. 144–146), and that route will be open for pack-train travel for a few years, or until the brush grows over it. In some soft ground, however, the passage of the pack train out and back reduced the trail to a quagmire, and it may be found necessary to chop detours around some of the softest places. Some pick and shovel work will also be necessary to recondition the trail across the moraine-covered glaciers, but for many years the route followed by the expedition of 1927 will be discernible, and the amount of work necessary to make it passable will be much less than to establish a new trail.

GEOLOGY

GENERAL OUTLINE

The areal distribution of the rock formations in the Mount Spurr region is shown on the accompanying geologic map, in so far as the formations have been differentiated. The region here shown was heretofore entirely unexplored, and the field work done in 1927 was of reconnaissance character only. Furthermore, on account of the difficulties encountered in travel, a considerable part of the time during the short field season was spent in building trail, often in areas of dense brush where rock exposures were scarce or lacking. The geologist worked under the further disadvantage that the preparation of the topographic base map was carried on concurrently with the geologic work, so that the completed map was not available at the time the field work was done, nor until the writing of the report was in large measure completed. As a consequence of these difficulties, all of which are more or less inherent to exploratory or reconnaissance surveys, the outlines of the rock groups that are differentiated on the accompanying geologic map (pl. 3) are only approximate.

No identifiable fossils have been found in the Mount Spurr region, and any age determinations here given are based upon correlations with similar rocks in adjacent regions or upon stratigraphic relations.

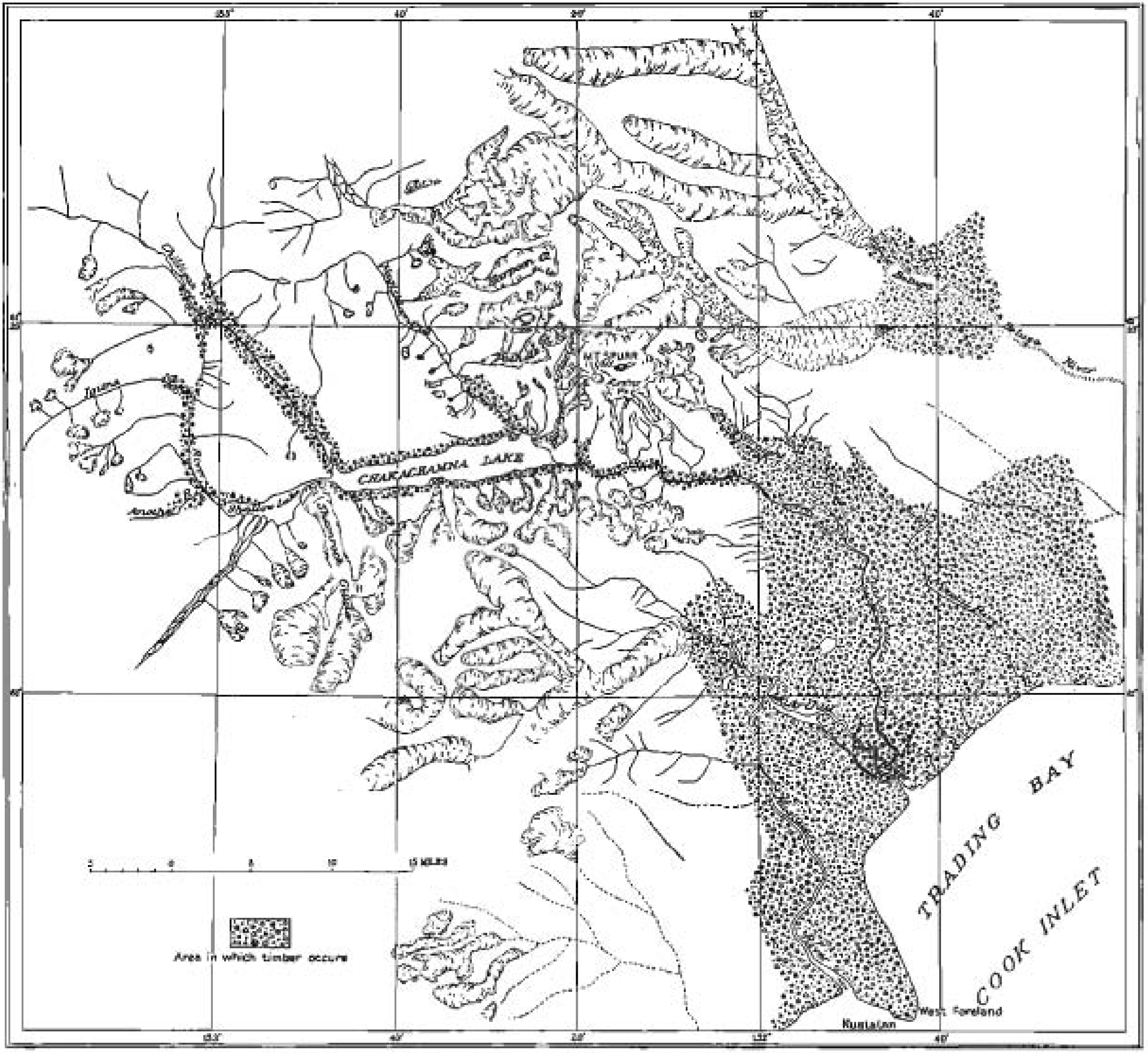
The geologic units shown on the accompanying map, with the exception of the lavas and tuffs of Mount Spurr, have all been described elsewhere in reports on contiguous areas, and elaborate descriptions are unwarranted here. In the following pages a brief description of each subdivision is given, with as definite a correlation as can safely be made and with references to more complete descriptions published elsewhere.

Probably the oldest rocks of the region are certain banded schistose rocks that occur on the mountain ridge 6 or 8 miles northwest of Mount Spurr and between the crest of that ridge and the Nagishlamina River. These rocks were not seen in place and are not represented on the geologic map, but their general location is known because of their abundance on the moraines of the southwestward-flowing Harpoon Glacier, which terminates in the Nagishlamina Valley 11 miles above the mouth of that stream. The age of these schists is not known, but they are believed to be of pre-Mesozoic age. Next younger is a group that comprises basaltic flows, andesitic, dacitic, and basaltic tuffs, and metamorphosed sedimentary rocks that include banded schists and rocks that were formerly shale, sandstone, and limestone. The rocks of this group are unfossiliferous but are believed to be Mesozoic and are probably of Jurassic and Cretaceous age.

A large part of the area here considered is occupied by granitic rocks that form a notable element of the Alaska Range from Lake Clark northward to Mount McKinley and beyond. Quite possibly granites of several ages are represented, but in the Mount Spurr region there is evidence for the belief that the major intrusions took place in late Mesozoic time, though earlier granites are present also.

Tertiary sedimentary rocks of Eocene age are present in the widespread deposits between the east flank of the mountains and the coast. These rocks include clay, sandstone, tuff, and lignitic coal.

The volcanic rocks of Mount Spurr range in age from early Tertiary to Recent. Tuffs and beds of lava pebbles included in the



MAP SHOWING DISTRIBUTION OF TIMBER IN THE MOUNT SPURR REGION

Eocene sediments indicate that this volcano was active in Eocene time, and lava beds interbedded with glacial deposits, deposits of volcanic ash, and fumaroles that still exist on the mountain give evidence of at least intermittent activity up to the present time.

A widespread mantle of glacial till and boulders over the piedmont area and the deeply excavated glacial troughs within the mountains testify to the great development of glacial ice within the region in Pleistocene time, and the remnants of those ancient glaciers are still vigorous ice streams that occupy the higher mountain valleys. Postglacial erosion has been active in cutting valleys within the relatively soft Eocene sediments and the older glacial deposits and in forming steep wave-cut cliffs along the shores of Cook Inlet. The sediments derived from this erosion have been deposited in Cook Inlet, as shown by beaches, bars, and extensive mud flats.

The stratigraphic sequence for this district, in so far as it has been determined, is shown below.

Quaternary.—Beach sand and gravel, bars, and mud flats; gravel, sand, and silt of present streams; talus accumulations; peat and impure organic deposits or muck; soil and rock disintegration products in place; deposits of existing glaciers; terrace and bench gravel, in part of glaciofluvial origin; morainal deposits, presumably of Wisconsin age; lava and volcanic ash and tuff from Mount Spurr.

Tertiary.—Eocene sediments, generally light-colored soft sandstone and moderately indurated clay, locally containing lignite. Contain tuff beds, largely made up of pebbles of volcanic rocks from Mount Spurr, which was probably active when these beds were laid down.

Mesozoic.—Granitic intrusive rocks. Probably some, at least, of the masses of metamorphosed shale, sandstone, and limestone surrounded by granite are of late Mesozoic age. Andesite and basalt tuff and basalt and dacite flows, probably of lower Jurassic age.

Pre-Mesozoic.—Hornblende schist and associated contact-metamorphic rocks.

STRATIGRAPHY

SCHISTOSE ROCKS

What are probably the oldest rocks in this region occur somewhere in the range north of Mount Spurr. They were not seen in place, but their presence is known from numerous boulders and blocks that have been brought down the Nagishlamina Valley by Harpoon Glacier, the upper of the two glaciers that push down into this valley from the northeast. These rocks include hornblende schist that consists essentially of green hornblende and quartz, with epidote, pyrite, and iron oxides as accessory minerals. In places the hornblende schist has flowed around knots and irregular lenses of dense siliceous material, which itself has locally been drawn out and interlaminated with the hornblende material. Associated with the schist, which appears to have been originally a basic igneous rock, are banded contact rocks that are composed of alternating bands of quartz and biotite, quartz and epidote, and nearly pure quartz, as well as some more massive graywackes. Both these contact rocks, which probably are contact-metamorphosed sedimentary rocks, and the hornblende schist itself locally contain scattered specks of pyrite and on weathered surfaces show oxidation stains.

No direct evidence concerning the age of these schistose rocks was obtained. Without doubt they are older than the unmetamorphosed granite with which they are associated, for fragments of the schist were found as inclusions in the granite. They also appear to be much older than the Mesozoic tuffs, lavas, and associated sediments, which are described below. Possibly they are to be correlated with the mica schist of the Willow Creek district,[7] but this is only a suggestion and as yet not capable of proof. At any rate they appear to be much older than any known Mesozoic rocks in this general region and are here classified broadly as pre-Mesozoic.

MESOZOIC ROCKS

Character and distribution.—In the basins of the Chilligan and Igitna Rivers occurs a group of rocks that includes basaltic lava flows; andesite, dacite, and basalt tuff and agglomerate; and metamorphosed sedimentary rocks that were originally shale, sandstone, and limestone. They occur in considerable masses within an area that is mainly granitic, and the volcanic and associated sedimentary rocks form irregular areas that are entirely or nearly surrounded by the granite. The main areas of this group of rocks are shown on the accompanying geologic map (pl. 3), but the group, which is capable on detailed study of being subdivided into a number of units, is here undifferentiated.

As the volcanic and sedimentary rocks occur in somewhat isolated patches that are engulfed within the surrounding granite, it has so far been impossible to carry stratigraphic correlations from one area to another. Perhaps the best area for study, though it may not be typical, is the mass that lies between the lower Chilligan and lower Igitna Rivers. Only the north end of this mass was examined, but there the lowest rocks exposed consist of an alternation of dacite, basalt, and basalt porphyry with andesitic and basaltic tuff and agglomerate. These rocks are succeeded above by metamorphosed sediments that include argillite, graywacke, and limestone and contact-metamorphic derivatives of all these rocks.

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[7] Capps, S. R., The Willow Creek district, Alaska: U. S. Geol. Survey Bull. 607, pp. 26–30, 1915.

The most conspicuous element of the lower, volcanic part of this group consists of several kinds of tuff and agglomerate. These rocks range in color from dark to light gray and shades of green and purple. The included fragments are angular to subangular or rounded and range in size from tiny bits the size of sand grains to pieces 8 inches or more in diameter. Most of the fragments consist of andesitic, dacitic, and basaltic lavas, though fragments and pebbles of granite and other granular intrusive rocks, as well as of slate and argillite, are also present. These tuffs are interbedded with lava flows that include dark hornblende basalt, basalt porphyry, and light porphyritic dacite, and there are present also some black argillaceous rocks that look like metamorphosed mudstones.

The upper portion of this group of rocks at the locality described above contains, in addition to volcanic rocks, a considerable amount of contact-metamorphosed sedimentary material that includes dense argillite and graywacke, thin beds of gray crystalline limestone, and banded contact rocks in which bands of calcite and zeolite alternate with bands of a mixture of hornblende, chlorite, and quartz. All these altered sediments contain disseminated pyrite.

At other places within this region there are areas of sedimentary rocks surrounded by granite, and these have been included in the same group with the volcanic and associated sedimentary rocks described above, although without definite evidence that they are of the same age. North of the pass between the head of the Nagishlamina River and the Chilligan River there are areas of such sedimentary rocks, which consist mainly of argillite and graywacke. Just south of that pass lies a narrow belt of rock, bordered to the east and west by granite, which consists of finely banded chert, showing zones of recrystallization into interlocking quartz crystals, simulating a quartzitic fabric. Much of the regrown quartz is cloudy, and some of it is sericitized, suggesting igneous metamorphism. Some of these beds of chert, which are blended in layers only a fraction of an inch thick, show straight, parallel zones, but others are intricately contorted and folded.

West of the Igitna River, in a region that was seen only from a distance, there is a large area of dark rocks cut by granite, presumably another area of sedimentary and associated volcanic rocks. Many similar areas were mapped by the writer in 1926 in the region directly north of that here described.[8]

Structure and thickness.—As a result of the mountain-building forces that have affected this whole region and of the profound intrusion of tremendous masses of granite that surrounded and

[8] Capps, S. R., The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797, pp. 82–86, 1929.

engulfed many areas of sedimentary and volcanic rocks, these beds exhibit a wide range in the degree of disturbance that they have suffered. In places, like the locality south of the pass between the Chilligan and Igitna Rivers, the beds are not greatly deformed and show a general monoclinal dip of 10°–15° NW. The banded cherts in the pass between the Nagishlamina and Chilligan Rivers, however, have high dips and show intimate distortion and crumpling. The separate patches of sedimentary rocks, now isolated by intruded granites, have little structural relation to one another, and, with the cursory field examination that has so far been given it has been impossible to trace the structure from one area to another or to correlate definite horizons in separate areas. Quite possibly detailed field studies might succeed in such an undertaking, though the complete lack of fossils would necessitate correlations on the basis of lithology only. In general, the beds of this group are commonly folded and faulted, and the folding is in the main more severe near the edges of the granite. Where the relatively competent lavas and tuffs form a large portion of the section the folding is likely to be less severe than where only argillite and graywacke are present. Many faults of small or unknown displacement were observed, and some of large displacement probably exist. For example, it is likely that the contact between this group of bedded rocks and the granite in the pass between the Chilligan and Igitna Rivers is marked by a fault that has a displacement of 2,000 feet or more. No reliable estimate can yet be made of the thickness of the beds included in this group. At one place in the Igitna Basin the series is certainly 2,500 feet or more thick. Farther north, in the basin of the Skwentna, the writer[9] estimated the beds to be at least 4,000 to 5,000 feet thick and possibly much more.

Age and correlation.—No precise evidence of the age of this group of volcanic and sedimentary rocks was obtained during the investigation here described. No fossils were found in them, and their assignment to any period must be based on their geologic relations and on lithologic resemblance to similar rocks of known age in other areas. Unfossiliferous argillite, shale, and graywacke make up a large element in the Alaska Range from the Mount Spurr region northward to and beyond Broad Pass, and in the Skwentna region they are associated with basic lava and tuff. These rocks are definitely older than the Eocene coal-bearing beds, which in places lie unconformably above them, and are older than the Cantwell formation farther north in the Alaska Range, which has been classified as Eocene but may be Upper Cretaceous. They are also known to be

[9] Capps, S. R., op. cit., p. 84.

younger than certain Middle Devonian limestones with which they are associated farther north in the Alaska Range.

The position within the range of these rocks in the Mount Spurr region leaves little doubt that they belong to the group of similar rocks in the Skwentna region,[10] immediately to the north. In the upper portion of this group the writer found a fossil leaf that was determined to be of Upper Cretaceous or Tertiary age. Still farther north in the range, and along the strike of this group of sediments, Brooks [11] found fossils near Rainy Pass that were of Middle Jurassic age. In the Yentna region Mertie [12] obtained a fossil of probable Upper Cretaceous age. Still farther north, in the basin of the West Fork of the Chulitna River, the writer [13] found a series of shale, argillite, and graywacke, presumably related to the beds here under discussion, that lay above a Triassic limestone and below the Cantwell formation. Thus all the localities in which fossils have been found in this widespread group of rocks indicate that the beds are of Mesozoic age and younger than Triassic.

The lower part of this group, in which basic lava and tuff predominate, is believed to be the correlative of the Skwentna group described by Spurr [14] and later by Brooks.[15] These writers made a definite separation of the Skwentna group, a volcanic series, from the Tordrillo "series," a sedimentary series. In the upper Skwentna region, however, the writer found that sedimentary and volcanic rocks were so intermingled that no such complete separation was possible in reconnaissance studies, and he therefore placed them together in a single undifferentiated group, and the same procedure is here followed for the Mount Spurr region. Brooks recognized the probable equivalence of the volcanic rocks to a similar assemblage of rocks in the Matanuska Valley named by Martin the Talkeetna formation and assigned by him [16] to the Lower Jurassic on the basis of its fossils. There is considerable ground for the belief that the lavas and tuffs of this group in the Mount Spurr region are the equivalent of the Skwentna group of Spurr and Brooks and of the Talkeetna formation of Martin, and the lower part of the group is considered to be of Lower Jurassic age. The upper part of the group, which con-

[10] Capps, S. R., op. cit., pp. 84–86.

[11] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, p. 90, 1911.

[12] Mertie, J. B., jr., Platinum-bearing gold placers of the Kahiltna Valley: U. S. Geol. Survey Bull. 692, p. 237, 1919.

[13] Capps, S. R., Mineral resources of the upper Chulitna region: U. S. Geol. Survey Bull. 692, pp. 217–218, 1919.

[14] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898; U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 149–155, 1900.

[15] Brooks, A. H., op. cit., pp. 75–90.

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

sists mainly of shale, argillite, and graywacke, is believed to be in part Upper Cretaceous. Whether or not beds of Middle and Upper Jurassic and of Lower Cretaceous age are present or whether there are great unconformities within the group has not yet been determined. It is a remarkable fact, of which there is still no adequate explanation, that this great group of Mesozoic sedimentary rocks is almost devoid of fossils in that part of the Alaska Range between Mount Spurr and Broad Pass, whereas in the area from Snug Harbor southwestward along the Alaska Peninsula and in the Talkeetna Mountains to the northeast the Mesozoic succession is remarkably complete and is fossiliferous throughout. The difficulty of subdividing the Mesozoic sediments of this part of the Alaska Range and of giving definite age assignments to the subdivisions is due mainly to this lack of fossils, and unless fossils are eventually found the geologic history of this region during Mesozoic time will be very difficult to decipher. At present all that can safely be said is that there is an undifferentiated group of volcanic and sedimentary rocks that probably range in age from Lower Jurassic to Upper Cretaceous.

TERTIARY ROCKS (EOCENE)

Character and distribution.—Eocene coal-bearing rocks are present in the Mount Spurr region only within the piedmont belt between the face of the mountains and Cook Inlet, and throughout most of that area they are concealed beneath a cover of glacial deposits or of vegetation and muck. These beds were first described by Spurr[17] as the Tyonek beds, and by Eldridge[18] as the Kenai formation, and their observations and his own were later summarized by Brooks,[19] who also published a cross section of the formation, which was not seen by the present writer. Brooks states that Eldridge observed about 1,000 feet of strata, striking N. 10°–15° E. and dipping 15°–60° SE. The beds consist of friable standstone, fine conglomerate, shale, and lignitic coal. There are 24 coal beds, ranging in thickness from 1 to 15 feet. Along the shores of Trading Bay for several miles east of the mouth of Nicolai Creek the bluffs are composed of glacial till and the Eocene beds are not exposed, although they are probably present beneath the glacial deposits. Farther west, in the piedmont belt between the inlet and the mountain front, no outcrops of this formation were seen for a distance of 18 miles from the beach, but still farther west, in the basin of the Straight River, there are many exposures of these beds, and fragments of lignite are common along the bars of the Straight River.

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[17] Spurr, J. E., op. cit., pp. 171–172.

[18] Eldridge, G. H., A reconnaissance in the Sushitna Basin and adjacent territory, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 16–17, 21–22, 1900.

[19] Brooks, A. H., op. cit., pp. 94–103.

The route traveled did not permit a careful study of the Eocene section exposed along the mountain front, though from a distance a series of exposures of beds that are certainly many hundreds of feet thick could be seen. At one locality, about a mile west of the point where the trail leaves the high piedmont ridge to descend to the valley of the Straight River, a section of this formation was examined. This section, given below, is far up in the formation and is underlain by many hundreds of feet of beds that from a distance seem to consist mainly of friable sandstone and shale. The general structure of the formation at that place is a strike about due north and a dip of 15° E. This dip is greater than the eastward slope of the piedmont ridge, so that the Eocene outcrops near Tyonek would appear to be higher in the formation than the section given herewith. The thicknesses stated are approximate only.

Section of Eocene beds 19 miles northwest of the mouth of Nicolai Creek

	Feet
Volcanic ash and soil	5
Glacial boulders and lava blocks	5
Glacial till	50
Poorly exposed, but mainly sandstone and shale; a thin bed of impure lignite near top	100
Coarse sandstone and pebbly sandstone	40
Coarse gray sandstone and fine conglomerate	10
Sandstone containing boulders, mainly granitic	15
Gray grit and fine white sandy clay	30
Purple, brown, and gray grit and tuff, with boulders 2 feet or less in diameter; pebbly beds with the pebbles mainly of volcanic materials	30
Unconformity.	
Gray, brown, and purple grit and tuff, with beds containing boulders, including lava blocks as much as 3 feet in diameter	50
Gray sandstone and white clayey sandstone	30
Unexposed.	
Total thickness exposed	360

The unconformity shown in this section is an angular unconformity, but there is evidence of the presence of coal beds both above and below it. The areal extent and stratigraphic significance of this unconformity are not known, but in a section containing so much coarse material it is likely that the break may be of only local significance and the unconformity only an intraformational one.

Earlier explorations have shown that beds of this formation extend from Tyonek northward across the Beluga and Skwentna Basins, occupy much of the lowland of the Susitna Basin, and occur in numerous outcrops almost entirely around the borders of Cook Inlet.

There is good reason to suppose that a great part of the Cook Inlet depression, from the Alaska Range on the west to the Kenai Mountains on the east, is underlain by beds of this formation, although in much of that region they are overlain and concealed by deposits of glacial till and glacial outwash gravel. In nearly every place in which these beds are extensively exposed they are found to contain lignitic coal, and in many places coal beds occur at a number of places in the formation and are fairly thick. At the present time these Cook Inlet coals are of too low grade to command other than local markets, but without doubt the quantity present in this basin is very great, and at some time in the future the coal will be valuable.

Structure and thickness.—The Eocene beds in the extensive exposures north of the lower end of the Straight River Glacier show a general eastward dip of about 15°, and this dip continues eastward to the point where these beds pass beneath the glacial deposits. It is possible that gentle monoclinal eastward dips continue to the coast. At the Tyonek exposures, described above, the dips are also eastward but steeper, ranging from 25° to 60°. This difference indicates that if the beds at Tyonek extend westward to the mountain front, as is probable, they are either folded or faulted. Otherwise such steep eastward dips, extending over a distance of 25 or 30 miles, would give a section much thicker than has been observed elsewhere in this formation. So much of the area occupied by Eocene rocks in this region is covered by younger deposits, however, and the exposures so far examined are of such small extent that at the present time no safe conclusions can be made about the general structure in this region. Likewise any estimates of the thickness of this formation are of minimum rather than of maximum thickness. Brooks[20] states that the Tyonek section exposes about 1,000 feet of beds. The exposures on the upper Straight River, as seen from a distance, appear to show as much as 2,000 feet or more of beds that probably belong in this formation. It is therefore probable that the formation in this region is at least 2,000 feet thick and it may greatly exceed that figure.

Age and correlation.—The Eocene rocks were laid down in fresh water as estuarine, river flood plain, or marsh and swamp deposits. They have yielded no invertebrate fossils but contain abundant plant remains in the form of coal, carbonized twigs, and leaf imprints, and from these a large number of plant forms have been identified. In spite of this abundance of organic material, however, it has been possible to collect determinable fossils only at a relatively

[20] Brooks, A. H., op. cit., p. 95.

few places, for the matrix in which the plants are found is generally poorly consolidated and too fragile to stand shipment. All the fossil collections from this formation have been determined to be of Eocene age. From the widespread occurrence of outcrops of this formation around the Cook Inlet Basin, in the valleys of the Susitna River and its tributaries, it is known that during Eocene time a great lowland that corresponded in general size and shape to the present lowland was in existence and was receiving deposits of sediments from surrounding higher lands. Also during that period there were recurring intervals during which, at many places within this lowland, organic material accumulated as peat or bog deposits, which were later transformed to lignitic coal. From our present knowledge of these coal beds it appears that no single bed is continuous over large areas and that at no one time was coal-forming material laid down over the entire basin. It is more likely that at any particular time vegetation was accumulating over rather local areas while sand and clay were being laid down elsewhere. In other words, the conditions of sedimentation at any one time differed greatly from place to place throughout the basin, and it is therefore difficult to correlate accurately a section exposed at one locality with that at another locality some distance away, but the general correlation of the scattered outcrops to a single formation can be made with little uncertainty. The significance of such intraformational unconformities as that shown in the section described above, however, is not yet known. So far as is known, therefore, all the exposures of the coal-bearing formation in the area of the Cook Inlet-Susitna lowlands are to be correlated with the Kenai formation and are of Eocene age.

QUATERNARY DEPOSITS AND HISTORY

Preglacial conditions.—The Quaternary history of this region includes all geologic events that have taken place there from the beginning of the great ice age, the Pleistocene epoch, to the present. In a geologic sense the Quaternary deposits are young, though in years the time is long, as the earliest events of the Quaternary took place at least several hundred thousand years ago. In reconnaissance field work it is inevitable that many details of this history should escape notice, but enough facts have been recognized here and elsewhere in Alaska to justify a general statement of the most noteworthy events of this time. Thus we know that by the end of Tertiary time or the beginning of the Quaternary the Alaska Range had reached about its present area and height, the main river valleys had been established in it, and the distribution of mountains and lowlands was about that of to-day. In detail, however, there were many differences. The mountain valleys, instead of being of the wide-floored, U-shaped type, were more nearly V-shaped in cross section; their gradients were very different from those of to-day; and many tributaries had quite different courses from those shown on the present map. The large lakes now found in the Beluga lowland and those in the mountains, such as Chakachamna Lake, did not then exist; the lowland between Cook Inlet and the mountains had an entirely different appearance, and the shore line of Cook Inlet was doubtless far different from the present one. Mount Spurr, long an active volcano, had probably already grown to about its present height, though its top was a great crater 3 or 4 miles across.

The glacial epoch.—The Pleistocene or glacial epoch—the first major division of the Quaternary—was characterized in Alaska and in many other parts of the world by a remarkable development of glaciers. Quite possibly there were mountain glaciers in the higher parts of the Alaska Range before Pleistocene time, as there are to-day, but they were small as compared with the great Pleistocene ice flood that overwhelmed the region. This great growth of glaciers was brought about by the more severe climate at that time, probably the result of a lowering of the mean annual temperature, and possibly also by an increase in precipitation, so that each winter more snow fell than was melted during the succeeding summer. This condition resulted in the formation of small glaciers, at first only in the protected gulches in the higher mountains, but later on these smaller ice streams lengthened and joined into great, many-branching valley glaciers that filled the mountain valleys and poured out from the mountains into the Cook Inlet lowland, there to join the great glacier that pushed down from the north. At the time of the greatest glaciation the great southward-moving ice mass in the Cook Inlet lowland filled that basin to a height, opposite Mount Spurr, of at least 3,000 feet. As a consequence, the surface of the tributary ice streams that joined this glacier from the mountains to the west also had at that time an altitude at the mountain front of 3,000 feet, and that surface sloped upward toward the valley heads. At the foot of Chakachamna Lake the ice level at one time reached a height of about 4,200 feet, or about 3,000 feet above the present level of the lake, and still farther toward the valley heads the glacier surface reached even greater altitudes, so that only the higher peaks and ridges projected above its surface. At that time a continuous glacier extended from the upper valley of the Nagishlamina River across the divide into the head of the Skwentna, and at the pass its surface stood at an altitude of 6,000 feet, so that the glacial ice was more than 3,000 feet thick at the pass. No doubt the direction of flow of the glacier through the pass was at times northward into the Skwentna Basin, and at other times southeastward into the Nagishlamina, depending upon which basin received the heavier snowfall. Similarly, glacial ice moved through other passes between the Chakachatna Basin and the Skwentna to the north and the Kuskokwim to the west. Thus the mountainous part of this region was so heavily glaciated that the valleys were filled with ice to a depth of several thousand feet. This ice in its movement followed the drainage lines and in the region here discussed pushed down into the valley of the Chakachatna River and thence eastward toward the Cook Inlet lowland, joining the great ice tongue that moved down that lowland from the north. As already stated, the west margin of the Cook Inlet glacier stood against the east flank of Mount Spurr at an altitude of at least 3,000 feet, and that glacier therefore must have pushed southward down the lowland a long distance beyond Mount Spurr. Just how far southward this great glacier extended we do not know, but there can be no doubt that it reached a considerable distance beyond the constriction formed by East and West Forelands, and it is possible that it filled the entire inlet and pushed eastward into the Gulf of Alaska between Kenai Peninsula and Afognak Island.

The long occupancy of these valleys by glacial ice, probably at several separate times during the Pleistocene epoch, resulted in profound changes in the topography of the country. A thick glacier, shod with abundant rock fragments and boulders, is admirably equipped to wear down the bed over which it moves, and all the valleys in these mountains show plainly the effects of erosion by glaciers. The steep-walled, troughlike valleys, with wide floors, point unmistakably to the scouring action of former glaciers. The valley walls, smoothed and fluted up to the height reached by the ice, contrast with the sharp, ragged ridges and peaks that stood above the ice surface.

Glacial deposits and bench gravel.—During the final shrinkage of the glaciers to their present dimensions many of the valleys were freed from ice, and the normal processes of stream erosion became effective. The valley floors left by the glaciers, however, were in many places out of adjustment to stream drainage, and the streams commenced the task, still far from completed, of reestablishing normal gradients. At many places the bedrock floor had been oversteepened by the ice, and the streams, flowing swiftly in those places, developed sharp canyons cut in bedrock. At other places overdeepened stretches became lakes, and the streams at once began to fill these depressions with sand, gravel, and silt brought from higher portions of their basins.

During some stage in the retreat of the ice lobe up the Chakachatna Valley the glacier terminated somewhere near the lower end of Chakachamna Lake, and at that time an extensive gravel filling was laid down along the Chakachatna Valley to and beyond the mountain front. With a further retreat of the main glacier and the formation of Chakachamna Lake behind the dam formed by Barrier Glacier, the load of gravel and sand brought down by the headward tributaries of the Chakachatna was trapped in the lake, and the river below the lake, freed from this burden of sediments, was able to intrench itself into the gravel filling of the valley and locally into the bedrock. As a result a fine series of terraces was developed in the valley for many miles below the lake, especially on the north slope of the valley. The upper and most prominent terrace stands about 100 feet above the river, and in places three or four lower terraces can be seen at levels 20 feet or so apart.

Terraces are also developed along the south slope of the piedmont ridge that extends from Cook Inlet back to the mountains just north of Nicolai Creek. These terraces are for the most part covered with heavy timber and brush and are not conspicuous, but one well-developed terrace, at an altitude of 100 to 150 feet above sea level, was traced back for several miles from the beach.

In the headward valleys of many tributaries of Chakachamna Lake there are deposits of terrace or bench gravel, but these are in general related to incidents that occurred during the retreat of the glaciers in those valleys and are of local rather than of general significance.

Present stream gravel.—Virtually all the larger streams in this region have fairly extensive gravel and sand flood plains in places, for all are glacier-fed and carry heavy loads of detritus during the summer, when the ice fields are melting. The flood plains are not continuous, however, for they are interrupted from place to place by rock canyons, by lakes, and by glaciers that push down across the larger valleys. Thus the McArthur and Chakachatna Rivers have extensive gravel flats in the lowland east of the mountains, but within the mountains the valley of the Chakachatna is constricted at a number of places by rock bluffs, by high terrace deposits, and just below Chakachamna Lake by Barrier Glacier. The Nagishlamina River has a delta at its mouth, built out into Chackachamna Lake, and for several miles above the lake flows through a wide-floored valley paved with coarse boulders. At 5 miles above its mouth the valley is narrowly constricted by rock bluffs, and a mile farther upstream by a vigorous glacier, which pushes out from a tributary valley from the east and across the main valley of the Nagishlamina. Above this glacial dam is a wide flat 3 miles long and a mile wide, occupied by a lake and by fine sands at its lower end and by gravel at its upper end. Above this flat the valley is again constricted by a second glacier from the east. On the upstream side of this second glacier is a wide, gravel-floored valley, which extends northwestward to the pass at the head of the Skwentna and down that stream for many miles.

The Chilligan River has in its upper reaches a broad, bare gravel floor over which the river flows in many channels. For the lower 8 miles of its course, however, its flood plain is narrower and flanked by terraces from a few feet to 15 or 20 feet high. The Igitna River likewise has a wide gravel floor in its upper valley, but for 7 miles above its mouth it flows through a series of short rock canyons alternating with wider stretches in which there is a narrow gravel flood plain.

Chakachamna Lake at present receives and retains a large amount of sand, gravel, and silt brought down to it by a great number of glaciers and glacial streams. The coarse materials are dropped at the mouths of the tributaries to form delta deposits, but the finer silt is carried farther from shore and laid down over the entire bed of the lake. Should the Barrier Glacier retreat a short distance, or the moraine at its lower end be trenched by the Chakachatna River so as to drain the lake, there would no doubt be found a large volume of lake beds in the area now covered by the lake.

Volcanic ash.—At many places throughout this region where fresh exposures are available a bed of volcanic ash may be observed on top of the deposits left by the old glaciers but beneath a layer of vegetal material and turf. The depth of the ash differs from place to place, as does the thickness of the soil and turf under which it lies. There are places on the piedmont ridge, northeast of the Straight River and above the altitude to which brush grows, where persistent snow banks have prevented the growth of moss or heather and where considerable patches of volcanic ash mixed with soil are exposed at the surface. On the southeast side of the Straight River, 3 miles below the glacier, the terrace face shows as much as 6 feet of volcanic ash overlain by 12 to 18 inches of vegetal material and soil, on the surface of which stands a forest of large spruce trees.

On the surface of the moraine of the Harpoon Glacier, in the Nagishlamina Valley, volcanic ash that ranges from 2 to 4 feet in thickness was seen beneath a foot of turf. Still farther west, in the pass between the Chilligan and Igitna Rivers, 4 feet of pale-buff to brown volcanic ash was seen immediately below the turf.

Similar occurrences of ash were observed in 1926 at several localities in the Skwenta Basin.[21] At that time it was not known that Mount Spurr is an active volcano, and the source of the ash was not determined. The observations in that year, however, together with those in 1927, show that a relatively recent fall of ash covered a large area to the west, north, and east of Mount Spurr and probably to the south also. No other volcano from which the ash could have come is known nearer than Redoubt Peak, 60 miles south of this area, and as Mount Spurr is still active and lies about in the center of the area of the ash, it seems almost certain that an explosion from that volcano supplied the ash in the surrounding region.

The ash is geologically very recent. It occurs on the surface of moraines in the Nagishlamina Valley that were not laid down until the main glacier in that valley had disappeared, and it now lies on surfaces that have suffered little erosion since the ash fell. It is buried by a few inches to a foot or two of soil, and on this soil grow trees that must be at least 200 years or more old. Apparently the ash was ejected several hundred but probably less than a thousand years ago.

IGNEOUS ROCKS

The rocks of igneous origin in the Mount Spurr region include relatively old gneisses and schists, lava flows, and tuffs of Mesozoic age, late Mesozoic granitic intrusive rocks, and the lavas, breccias, and eruptive volcanic materials from Mount Spurr, which range in age from Eocene almost to the present. The gneisses and schists have already been described (pp. 155–156), and the Mesozoic lavas and tuffs, which are interbedded with sedimentary materials, have been described in connection with the Mesozoic sediments.

GRANITIC ROCKS

The most conspicuous single group of rocks in this region, on account of its widespread distribution and of the rugged topographic forms produced from it by erosion, is that which includes the granitic intrusive rocks. Granitic rocks occupy much the larger portion of the mountain province in this region and belong to the great group of intrusive rocks that extends from Iliamna Lake northward to and beyond Mount McKinley and constitutes a conspicuous element in

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

the Alaska Range. The mountainous portion of the region here considered is entirely made up of granitic rocks except for the more recent volcanic rocks of Mount Spurr and certain relatively small areas of gneiss and of Mesozoic sediments, lavas, and tuffs. The great intrusive masses of granitic material are commonly gray, though more rarely of a pink hue. Thin sections cut from a dozen specimens from different parts of the region show only one rock that would be classed as a diorite, and the others are all granites. Later dikes that cut the granites include both rhyolite and diorite porphyry, and still later are more basic types that include augitite, pyroxenite, diabase, basalt, and basalt porphyry. These basic dikes, although their dark colors are conspicuous in contrast to the lighter colors of the granite, are not quantitatively abundant.

The granites have a considerable range in color, texture, and composition. Specimens collected within a few hundred yards of one another range from a fairly coarse dark-gray hornblende granite containing quartz, orthoclase and plagioclase, hornblende, apatite, zircon, and iron oxides through finer-grained light-gray biotite granite containing quartz, orthoclase, acidic plagioclase, biotite, ilmenite, and titanite to a nearly white sugary-textured aplitic granite containing quartz, orthoclase, and acidic plagioclase but with a very small proportion of muscovite and biotite or other dark minerals. In places, as in the extreme headward basin of the Nagishlamina River, a common phase of the granite is a coarse-grained pinkish-gray granite porphyry that is studded with prominent orthoclase phenocrysts. Many of the phenocrysts are euhedral and attain a greatest diameter of 2 inches or more. In the same vicinity occur hornblende phases in which the proportion of hornblende ranges from 25 to 90 per cent.

No positive evidence of the age of the granitic intrusive rocks was obtained during this investigation, but it is certain that granites have been intruded into this general region during at least two periods in its history, for granitic pebbles were observed in the tuffs of probable Lower Jurassic age and these tuffs were later cut by other granites. Most of the granite of the region is believed to be of late Mesozoic age. In the upper Skwentna region [22] these granites cut shale from which was collected a fossil leaf that was identified as of Upper Cretaceous or Tertiary age and are directly continuous with the same great intrusion that brought in most of the granites of the Mount Spurr region and are probably a part of it. In the basin of the Igitna River the granite cuts the tuffs and sediments that are classi-

[22] Capps, S. R., op. cit., p. 89.

fied as of Mesozoic age and contains blocks and fragments of the still older schists of the Nagishlamina Basin. It is older than the Eocene beds, and it was through this granite that the volcanic vent of Mount Spurr broke its way to the surface. The best evidence available therefore points to a late Mesozoic age for the bulk of the granites of this region.

VOLCANIC ROCKS OF MOUNT SPURR

Mount Spurr is a volcanic mass that lies on the east face of the Alaska Range and so far as is known is the northernmost of a long line of craters that extends down the Alaska Peninsula to the Aleutian Islands and includes Mount Spurr, Redoubt Peak, Iliamna Peak, Mount St. Augustine, Mount Katmai, Mount Peulik, Aniakchak Crater, and many others. It is thus one of the conspicuous series of volcanoes that border the Pacific Ocean, and many of these mountains are still active. The mass of which the highest peak is called Mount Spurr consists of a great outer crater, now breached by the valleys of a number of glaciers that flow radially from it, and a central cone within this older crater, the highest peak of the mountain, from vents near the top of which steam still issues. One small subsidiary crater, now occupied by a small glacier, was recognized on the south rim of the old, outer crater.

As has already been shown, volcanic activity at this place began at least as long ago as Eocene time, the vent having been formed through the somewhat older granitic rocks. It is likely that this mountain, like other volcanoes, has been active intermittently, the active periods alternating with periods of relative quiescence. Volcanic ash is widely scattered in this region and is found immediately beneath the turf, indicating that the last violent explosion, probably from Mount Spurr, took place within the last few centuries. At present a moderate steam plume is the only indication of activity.

The rocks of which Mount Spurr is composed include breccia, tuff, and lava flows, together with minor amounts of dikes and sills. They range in composition from diorite porphyry, which occurs in minor amounts, to basalt porphyry, which makes up the bulk of the mountain. A thin section of a quartz-bearing pyroxene diorite porphyry showed phenocrysts of plagioclase, basaltic hornblende, and augite in a holocrystalline groundmass of plagioclase, augite, basaltic hornblende, biotite, magnetite, and apatite. The commonest type of basalt porphyry consists of a glassy to microcryptocrystalline matrix containing phenocrysts of plagioclase and augite, with small amounts of apatite and iron oxides. Another type consists of a holocrystalline groundmass of labradorite, titaniferous augite, magnetite, and apatite, with phenocrysts of labradorite and augite.

MINERAL RESOURCES

Metallic minerals.—The Mount Spurr region has been so little visited by white men that only the most superficial prospecting has been done, and little definite information is available about its mineral resources. The few white men who have entered the region have doubtless done some panning for placer gold, but without success. Members of the Geological Survey expeditions of 1926 and 1927 also did some panning but found scarcely a color of gold. This failure, however, is scarcely surprising, for the valleys have been so recently occupied by great glaciers and were so severely scoured out by the ice that there has been too little weathering and decomposition of the rocks to release a new supply of placer gold to the streams, even if the rocks were gold bearing. Furthermore, all the large and most of the smaller streams are supplied by glaciers, carry great quantities of gravel, sand, and silt, and are building up extensive gravel flats. This process does not tend to concentrate any heavy metallic content into a sharply defined channel or pay streak. It therefore seems unlikely that extensive or continuous placer channels will be found in the rugged portions of this region.

The possibilities of the presence of valuable lode deposits in this part of the Alaska Range are somewhat better. The extensive masses of granite intruded into sediments of different ages have been the cause of the mineralization of some of the intruded rocks, as can be seen from the rusty color of those rocks at many places and from the presence of scattered pyrite at many localities. No deposits of more valuable metals were actually observed, but the association of lodes carrying gold, silver, lead, copper, and zinc with granitic intrusive bodies is so common that any region where such intrusives are present and in which iron sulphides are abundant deserves at least a careful scrutiny for more valuable minerals.

Coal.—The Tertiary formations of the Cook Inlet depression, between the beach and the mountain front, are known to contain lignite, and in the vicinity of Tyonek a section about 1,000 feet thick shows 24 coal beds ranging in thickness from 1 to 15 feet. This formation is known to crop out at many places throughout the piedmont area and is probably present in most of it, though generally covered by glacial deposits, gravel, and vegetation. Too little is known of the section or of the structure of the beds to warrant any estimate of the amount of coal present, but it is undoubtedly large and may be a valuable reserve of fuel at some distant time. At present this coal has no value for other than strictly local use. Much better coal is now being mined in the Matanuska Valley and in the Nenana field, and numerous exposures of coal are known around Cook Inlet and in the Susitna Basin that are more accessible to transportation and probably of equally good or better quality. Recently developed methods of manufacturing liquid fuels for internal-combustion engines from low-grade coals, however, suggest the possible future value of such coals.

INDEX

Page

Acknowledgments for aid 4-5, 91
Administrative staff, resident, Federal and Territorial agencies and miners aided by 84-85
Admiralty Island, coal mining on 58
Aerial photographic survey, results of 74-75
Airplane, prospecting by, proposed 38
Alaska Juneau Gold Mining Co., operations by 10-12
Alaska Juneau mine, production of, 1893-1927 11
    lead produced from 51
Alaska Mexican Gold Mining Co., sale of properties proposed 12
Alaska Nabesna Corporation, development work by 47
Alaska Palladium Co., closing of mine of 51-52
    sale of mine of 13
Alaska Treadwell Co., sale of properties proposed 12
Americán Creek Mining Co., operations by 28, 41
Antimony, occurrence of 62-63
Apex-El Nido Mining Co., operations by 12
Appropriations, amount and purposes of 67-68
Areas surveyed, 1898-1927 71-72

Bonanza district, prospecting in 36
Brooks Range, features of 103

Capps, Stephen R., The Mount Spurr region, Alaska 141-172
Carboniferous rocks of the Chandalar-Sheenjek district 118-128
Chakachamna Lake, features of 147-148
Chandalar River, benches on 101-102
    East Fork of, survey on 73
    general features of 95-98
Chandalar-Sheenjek district, animals of 105
    climate of 103-104
    drainage of 91-99
    explorations in 87-91
    features of relief in 99-103
    geologic map of pl. 2 (in pocket)
    geology of 110-139
    igneous rocks of 135-137
    location of 87
    oil shale in 138-139
    sedimentary rocks of 110-134
    settlements in 109-110
    topographic map of pl. 1 (in pocket)
    vegetation of 105-109
Chichagoff Development Co., operations by 12
Chilkat Oil Co., operations by 58-59
Christian River, features of 98-99
Circle district, gold-placer mining in 28-29
Coal, future of market for 55-56
    production and consumption of 54-58
Coal in the Mount Spurr region, occurrence of 171-172
Coal properties, Government, care and maintenance of 84

Page

Collection of information 1-4
Cook Inlet, placer mining on 22-23
Copper, losses in extracting 43
    mining of 42-47
    production of 45
    valuation of 44-45
Copper Creek mines, development work at 46-47
Copper River region, operations in 17
    placer mining in 21-22
    surveys in 72, 78
Council district, gold-placer mining in 35
Cross, J. C., prospecting by 37-38

Devonian (?) rocks of the Chandalar-Sheenjek district 115-118
Dredges, operation of 39-42
    production by 38-39

Eagle district, gold-placer mining in 29-30
Eocene rocks of Mount Spurr region 160-163
Erickson, E. T., test of oil shale by 139
Evan Jones Coal Co., operations by 56
Expenditures, distribution of 80-83, 85

Fairbanks district, gold-lode mining in 14-15
    gold-placer mining in 25
Fairhaven district, gold-placer mining in 34
Fern Gold Mining Co., operations by 14
Field work, general 79
Fortymile district, gold-placer mining in 29

General Petroleum Corporation, drilling by 59-60
Georgetown-Tuluksak-Aniak district, gold-placer mining in 31-32
Girty, G. H., fossils determined by 127
Gold, production of, 1880-1927 8-9
    sources of 10
Gold lodes, production from 10
Gold-placer mining, future of 19-20
    production from 20
    unfavorable season for 18-19
Golden Center Mines (Inc.), operations by 34
Goodnews Bay district, gold-placer mining in 32
    prospecting for platinum metals in 52-53

Hammon Consolidated Gold Fields, operations by 33-34
Helmet Mountain, features of 100-101
Hirst-Chichagof Mining Co., operations by 12
Hot Springs district, gold-placer mining in 28
    tin mining in 53
Hyder district, gold mining in 12-13
    lead-silver mining in 49, 51

Iditarod district, gold-placer mining in 27
Innoko district, gold-placer mining in 26

Jacob Marty Mines, development by 13
Jaggar, T. A., jr., volcanologic studies by 74

Kassan Gold Mining Co., operations by 13
Kenai Peninsula, gold-lode prospecting on 17

Page

Kennecott Copper Corporation, operations by ... 45-46
Ketchikan district, gold mining in ... 13
topographic mapping in ... 77
Kougarok district, gold-placer mining in ... 35-36
Koyuk district, gold-placer mining in ... 36
Koyukuk district, gold-placer mining in ... 27-28
Kuk Inlet, coal mining on ... 58
Kuskokwim region, gold-placer mining in ... 31-32

Lead, production of ... 50-51
Leasing of mineral lands, administration of ... 83-85
transfer of administration of ... 79-80
Limerock, preparations for mining ... 62
Lisburne limestone of Chandalar-Sheenjek district, features of ... 125-128

Marble, production of ... 62
Marion-Twin Mining Co., operations by ... 14
Matanuska coal field, operations in ... 56-57
Mertie, J. B., jr., The Chandalar-Sheenjek district, Alaska ... 87-139
Mesozoic rocks of Mount Spurr region ... 156-160
Mineral industry, compilation of report on ... 75-76
Mineral production, 1880-1927 ... 7
Mining, indications of revival in ... 6-7
Mint mine, development on ... 50
Miscellaneous mineral products, production of ... 61-64
Mother Lode Coalition Mines Co., operations by ... 45, 46
Mount McKinley district, gold-placer mining in ... 31
Mount Spurr, surveying near ... 73-74, 78
Mount Spurr region, animals of ... 151-152
climate of ... 150
drainage of ... 146-149
field work in ... 143-146
general character of ... 141
geologic map of ... pl. 3
geology of ... 153-171
igneous rocks of ... 168-171
location of ... 141
map showing distribution of timber in ... pl. 4
mineral resources of ... 171-172
previous surveys in ... 141-143
relief of ... 149
routes of travel in ... 152-153
schistose rocks of ... 155-156
stratigraphic sequence in ... 155
vegetation of ... 150-151

Naval Petroleum Reserve No. 4, report on exploration of ... 61
Nenana coal field, operations in ... 57
Nome district, gold-placer mining in ... 33-34
Northwestern Alaska, gold-placer mining in ... 36-38
Nuka Bay, development at ... 16

Oil shale of Chandalar-Sheenjek district, test of ... 139

Paleozoic rocks, early, of the Chandalar-Sheenjek district ... 110-113
Pearson & Strand mine, operation of ... 15-16
Peerless Consolidated Mining Co., operations by ... 13
Peterson-Hill Association, drilling by ... 60-61

Page

Petroleum, production and consumption of ... 58-59
Placer-mining camps, reconnaissance of ... 74
Platinum metals, occurrence and production of ... 51-53
Pleistocene deposits in the Chandalar-Sheenjek district ... 129-133
Porcupine River, general features of ... 92
Port Clarence district, gold-placer mining in ... 36
Premier Coal Mining Co., operations by ... 56
Prince William Sound, gold-lode mining near ... 16-17
Production, causes of decline of ... 5-6
general features of ... 5-8
Production of 1927 compared with 1926 ... 8
Projects for season of 1927, scope of ... 70-76
Projects for season of 1928, scope of ... 76-80
Publications issued or in preparation ... 68-70
Publications, work on ... 76
Public lands, supervision of developments on ... 84

Quaternary deposits and history of Mount Spurr region ... 163-168

Revillagigedo Island, map of ... 75
Richardson district, gold-placer mining in ... 26
Riverside Mining & Milling Co., operations by ... 12
Ruby district, gold-placer mining in ... 29
prospecting for tin in ... 54
Ryan lode, reported purchase of ... 15

Salmon Creek, prospecting for platinum metals on ... 52
Salmon River, prospecting on ... 37-38
Scale of surveys ... 72
Scope of the Survey's work ... 65-66
Seward Peninsula, coal mining in ... 57-58
gold-placer mining in ... 32-36
Sheenjek River, benches on ... 102-108
general features of ... 93-95
Silurian rocks of the Chandalar-Sheenjek district ... 113-115
Silver, production of ... 9, 10, 45, 47-50
sources of ... 10
Skajit limestone in the Chandalar-Sheenjek district, features of ... 113-115
Smith, Philip S., Administrative report ... 65-85
Mineral industry of Alaska in 1927 ... 1-64
Smoke Mountain, features of ... 101
Solomon district, gold-placer mining in ... 34-35
Southeastern Alaska, aerial photography in ... 74-75
placer mining in ... 20-21
topographic surveys in ... 77
Susitna region, placer mining in ... 22-23

Tanana River, surveying north of ... 78-79
Tertiary rocks of Mount Spurr region ... 160-163
Tin, production of ... 53-54
Tolovana district, gold-placer mining in ... 26-27

Valdez Creek region, prospecting and development in ... 17-18
Volcanologic studies by T. A. Jaggar, jr ... 74

Willow Creek Mines, operations by ... 14

Year, fiscal, relation of Alaskan projects to ... 66-67
York district, mining of tin in ... 53
Yukon Flats, general features of ... 99-100
Yukon Valley, gold-placer mining in ... 28-30
placer gold produced in ... 24

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

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

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

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

The Mesozoic stratigraphy of Alaska, by G. C. Martin. Bulletin 776, 1926, 487 pp. 75 cents.

In preparation

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

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; 1927. 10 cents retail or 6 cents wholesale.

Map of Alaska (C); scale, 1:12,000,000; 1916. 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; 1927. Free on application.

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

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

SOUTHEASTERN ALASKA

REPORTS

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

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

The Ketchikan and Wrangell mining districts, by F. E. and C. W. Wright. Bulletin 347, 1908, 310 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, southwestern Alaska, by Adolph Knopf. Bulletin 502, 1912, 61 pp. 25 cents.

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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. 60 cents.

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

*The geology and mineral resources of the west coast of Chicagof Island, by R. M. Overbeck. In Bulletin 692, 1919, pp. 91-136.

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

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

Marble deposits 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, 1928, pp.———. Free on application.

In preparation

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

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

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

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

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

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

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

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

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

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

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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.

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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. 60 cents.

The Port Wells gold-lode district, by B. L. Johnson. In Bulletin 592, 1914, pp. 195–236. 60 cents.

*The 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.

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

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

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

*Mining on Prince William Sound, by B. L. Johnson. In Bulletin 692, 1919. Similar previous reports in Bulletins 592, 1914, 60 cents; 622, 1915, 30 cents; 642, 1916, 35 cents; 662, 1917, 75 cents.

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

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

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

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

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

In preparation

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

Geology of upper Nizina River, by F. H. Moffit. In Bulletin 810.

TOPOGRAPHIC MAPS

Central Copper River region; scale, 1:250,000; by T. G. Gerdine. In Professional Paper 41, 1902, 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.

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

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

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

Port Valdez district (No. 602B); scale, 1:62,500; 1915, by J. W. Bagley. 20 cents retail or 12 cents wholesale.

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

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

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

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

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

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Prince William Sound region; scale, 1:250,000; by J. W. Bagley, D. C. Witherspoon, and others.
Valdez and vicinity; scale, 1:62,500; by J. W. Bagley and C. E. Giffin.

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. 25 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 in 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 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, 1928, pp. 67–98. Free on application.

In preparation

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

The Mount Spurr region, by S. R. Capps. In Bulletin 810.

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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.

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Lower Matanuska Valley (No. 602A); scale, 1:62,500; 1918, by R. H. Sargent. 10 cents.

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, 1:250,000; 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, 1:250,000; 1924, by J. W. Bagley, T. G. Gerdine, R. H. Sargent, and others. 50 cents retail or 30 cents wholesale.

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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. 50 cents. Not issued separately.

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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, 138 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, 1918, 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.

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

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*Aniakchak Crater, Alaska Peninsula, by W. R. Smith. Professional Paper 132–J, 1925, 11 pp.

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*Herendeen Bay and Unga Island region; scale, 1:250,000; by H. M. Eakin. In Bulletin 467, 1911. Not issued separately.

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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). Free on application.

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. Published also, with geologic overprint, in Bulletin 797, 1928. Free on application.

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.

The Nabesna-White River district, by F. H. Moffit, Adolph Knopf, and S. R. Capps. Bulletin 417, 1910, 64 pp. 25 cents.

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 and F. J. Katz. 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, 1917, pp. 221–277. 75 cents.

Lode mining in the Fairbanks district, by J. B. Mertie, jr. In Bulletin 662, 1917, pp. 403–424. 75 cents.

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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, 116 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. 338–351.

*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. Bulletin 739–D, 1922, 17 pp. 5 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 Toklat-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, pp. 99–123, 1928. Free on application.

In preparation

Geology of the Eagle-Circle district, by J. B. Mertie, jr.

The Chandalar-Sheenjek district, by J. B. Mertie, jr. In Bulletin 810.

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, 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, 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.

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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.

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