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MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN 1925

BY

F. H. MOFFIT AND OTHERS

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MINERAL INDUSTRY OF ALASKA IN 1925

By Fred H. Moffit

INTRODUCTION

This volume is the twenty-second of a series of annual bulletins[1] summarizing the results achieved during the year in the investigation of the mineral resources of Alaska, describing the mineral deposits, and presenting statistics of mineral production.[2] It has for its chief purpose the prompt publication of notes on the more important mining developments of the year and of the principal results of the field work carried on by members of the Geological Survey who are engaged in the investigation of Alaska's mineral resources, especially any facts or conclusions coming from these investigations which may be of immediate use to the mining public. The papers included in this volume are for the most part preliminary statements or summaries of the results of work which are expected to be published in greater detail at a later time, as the study of the field collections in the office is not yet completed and the final maps are not prepared. The omission in this volume of engraved maps and the illustrative material which ordinarily accompanies a more detailed report on the geology and mineral resources of a district makes possible its publication with much greater promptness than otherwise could be attained. It is evident that the later conclusions of the final reports may differ in some measure from the statements of this volume, yet it is believed that any changes of this kind which may be found necessary will not modify radically the conclusions here set forth. Those who desire more detailed information regarding a particular district or particular problem in Alaska, especially those who require the geologic and topographic maps of areas that are being surveyed, are urged to obtain copies of the final reports when they become available. Although as a rule it is not possible to state even approximately the date of publication of a paper in

[1] The preceding volumes in this series are U. S. Geol. Survey Bulls. 259, 284, 314, 345, 379, 442, 480, 520, 542, 592, 622, 642, 662, 692, 712, 714, 722, 739, 755, 773, and 783.

[2] The statistics in this report have been compiled principally by Miss Erma C. Nichols.

course of preparation, requests for such reports are filed, and the reports are mailed to those requesting them as soon as they come from the press.

The information for the general survey of the mining industry of Alaska in 1925 here presented comes from a number of sources, chiefly the schedules of lode mines and gold placers which are furnished by the owners or operators of mining properties at the request of the Geological Survey; the reports furnished by banks, the Bureau of the Mint, the Bureau of Mines, the Customs Service, and others with special knowledge of mining developments or production; and the data gathered in the field by the Geological Survey. Some items of interest and notes on important events are obtained from the Alaskan newspapers and the technical press. The information from the operators themselves is the most valuable, for it brings the Geological Survey into close touch with the mining men of Alaska, makes possible a more accurate knowledge of the conditions under which the miner is working and of his needs, and increases the value of the statistical records of production by increasing their accuracy. All operators who receive each year the schedules asking for statistics of mineral production are therefore urged to fill out and return them promptly, in order that the figures for production may be as nearly accurate as is possible and compiled without delay in the Geological Survey. In order to make the records accurate and complete it is necessary to have returns not only from operators of mines of large production, but also from those that produce little or none at all. All the schedules are regarded as confidential and are used for no other purpose than compiling the tables of mineral production of Alaska which are published each year in this series of volumes. In preparing these tables care is taken to combine the figures in such a way as not to reveal the production of individual operators or companies, except such companies as themselves publish the figures of their production in the annual reports to their stockholders. It is for this reason that the grouping of minerals produced and of creeks or properties in some of the tables is not entirely natural or not always logical. It is gratifying that so large a number of Alaskan mining men are willing to assist in the work of collecting the statistics by placing at the command of the Geological Survey the figures of their individual production.

Many persons have contributed information or rendered other aid toward the compilation of the statistics and descriptive material in this report. The list is too long to be included here, although such recognition of appreciation would gladly be given. A number, however, have given special assistance and should be mentioned.

Special acknowledgment is due to the directors and other officers of the Bureau of Mines and Bureau of the Mint; the collector and

other officers of the Alaska customs service; the officers of the Alaska Railroad; N. L. Wimmler, formerly of the Bureau of Mines, now a member of the Geological Survey, for information about gold placers; Volney Richmond, of the Northern Commercial Co.; John C. McBride and the Alaska Juneau Gold Mining Co., of Juneau; E. H. Bartholf, of Hyder; J. H. Cann, Hirst-Chichagof Mining Co., and Chichagoff Development Co., of Chichagof; Kennecott Copper Corporation, of Kennecott; Thomas Larson, of Kotsina; M. J. Knowles, of Valdez; S. W. Jansen and H. W. Nagley, of Talkeetna; Alex Liska and Sumner Smith, of Anchorage; N. E. Bolshanin, of Unalaska; Arthur Moose Johnson, of Chulitna; J. H. Lander, of Wasilla; L. A. Levensaler, of the Nicolai Placer Mines, Dan Creek; Charles Zielke, of Nenana; Carl F. Whitham, of Chisana; J. J. Hillard, of Eagle; James P. Collins, Henry Cook, the First National Bank, George Hutchinson, and G. E. Jennings, of Fairbanks; Charles E. M. Cole, of Jack Wade; the Miners & Merchants Bank, of Iditarod; E. J. Stier, of Flat; William Schneirla and Frank Speljack, of Ophir; B. Cascaden, of Livengood; Alex Mitchell, of Kantishna; W. D. English and Frank H. Smith, of Bettles; H. S. Wanamaker, of Wiseman; Tom Plunkett, of Fortuna Ledge; William Yanert, of Purgatory; A. J. Griffin, of Richardson; B. J. Bower, of Long; George Jesse, of Poorman; Lynn Smith, of Ruby; J. R. Murphy, of the Kuskokwim Dredging Co., McGrath; E. M. Whelan, of Medfra; John Haroldsen and A. Stecker, of Kwinak; the Miners & Merchants Bank, G. R. Jackson, S. M. Gaylord, R. W. J. Reed, and K. L. Gravem, of the Coffee Creek Mining Co., of Nome; E. M. Marx, of Teller; A. V. Cordovado, of Deering; A. S. Tucker, of Bluff; James C. Cross, Lewis Lloyd, Fred Johnson, Michael Tuohy, and F. R. Ferguson, of Shungnak; and Arthur W. Johnson, of Haycock.

MINERAL PRODUCTION

The mineral industry of Alaska was until a few years ago the principal source of wealth in the Territory, but the growth of other industries, notably the fisheries, together with the decrease in mineral production resulting from increased cost of mining and supplies and decreased output from bonanza gold placers, has displaced it from its leading position, notwithstanding the fact that the loss in gold production has been partly made up by increased production in other metals and mineral substances. This change in relative rank of the mining industry is evidence of the growing importance of Alaska and the certainty of its commercial future, for a diversity of commercial interests argues for growth and stability of population. The tables that follow show, however, that mineral production still holds an honorable place among the sources of wealth in Alaska and that the present scale of production is likely to be maintained if not raised.

Alaska has produced more than $553,000,000 in gold, copper, silver, lead, and other mineral substances since the year 1880, which may be regarded as marking the beginning of its mining industry. From 1880 to 1897 there was a slow but steady increase which brought the annual production up to about $2,500,000. Beginning with 1898 a rapid increase in production took place as a result of the discovery of rich gold-bearing gravel in many parts of Alaska. The output of other metals besides gold, such as copper and silver, also increased, and the curve of gold production was no longer coincident with the curve of total mineral production. From 1898 to 1906 the total mineral production increased from less than $2,500,000 to over $20,000,000. Since 1906 Alaska's mineral production has varied a little above or a little below the $20,000,000 mark, except during the extraordinary years of the war (1916–1918), when the high price of copper and resulting stimulus to production carried the value of the minerals produced to nearly $50,000,000 in 1916. The year 1906 marks the peak of Alaska's yearly gold output. Since then the amount of gold produced from the placers has slowly diminished as the bonanza gravel deposits were exhausted, till now the proportion of placer gold in the annual output is not greatly different from that of lode gold. There is much reason to believe that, although the high record of the bonanza placer days is not likely to be repeated, the present rate of gold production will probably be maintained and may reasonably be expected to increase.

The total mineral production of Alaska is given in the following table and shown graphically by the curves of Figure 1, on which are included also the production of copper, the total production of gold, and the production of gold from placers. This diagram brings out clearly the effect of the war on the production and price of copper and the increasing proportion of other minerals to gold in the total mineral production.

Previous volumes of this series, except that for 1924, contain tables giving the values of the principal metals by years as far back as the records go, but in order to save space and the cost of printing, the tables were condensed in the report for 1924 by combining the earlier years into one item and giving the total annual production by years only from 1891 and the production of individual metals from 1916. Those who are interested in obtaining the full record should consult Bulletin 773 in connection with the present volume.

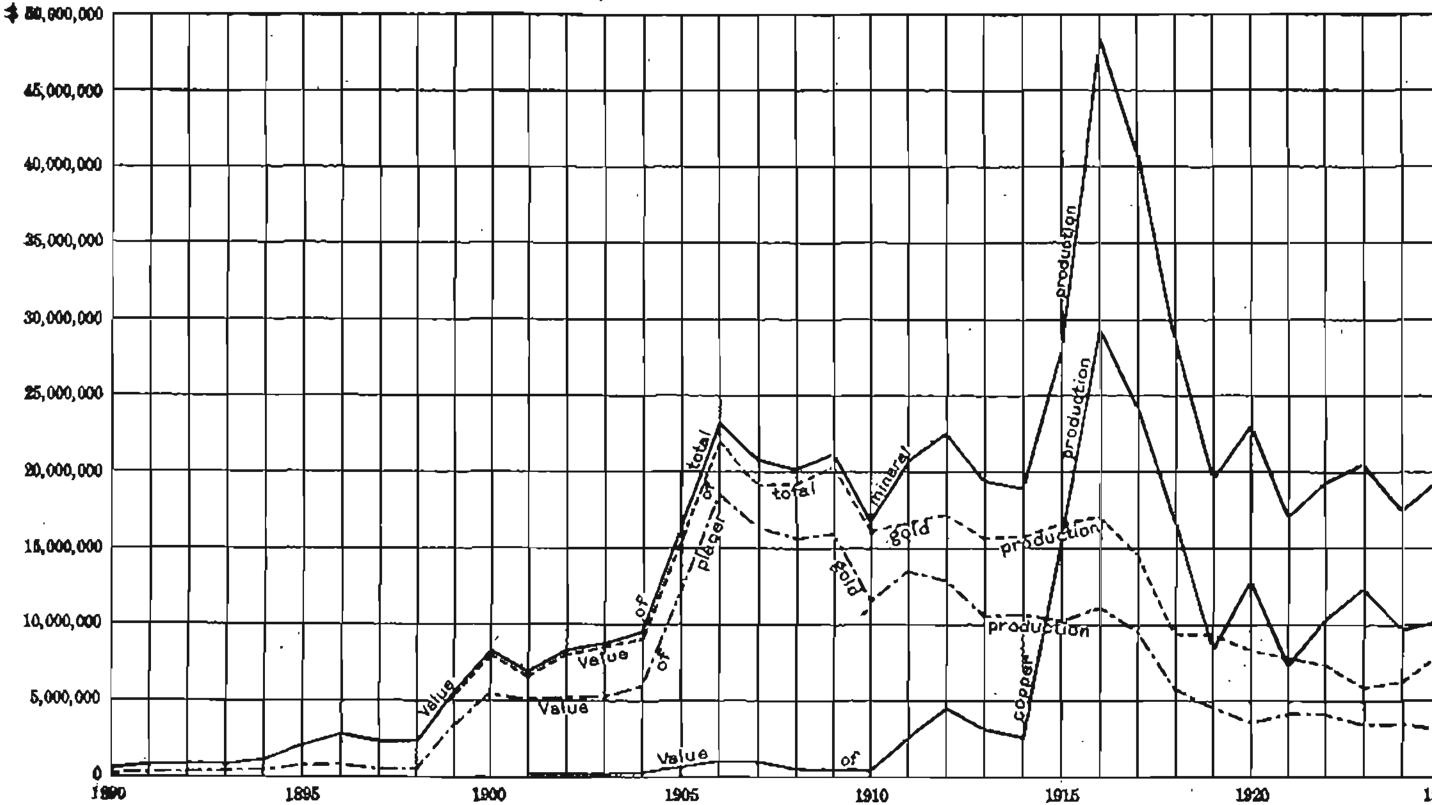

FIGURE 1.—Value of mineral production of Alaska, 1890-1925

Value of total mineral production of Alaska, 1880–1925

By years				By substances	
1880–1890	$4,193,919	1909	$21,140,810	Gold	$353,601,079
1891	1,014,211	1910	16,875,226	Copper	178,174,215
1892	1,019,493	1911	20,720,480	Silver	10,433,088
1893	1,104,982	1912	22,581,943	Coal	4,545,097
1894	1,339,332	1913	19,547,292	Tin	962,207
1895	2,588,832	1914	19,109,731	Lead	1,070,884
1896	2,885,029	1915	32,790,344	Platinum (placer)	112,978
1897	2,539,294	1916	48,386,508	Antimony	237,500
1898	2,329,016	1917	40,694,804	Marble and other products (including lode platinum metals)	4,167,920
1899	5,425,262	1918	28,218,935		553,304,968
1900	7,995,209	1919	19,626,824		
1901	7,306,381	1920	23,330,586		
1902	8,475,813	1921	16,994,302		
1903	9,088,564	1922	19,420,121		
1904	9,627,495	1923	20,330,643		
1905	16,490,720	1924	17,457,333		
1906	23,501,770	1925	18,220,692		
1907	20,840,571				
1908	20,092,501		553,304,968		

From this table, which gives the total mineral production of Alaska during 45 years of mining, it is seen that the production of 1924 was the smallest since 1905, except that of 1910 and 1921, and that the production of 1925 exceeded that of 1924 by $763,359. A comparison of the quantities and values of the principal mineral products of Alaska for the years 1924 and 1925 is made in the following table, which gives a view of the present condition of the mining industry not obtainable from the table of total production.

Mineral output of Alaska, 1924 and 1925

	1924		1925		Decrease or increase in 1925	
	Quantity	Value	Quantity	Value	Quantity	Value
Gold .... fine ounces	304,072	$6,285,724	307,679	$6,360,281	+3,607	+$74,567
Copper .... pounds	74,074,207	9,703,721	73,855,298	10,361,336	−218,909	+657,615
Silver .... fine ounces	669,641	448,659	698,259	482,495	+28,618	+33,836
Coal .... short tons	99,663	559,980	82,868	404,617	−16,795	−155,363
Tin, metallic .... do	7	7,028	13.8	15,980	+6.8	+8,952
Lead .... do	631	100,899	789	140,571	+158	+39,672
Placer platinum metals .... fine ounces	21.98	2,594	10.21	1,205	−11.77	−1,389
Miscellaneous mineral products, including petroleum, marble, gypsum, quicksilver, and lode platinum metals	....	348,728	....	454,207	....	+105,479
	....	17,457,333	....	18,220,692	....	+763,359

The values given for copper, silver, and lead differ somewhat from the values published by the Bureau of Mines, but this is an apparent rather than a real discrepancy. Where the prices actually received for the metals are known and apply to the principal part of the production from Alaska, the average of those prices for each metal is used to multiply the known quantity produced, rather than the average yearly market price for the whole country, which is commonly used in computing such statistics. Only where the selling price is not known is the average yearly price used in compiling the tables. For this reason the tables show a somewhat greater value for the mineral products of Alaska in 1925 than would be assigned if the average price of the several metals for the year had been used, indicating that the price received for some of the Alaskan metals was slightly above the average for the year. The average market prices of copper, silver, and lead as computed by the Bureau of Mines for 1925 were as follows: Copper, 14.2 cents a pound; silver, 69.4 cents an ounce; lead, 8.7 cents a pound.

The table of mineral output for 1925 compared with that for 1924 shows a decrease in production of coal and an increase in gold, copper, silver, and lead. The reasons for some of the changes are considered in the discussion of the individual minerals, but it may be said here that the decrease in coal is due in part to special temporary causes and that an increase may be expected in the future. An increase in silver production follows naturally from an increase in that of copper, as a considerable proportion of the silver is obtained from copper ores. Lead is obtained from gold ores and from silver ores in southeastern Alaska, where the production of ores of both types was greater than in the preceding year.

Tables giving the annual production of gold, silver, copper, coal, tin, lead, and placer platinum metals are presented in their proper places in succeeding pages, but the figures for certain other minerals, including petroleum, marble, and lode platinum minerals, either have not been compiled or are included in the item of miscellaneous mineral products in the following table:

Value of output of miscellaneous mineral products of Alaska, including petroleum, gypsum, marble, and other products, 1901–1925

Year	Value	Year	Value	Year	Value
1901	$500	1910	$96,408	1919	$214,040
1902	255	1911	145,739	1920	372,599
1903	389	1912	165,342	1921	235,438
1904	2,710	1913	286,277	1922	266,296
1905	710	1914	199,767	1923	229,486
1906	19,965	1915	205,061	1924	348,728
1907	54,512	1916	326,737	1925	454,207
1908	81,305	1917	203,971		
1909	86,027	1918	171,452		4,167,920

GOLD

TOTAL PRODUCTION

As is seen from the curves of Figure 1, gold made up practically the whole of Alaska's mineral output from 1880 to 1900 and was never less than 92.3 per cent of the total prior to 1910. In 1925, however, gold formed only 34.9 per cent of the total. In spite of the large increase in the proportionate value of other minerals to gold produced in Alaska, gold still leads in value. The gold produced from Alaskan lode and placer mines from 1880 to 1925 amounted to $353,601,079, or 63.9 per cent of the value of all mineral products for the same years. The following table shows that from 1880 to 1925 more than two-thirds of the total output has come from the placers, although now the gold from placers is only a little more than that from lode mines.

Gold and silver produced in Alaska, 1880–1925

Year	Gold		Silver		Value of gold by sources	
	Fine ounces	Value	Fine ounces	Commercial 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, 273	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
	17, 105, 451	353, 601, 079	13, 646, 141	10, 433, 088	239, 909, 944	113, 691, 135

Gold and silver produced in Alaska, 1925, by sources

Source	Gold		Silver	
	Fine ounces	Value	Fine ounces	Value
Gold ores (3,573,540 tons)	150, 045. 46	$3, 101, 715	67, 186	$46, 445
Copper and lead ores (860,270 tons)	1, 720. 53	35, 566	606, 929	419, 294
Placers	155, 912. 62	3, 223, 000	24, 144	16, 756
	307, 678. 61	6, 360, 281	698, 259	482, 495

GOLD LODES

In 1925 the gold produced from lodes in Alaska amounted to 151,765.99 ounces, valued at $3,137,281, or $415,557 more than in 1924. These figures represent the output of 20 established gold mines, a number of small prospects, and a few mines whose principal product is copper or some other metal. All of these contribute to the total and help swell the final figures, although the amount contributed by a given property may be insignificant. It is for this reason especially that returns from all those engaged in mining in Alaska are desired. The production in 1924 was derived from 19 mines. A lode property reporting an output of less than $1,000 is arbitrarily considered to be a prospect rather than a mine. The next table gives the production of gold and silver in Alaska in 1925, by districts.

Gold and silver produced from gold-lode mines in Alaska in 1925, by districts

District	Number of mines	Ore mined (short tons)	Gold		Silver	
			Fine ounces	Value	Fine ounces	Value
Southeastern Alaska	7	3,552,789	121,945.29	$2,520,833	63,486	$43,877
Willow Creek	5	15,834	21,990.37	454,581	1,728	1,199
Fairbanks district	4	3,663	4,064.00	84,010	919	638
Other districts	4	1,254	2,045.80	42,291	1,053	731
	20	3,573,540	150,045.46	3,101,715	67,186	46,445

It is evident from this table that by far the larger part of the lode gold comes from southeastern Alaska, and the next table shows that much the larger part of the output from southeastern Alaska comes from the mines of the Alaska Juneau Gold Mining Co., at Juneau. This company publishes the record of its operations each year, and the table which follows is compiled from these reports.[3]

Production of Alaska Juneau mine, 1893–1925 [a]

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 tailings		$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	121,379
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	791,390
1921	1,613,600	904,323	709,277	969,703	40,619	550,913	1,035,251
1922	2,310,550	1,108,559	1,201,991	1,296,157	49,404	687,315	1,388,679
1923	2,476,240	1,134,759	1,341,481	1,427,199	41,876	755,423	1,514,774
1924	3,068,190	1,367,528	1,700,662	1,907,374	63,191	1,256,857	2,055,782
1925	3,481,780	1,537,884	1,943,896	2,030,067	55,971	1,288,974	2,184,384
	16,785,448	9,308,680	7,476,768	10,796,165	323,952	6,134,393	11,523,520

[a] Compiled from published reports of mining company.

The outstanding feature in the Alaska Juneau's operations in 1925 is the great amount of ore mined, which during some months exceeded 10,000 tons a day; the average for the year was 9,618 tons, as compared with 8,476 tons in 1924. Work on additions to the general plant and mill, which treats the ore from the mines of this company, proceeded throughout the year in accordance with the plan eventually to increase the capacity of 10,500 tons a day, which was reached in 1925, to 14,000 tons. A contract has been made whereby the company is to mine ore from the adjoining Ebner property, and in addition to the improvement and enlargement of its own mill the company did considerable work in preparing the Ebner mine for the production of 1,000 tons of ore a day in accordance with the contract.

[3] Alaska Juneau Gold Mining Co. Eleventh Ann. Rept., for 1925, Mar. 1, 1926.

Some gold was produced by the Alaska Treadwell Gold Mining Co. in the course of cleaning up the old property.

A mill was erected on the Peerless property, on Windham Bay, at the south end of Stephens Passage between Juneau and Petersburg, and a mill test of the ore was started but was not completed at the end of the season.

Development work was continued on gold-bearing quartz veins on Hawk Inlet and Funter Bay, on the north end of Admiralty Island. These two localities are only a few miles apart and are similar in geologic character. A large number of gold-bearing quartz veins have been discovered, and considerable work has been done, but none of the properties were productive in 1925.

Aside from the output of the Alaska-Juneau mine, the largest quantity of lode gold in southeastern Alaska in 1925 came from Chichagof Island. Work was continued on the properties of the Chichagoff Development Co., the Hirst-Chichagof Mining Co., and the Apex-El Nido Mining Co. and resulted in a considerable production by the first two companies. These properties are all in the northwestern part of Chichagof Island.

The lode-gold production of the Ketchikan district was small. Some gold is obtained with the platinum minerals of the Saltchuck or Palladium mine, on Kasaan Bay, but gold does not constitute the principal product. The mine of the Kasaan Gold Co., near Hollis, sometimes known as the Julia or Dunton mine, was not in operation in 1925.

Gold is contained in some of the ores of the Hyder district, but as silver and lead are the most valuable metals of this district the output will be considered elsewhere.

The Prince William Sound district contributes only a little to the gold production of Alaska. Mining for gold has been carried on during the last three years at a property on the east side of Valdez Glacier, commonly known as the Ramsey-Rutherford mine, and a small production has resulted. These operations require only a few men and are conducted in an economical way, apparently with profit. It is reported that the scale of operation will be increased in the near future.

Although little further gold production is reported from the vicinity of Port Valdez, prospecting and development work were done on claims on Mineral Creek and in the vicinity of Columbia Glacier. At the Little Giant group, on Mineral Creek, development work was done, but there was no production. This property is equipped with a 2-stamp mill, which was not in operation. A few ounces of gold was produced from the Tuscarora claim, near Shoup Glacier. A small shipment of gold ore was made from the Culross mine, on the north end of Culross Island, in the early part of 1925, but with this exception no mining other than assessment work was done in the vicinity of Port Wells. The Culross mine is about a quarter of a mile from the beach and 200 feet above it. The ore body is a gold-bearing quartz vein in greenstone near slate. Mining has been carried on intermittently here for some years.

The Herman-Eaton prospect, on the west side of Port Wells, in Bettles Bay, contains a promising gold-bearing quartz vein, cutting slate adjacent to a light-colored granitic dike, on which considerable development work was done a few years ago. In 1925 a tunnel 550 feet long was opened to tap at about the 200-foot level a well-defined vein that is exposed in a creek bed 400 feet above the beach and has been explored by an incline and a drift 165 feet long. No raise has yet been made to connect the tunnel with the drift, and the extent of the vein below the drift is not known.

A substantial production of lode gold is reported from the Paystreak mine, in Nuka Bay, on the south coast of Kenai Peninsula, but none from the Moose Pass district, north of Seward, although prospecting and assessment work was done in that district. Mining was in progress at the Lucky Strike mine, near Hope, and a little gold was produced. Mining operations were interrupted, however, by a snowslide that destroyed bunk houses and part of the mill and assay office and entailed the loss of considerable time while repairs were made, so that only a small amount of underground development work was accomplished. The Lucky Strike mine is equipped with a 5-stamp mill.

The Willow Creek district, after the Alaska Juneau mine and Chichagof Island, made the largest production of lode gold in Alaska in 1925. Much the larger part of its output came from the Lucky Shot mine, on Craigie Creek, which was worked intensively. The War Baby, which in 1924 was the chief gold producer, was much below both the Lucky Shot and the Fern in 1925. The Fern Gold Mining Co.'s property, near the head of Archangel Creek, made a substantial production. This company recently acquired the adjoining Talkeetna mine. The Mabel mine, on the ridge west of lower Archangel Creek; the Gold Bullion, on the ridge south of Craigie Creek; and the property of Elder & Thorpe, on Grubstake Creek, each had a small production. The Elder & Thorpe property is of special interest in that it lies in an area of mica schist rather than in intrusive quartz diorite, like all the other gold mines of this vicinity.

There was a considerable falling off in the production of lode gold in the Fairbanks district in 1925, as compared with 1924. The largest output came from the Mohawk lode, sometimes called the Henderson mine, near the head of St. Patrick Creek, 10 miles west of Fairbanks. The ore body is a granular quartz vein from 1 to 5 feet thick, carrying a number of metallic sulphides including stibnite, arsenopyrite, galena, and sphalerite. The gold is mostly free, but a small proportion is contained in the sulphides and is lost in milling. The narrow parts of the vein are the richest, and the quartz near the stibnite pockets is of high grade, although the stibnite is not auriferous. Some of the assays show silver. The property is equipped with a Lane Chilean mill of 20-ton capacity with amalgamation under the rolls. It is fed from a jaw crusher.

A number of auriferous veins are known on the ridge west of St. Patrick Creek, and several of them are being prospected. A shaft 40 feet deep and a short drift on the First Chance claim expose a vein from 2 to 3 feet thick, of the same general character as the Mohawk, from which 43 tons of ore was taken for a mill test in 1925. A shaft 30 feet deep on the Blue Bird claim exposes a horse of mineralized schist 2 feet thick, with quartz veins 12 to 15 inches thick on the footwall side and 2 to 10 inches thick on the hanging wall. No assays or mill tests of this material have been made, but specimens of visible free gold indicate some high-grade ore. The Gem claim has several open cuts and a shaft 30 feet deep exposing a vein a few inches thick with considerable gangue along the footwall.

The Hi Yu group, of Crites & Feldman, on Moose Creek, tributary to Fairbanks Creek, continued to produce gold in 1925. Four adits with an aggregate length of over 4,200 feet have been driven, and a number of productive veins have been found. As the ground is extensively faulted, some trouble is experienced in keeping on the ore bodies. Four men are engaged in mining, and under favorable conditions about 300 tons of ore a month is put through the mill.

The old Rhoads-Hall mine, on Bedrock Creek, at the head of Cleary Creek, is being reopened by Gustafson Bros., under the name of the Cleary Hill mine. The workings of the old mine include an adit 840 feet long and two levels below, driven from a winze at the 70 and 120 foot levels. The mine is flooded, and a new adit 400 feet long at the 70-foot level is being driven. The Cleary Hill vein is an east-west (magnetic) vein dipping steeply south. Seven men are employed in mining and operating a 5-stamp mill.

About a quarter of a mile south of the Cleary Hill vein is the Wyoming vein, or Wackwitz property. The vein varies in thickness but reaches a maximum of 2 feet and is much crushed and faulted. It contains kidneys of stibnite, around which the gold mineralization is said to be good, and much scheelite, particularly at the margins of the vein and in the adjacent mineralized country rock. A new ball mill was installed in 1925 and was in operation for one month.

The Tolovana mine, on Willow Creek, the next tributary of Cleary Creek west of Bedrock Creek, was operated in a small way in 1925, principally by assessment work and prospecting.

The Kuskokwim Basin, in spite of its great extent, produced lode gold from only one locality—the Whelan mine, on the Nixon Fork, in the upper part of the basin. This property was formerly operated by the Alaska Treadwell Gold Mining Co. and since the withdrawal of that company has been operated by the original owners. The lode deposits are evidently connected with the intrusion of a mass of granitic rock and have given rise to the placer-gold deposits of this vicinity. A substantial production of lode gold is reported from the Whelan mine in 1925.

GOLD PLACERS

GENERAL FEATURES

Alaska's gold placers were probably the most important of its resources in first arousing a wide public interest in the Territory and attracting settlers to it. Placer mining is peculiarly the kind of mining that is most open to the man who has little or no capital aside from his own strength and the simple equipment required. For this reason the widely distributed gold-bearing gravels of Alaska attracted a horde of prospectors, who penetrated the remotest parts of the Territory and left few places of promise unvisited. Many widely separated localities have contributed and still contribute to the great sum of gold produced since the days of the Klondike rush. It is probable that the bonanza days, when every prospector held himself ready to take his place in the stampede to some newly discovered placer-gold field, are over. The steady decline in the production of placer gold since 1906 is due largely to the exhaustion of the richer, more easily mined gravels and the failure to find new fields of similar richness and extent. The pick and shovel are now in great measure replaced by machinery requiring the expenditure of large sums of money and the control of sufficient proved ground to attract capital by the possibility of a reward commensurate with the risk. Better transportation, more economical operation, improved methods of thawing frozen ground, and many other advances tend to stabilize the industry and give it the promise of long life through the possibility of mining gravel of lower gold content than could be handled in the past.

More than two-thirds of the total gold production of Alaska has come from the placers. The total production from this source to the end of 1925 was $239,909,944, of which $29,859,474 came from the dredges. The proportion of the total placer gold produced by dredges is thus about 12.5 per cent, though the present rate of production by the dredges is about 48 per cent of the annual placer gold recovered.

Statistics of placer mining in Alaska in 1924 and 1925

Region	Number of mines		Value of gold produced		
	1924	1925	1924	1925	Decrease or increase, 1925
Southeastern Alaska	4	5	$7,000	$5,000	−$2,000
Copper River region	9	15	130,000	144,200	+14,200
Cook Inlet and Susitna region	39	33	168,800	214,400	+45,600
Yukon Basin	374	348	1,740,500	1,564,600	−175,900
Kuskokwim region	25	21	268,700	191,400	−77,300
Seward Peninsula	84	78	1,245,000	1,088,500	−156,500
Kobuk region	5	8	4,000	14,900	+10,900
	540	508	3,564,000	3,223,000	−341,000

Silver, platinum, and tin ore (cassiterite) are also obtained from the gold placers and are noted in the tables of production of these metals.

The table of placer-gold production shows a considerable falling off from the output of the two preceding years, the production for 1925 being about 90 per cent of that in 1924. Among the regions of larger production, the Cook Inlet-Susitna River region shows an increase of 27 per cent over 1924, but Yukon River and Seward Peninsula show decreases of about 10 and 12 per cent, respectively. These decreases are less in proportion to total output than those in some other districts, but they result in a noticeable reduction in the total output of Alaska, as the districts are large producers. Some of the decrease in total output is due to dry weather in the early part of the season and to floods in the fall. The decrease in the Nome and Fairbanks districts, however, was not due wholly to weather conditions but to the fact that the companies which have recently acquired large holdings of placer ground through the consolidation of many smaller interests were making preparation for future operations and were not mining at full capacity. This was especially true at Fairbanks, where the Fairbanks Exploration Co. spent most of the season in stripping a large part of the valley of Goldstream Creek, drilling test holes to determine the gold content of the gravel, and building ditches.

Two of the large dredges in the Nome district were tied up while extensive experiments were being made to determine the most efficient method of thawing frozen ground in advance of dredging. Such operations are necessary but are only preliminary to the production of gold.

SOUTHEASTERN ALASKA

The output of placer gold from southeastern Alaska is small. Most of the gold comes from the creek gravel of Silver Bow Basin at Juneau and the beach gravel at Yakataga. These gravels have been mined for many years. In 1925 a small amount was taken out in the Porcupine district in the course of assessment work and the dead work preliminary to more extensive mining operations. A little gold is also mined on Shuk River, in the Windham Bay district, between Juneau and Petersburg, where, it is reported, drilling operations were to be carried on to test the gravel with a view to install a dredge. There was no placer mining on Lituya Bay in 1925.

COPPER RIVER REGION

Most of the placer gold mined in the Copper River Basin in 1925 was produced from the gravels of Dan and Chititu Creeks, in the Nizina district. The gold deposits of these two streams have been mined for more than 20 years and have yielded regularly, although the amount has varied considerably from year to year. On each stream the principal part of the production is due to the operations of a single mining company, but in addition to the output of these two companies a few thousand dollars in gold is produced by smaller operators on independent claims. The production of Chititu Creek for 1925 was much above the average, but that of Dan Creek was somewhat less, so that the district produced about the same amount of gold as for several years past.

The Chisna district was the second largest producer of the Copper River Basin. Full production by all claims in this district has never been maintained in recent years, owing to the lack of water or of dumping ground that could be used without covering the unmined gravel of other owners. In 1925, as in previous years, some claims were idle.

A few thousand dollars from the Nelchina district and a few hundred from deposits near Tiekel, on the Richardson Highway, make up the remaining placer-gold production of the Copper River Basin.

COOK INLET-SUSITNA BASIN

The Cook Inlet-Susitna Basin includes a number of placer-gold districts, one of which, the Yentna, is a large producer. Kenai Peninsula, Valdez Creek, and Willow Creek are the remaining districts, as the gold-bearing streams around Fairview Mountain are regarded as part of the Yentna district. In the Yentna district there was an abundance of water, and the weather allowed placer operations to continue later than usual. The dredge on Cache Creek had a highly successful season, and the smaller operators on other creeks helped to bring the total production of the district to about $195,000, a considerable increase over the production of 1924. Unusual interest was shown in the possibilities of the Fairview streams. The

Valdez Creek district made a small production and experienced a period of excitement over the discovery of gold outside the area of recent mining. The importance of the discovery has not yet been determined. The work of the Bureau of Public Roads in the Kenai district is of much benefit to the miners on Canyon and Sixmile Creeks. An interesting project of this district is the construction of a high dam on Canyon Creek to divert water from the creek for mining gravel in an old channel and to allow the gravel of the creek itself to be mined. Placer mining was done on Resurrection Creek near Hope and on Crow Creek north of Turnagain Arm.

YUKON BASIN

The Yukon Basin includes at least 16 widely separated placer-mining districts besides a number of lesser districts whose production is here included with that of larger districts in order that the output of individual operators may not be disclosed. The total production of placer gold from the basin for 1925 amounted to over $1,500,000 but was $175,900 less than the production of 1924. The collection of statistics for several of the largest producing areas of the region has proved particularly difficult, through failure to get returns of production from a large number of operators. This is especially true of the Fairbanks district, where the consolidation of individual properties has complicated the mailing lists and made it difficult to ascertain which of the former producers were mining independently and which had disposed of their interests.

The following table gives the production by districts for 1924 and 1925. For districts from which only incomplete individual reports were obtained it was necessary to make estimates based on whatever other information was available. There are undoubtedly errors in the figures given for some districts, but it is believed that to a certain degree these errors compensate one another, so that the figures for total production are fairly accurate.

Placer gold produced in Yukon Basin, 1924 and 1925, by districts

District	Value of gold		Number of mines	
	1924	1925	1924	1925
Fairbanks and Richardson	$680,400	$520,800	74	58
Iditarod	207,100	223,100	21	17
Tolovana	189,500	194,100	20	19
Innoko (including Tolstoi district)	161,200	167,500	19	16
Circle	90,200	149,600	26	35
Ruby	84,600	39,900	32	24
Hot Springs	83,400	73,200	22	19
Fortymile	31,800	39,800	51	58
Chandalar	17,900	8,000	6	4
Koyukuk (including Indian River district)	54,000	49,800	27	30
Chisana	23,400	24,000	8	6
Eagle	49,800	35,000	19	12
Rampart (including Gold Hill district)	16,000	8,000	8	7
Bonnifield	12,500	10,000	13	14
Kantishna	18,800	11,900	18	17
Marshall	19,900	9,900	10	12
	1,740,500	1,564,600	374	348

The table shows a reduction in the output of several of the larger districts, including the Fairbanks, Ruby, and Hot Springs and an increase from the Iditarod, Innoko, and Circle districts. Practically all the other districts show some decrease.

The Fairbanks district, which includes Cleary, Goldstream, Ester, Fairbanks, Dome, Vault, and other gold-producing creeks in the vicinity of the town of Fairbanks, continues to be the most productive district within the Alaska part of the Yukon drainage basin. The outstanding development in connection with placer-mining operations in this district is the progress made by the Fairbanks Exploration Co. in preparing its holdings of gold-bearing gravel for mining. This work involves the construction of dredges and an extensive system of ditch lines to provide water for sluicing and will require several years for its completion. In 1925 a large amount of drilling to determine the extent and value of placer gravel on different streams, especially Ester, Cleary, Fairbanks, and Goldstream Creeks, was done, buildings were erected at Fairbanks and Chatanika, and some ditch line was dug on Chatanika River and Cleary and Goldstream Creeks. A resurvey of the Davidson ditch was made. This ditch, which is one of the most important projects connected with the enterprise, is nearly 80 miles long and brings water from Chatanika River near its head to Cleary, Goldstream, and other creeks. One result of the work of the Fairbanks Exploration Co. is to close a considerable number of small mining plants and thus reduce the number of mining operators in the district. About 19 summer drift mines were in operation, principally on Little Eldorado and Fairbanks Creeks. When these preparations are completed much of the gold-placer ground of the Fairbanks district will be ready to be mined under the most efficient methods that abundant capital and years of experience in the handling of frozen gold-bearing gravel in an Arctic country can provide. It is evident that the success of these operations means the addition of many years to the productive life of the Fairbanks placers.

Mining operations in the Fairbanks district are being facilitated by the activities of the Alaska Road Commission in the construction of highways and the lessening of transportation costs. It is expected that eventually Fairbanks will be connected by an automobile road with Circle, on the Yukon.

In the Bonnifield district the Alaska Road Commission constructed about 11 miles of road between Ferry and Eva Creek. There was little placer-mining activity in this district.

Shortage of water resulted in a reduced output of gold in the Hot Springs district. Some of the placers of this district produce stream tin as a by-product of the mining of gold.

Placer mining in the Chandalar district was carried on about as in other recent years. The miners in this district work under the disadvantage of especially high costs for labor and supplies, so that it is said the ground must contain not less than $2 in gold to the square foot of bedrock for profitable mining.

The Circle district had a long favorable season with a resulting large increase in gold production. The Berry dredge on Mastodon Creek did not shut down till October 24. There was abundant water for mining in the Eagle district, especially in the later part of the season. The remarkably high water in the Yukon in the spring did little damage at Eagle.

The Fortymile district increased its gold output considerably above that of 1924. The Ingle Creek Gold Co., operating on and near Mosquito Fork, carried on an extensive drilling campaign preliminary to expanded future operations. This company is also operating the Dome property in the Eagle district. The Walker Fork Gold Corporation completed the installation of a new hydraulic plant, including over 2 miles of ditches and flumes and nearly a mile of hydraulic steel pipe. Extensive damage was done on lower Fortymile River by the high water of spring.

Shortage of water interfered greatly with some of the placer-mining operations in the Iditarod district. Transportation of freight on the river was delayed, water was lacking for sluicing, and some operators had to lay off men. Two dredges were operated in the Otter Creek section. About 11 miles of ditch line was constructed to bring water from upper Bonanza Creek to Willow Creek.

The Innoko district had a long season of fine weather but a shortage of water from the middle of June till early August. A new dredge built by the Flume Dredge Co. on Little Creek was put into operation and did not close down till late in October. Excellent progress was made by the Alaska Road Commission in constructing a road from Takotna to Ophir. About 15 miles of this road is now completed for automobile traffic.

The Kantishna district made a small production of placer gold. Considerable interest was aroused in the later part of the year by the discovery of coarse gold on a tributary of the Kantishna.

A dry season resulted in decreased production in the Koyukuk district. This is an old camp, and little in the way of new development took place in 1925, although it is reported that an English company took over a large number of claims on Hammond River and intended to begin developing them in 1926. Prospects were found on a new creek near Wild River Lake during the summer of 1925, which were encouraging enough to justify further work during the following winter.

The Marshall district showed a considerable falling off in production in 1925, although the weather was favorable all the season.

There was an acute shortage of water in the Rampart district and a reduction in output. The lack of water was such that some miners were unable to clean bedrock and were obliged to let the ground lie over till the next season.

The production of the Ruby district was much reduced, and there was less mining activity than usual.

Operators in the Tolovana district were seriously handicapped by lack of water at times, yet the season's work was fairly satisfactory. Hydraulic mining was conducted on Olive, Lillian, and Ruth Creeks and Livengood bench, where three drift mines also were in operation.

KUSKOKWIM REGION

The production of placer gold in the Kuskokwim Basin, including streams tributary to Kuskokwim Bay, in 1925 amounted to $191,400. This sum includes the dredge gold and was produced in four widely separated districts, distributed from the head of the river to its mouth. Two of these districts, the Mount McKinley and Georgetown, are on the north side of the Kuskokwim, adjacent to the Innoko and Iditarod districts of the Yukon Basin, and except for the accidents of drainage development might be included with them. Of the remaining two, the Tuluksak-Aniak district is southeast of the lower river, and the Goodnews Bay district lies still farther south, on the east side of Kuskokwim Bay. The nearness of these districts to the deep navigable waters of Kuskokwim Bay and River makes them relatively easy to reach during the open season, although travel within the districts is often difficult. On the other hand, the great area drained by the eastern tributaries of the Kuskokwim is difficult of access and has probably been less prospected than any other equal area of Alaska south of the Brooks Range. Except along the coast where missions or canneries have been established and at the few places where mining is in progress, the whole of this region is practically without white inhabitants.

Much the larger part of the placer gold from Kuskokwim Valley was mined by the dredge on Candle Creek near McGrath. After that the largest production came from the creeks of the so-called Nixon Fork district, which includes streams in the vicinity of the Whelan mine, north of Berry's landing on Kuskokwim River. The Georgetown district had a small production. In the Tuluksak-Aniak district there was a shortage of water and a general falling off in mining. Cripple Creek and Marvel Creek were both idle. Construction of a dredge on Bear Creek was begun by the New York-Alaska Gold Dredging Co. This dredge was not completed in 1925 but was expected to be ready for operation in June, 1926. The ground for dredging had been thoroughly tested by drilling, and the success of the project was believed to be assured. Placer mining in the Goodnews Bay district was retarded by a shortage of water and labor, and only a few claims were worked. Butte Creek was reported to be idle, and little prospecting was going on.

SEWARD PENINSULA

Seward Peninsula is remarkable for the wide distribution of gold in its gravel deposits. There is scarcely a stream from which colors have not been obtained, and although the gold was not always found in sufficient amount to afford profitable mining, the number of streams that have yielded gold in commercial quantities is large. Furthermore, the gold-bearing beach gravels, including those of the present wave-washed beaches and the numerous ancient beaches deeply buried beneath more recent deposits, afforded some of the most notable gold placers ever discovered and still contribute to the output of the peninsula. The Nome district, although not the first gold-placer district known in Alaska, was the first of the greater and more famous placer districts to be discovered.

The first mining at Nome was done with simple equipment. This, however, was soon replaced by more efficient and economical machinery, and early in the history of the district the dredge was introduced to dig and wash gravel. The early dredges were small, crude, and inadequate and have long since been replaced by others of more powerful and costly types, capable of withstanding the great strains to which they are subjected and able to handle great quantities of gravel at low cost. The use of dredges increased as the richer gravel was mined out, so that now several times as much gold is obtained with the dredges as with other methods of mining. Each year sees the construction of new dredges or preparations for installing them, so that a description of placer mining in this district has become largely an account of dredging operations.

The early placer miners of the Yukon Valley and of Seward Peninsula found in the frozen gravel of the Arctic and sub-Arctic regions a problem which was new even to the most experienced miners from the Western States. Various methods, from exposure to the sun and direct contact with fire to steam applied through pipes driven into the ground, were used to thaw the ice and loosen the sand and gravel so that they could be washed through the sluice boxes to free and collect the gold. Recently experiments have been conducted to test the value of water at normal atmospheric temperature for thawing frozen ground. Such experiments were carried on at Nome by the United States Smelting, Refining & Mining Co. in 1925. Details of the operations are not at hand, but it appears that for deep ground the most successful method is to drill to bedrock and insert a pipe down which cold water is forced under pressure, rather than to drive the pipe as is usually done in steam thawing. The process is slow, but it is reported that gravel from 40 to 70 feet thick has been successfully thawed in this manner.

The work of the Alaska Road Commission is highly commended in some of the schedules returned by placer miners, and as instances of the things accomplished are cited the reconstruction of the tramway from Nome to Shelton, the maintenance of roads in the vicinity of Nome, grading of the aviation field, and construction work in Nome Harbor.

The last regular passenger boat for the season left Nome for Seattle on October 25. The fall was an open one, with no snow and little frost. Plenty of water during the summer season is reported.

The placer-gold production of Seward Peninsula showed a decided falling off in 1925. The output was $1,088,000, as compared with $1,245,000 in 1924, a decrease of $156,500, or over 12½ per cent. This reduction was due in large part to the fact that a number of dredges did not begin operations till late in the season and some that operated in 1924 were not working in 1925.

Most of the gold from Seward Peninsula is obtained from the vicinity of Nome, but many other localities contribute to the total, and in most of them, as at Nome, a dredge either has been installed or is contemplated as a means of reducing the cost of mining.

It was reported that a large tract of placer ground on American Creek, in the Casadepaga district, was under option and would be drilled with a view to installing a dredge.

In the Council district the property of the Wild Goose Mining & Trading Co. was idle. The dredge and hydraulic plant were sold to other operators and will be active again in 1926.

Little change is noted in the Solomon district. It is reported that a mining engineer was engaged during the summer in testing the gravel on upper Big Hurrah Creek, and as a result of his examination a dredge for handling the gravel is under consideration.

The Koyuk district, at the head of Norton Bay, although one of the smaller gold producers of the peninsula, is of special interest as it is the chief producer of placer platinum in Alaska. Three mines were in operation in winter and nine in summer in this district.

The Fairhaven district includes Inmachuk River and Candle Creek together with their tributaries and some other streams. This district experienced a dry season with little rain until September. The two dredges on Candle Creek, operated by the Fairhaven Gold Dredging Co., were working part of the season. Water is provided by a ditch line 37 miles long and is used to strip away the overburden before dredging begins. An interesting project of the Inmachuk River locality is the search for gold-bearing gravel beneath the geologically recent lava flows that were poured out over the gravel deposits and later partly removed by erosion. Remnants of these flows are conspicuous in the Fairhaven district. Shafts have been sunk through the lava beds on the Inmachuk to depths of 130 to 200 feet, disclosing gravel deposits from 6 to 16 feet thick. Drifting from these shafts has not yet disclosed a pay streak, but colors are reported. A small output of gold was made from Kugruk River and also from Koopuk Creek, tributary to Buckland River. The Koopuk district has small and uncertain rainfall. Prospecting has been done on Buckland River for many years, but thus far with only indifferent success. The miners of the Fairhaven district are interested in the contemplated extension of the Nome-Shelton tramway to Candle Creek, which is proposed to improve the transportation of coal from the Chicago Creek mine and help reduce the cost of fuel. The Chicago Creek coal is a lignite and is less efficient than higher-grade coals shipped from the outside, but as it costs less it has been used to some extent in place of the better coal.

The placer gold produced in the Kougarok district is obtained partly by dredges and partly by other methods of mining. Only one dredge, however, was in operation in 1925, that of the Behring Dredging Corporation on Kougarok River. The Kelliher dredge did not operate, as the company was undergoing reorganization. On Dick Creek a mechanical tailings stacker driven by a gasoline engine was installed and is reported to be giving satisfaction. The use of gasoline for power releases a part of the water for piping, which is an advantage where water is scarce. A ditch line was built on Henry Creek to furnish water for use on Merritt Gulch in 1926. The miners of the Kougarok district are also interested in the extension of the tramway from Nome as a means of reducing mining costs, which in some localities are reported to be so high as to prohibit mining.

Port Clarence is one of the minor districts of Seward Peninsula and had a small production in 1925. Considerable prospecting was done on Coyote Creek, and a ditch line 1½ miles long was built preparatory to mining in 1926.

Preparations were made to install two dredges on Bluestone River in 1926. Both of the dredges are old, one reconstructed and one moved from another locality.

KOBUK REGION

The placer gold of the Kobuk region comes from two districts—the vicinity of Shungnak, on the middle course of Kobuk River, and the valley of Squirrel River, a tributary of the lower Kobuk. Shungnak is nearly 150 miles in an air line from Kotzebue Sound, but the distance is much greater along the winding river. Kiana, at the mouth of Squirrel River, is about 50 miles from the sound. The production in both these districts is small. Prospecting was done in the Kobuk region before the discovery of gold at Nome, but the region is difficult of access, and the cost of mining there is high. It seems probable that the possibilities of this region have not yet been fully realized.

Most of the gold from the Shungnak district comes from California and Dahl Creeks, although Lynx Creek and Shungnak River contribute some. Hydraulic plants have been installed on California and Dahl Creeks, replacing the pick and shovel. The gravel in many places is not frozen, and there is difficulty with seepage water. Moreover, the overburden is chiefly gravel with little muck, so that machinery capable of handling large yardage is required rather than hand methods of mining. The equipment of the Ferguson property, on California Creek, includes 2 miles of ditch, a long pipe line, three giants, and an elevator. The plant on Dahl Creek encountered some poor ground in 1925 and was delayed by dead work, so that only a small production was made. Two floods during the summer did much damage to the placer mines of the Shungnak district, causing delay and adding to the expense of mining.

Klery Creek is the principal producer of the Squirrel River district. Only a few men are employed, and the gold production is less than that of the Shungnak district. A nugget valued at nearly $100 was taken from Klery Creek during the summer. Coarse gold is characteristic of both the Squirrel River and Shungnak districts.

DREDGING

Reference to the dredges has been made in the foregoing comments on placer-mining districts, but the importance which they have attained in the production of placer gold in Alaska and their probable future still greater importance makes a special discussion of them desirable. Alaska possesses large amounts of gold-bearing gravel which does not contain sufficient gold to make mining by the older, simpler, and more costly methods of mining profitable. Where the general conditions, such as location, character, depth of gravel, and water supply, are favorable and where tracts of auriferous gravel of sufficient extent to justify the large initial cost of installation can be controlled, dredging has proved to be one of the most economical and effective methods of placer mining. One of the obstacles to dredging in Alaska has already been pointed out. The frozen condition of much of the gravel adds an item of expense which is not met in regions of warmer climate. Steam and hot water have been used to thaw the frozen gravel before dredging, but within the last few years increasing attention has been paid to the use of cold water for this purpose, and favorable results have been obtained. Although somewhat slower, the cold-water method does away with the need for fuel to heat water and thereby reduces the operating cost. It now seems certain that as more and more of the higher-grade gravel becomes exhausted the use of this method of mining will be much extended, especially as improvements in transportation and methods of application continue to be made.

Reports of dredging operations for 1925 were furnished by owners or operators of 20 dredges, and information concerning others was obtained from different sources. Apparently 27 dredges were active, although several of them had short seasons due to delay in starting or interruptions from various causes. Of this number 16 were on Seward Peninsula, 3 in the Fairbanks district, 3 in the Innoko district, 2 in the Iditarod district, and 1 each in the Yentna, Circle, and Mount McKinley districts. A list of the operating dredges follows:

Seward Peninsula:	
Casadepaga district—	
Peck	Casadepaga River.
Council district—	
Northern Light Mining Co	Ophir Creek.
Mebes & Hansen	Albion Creek.
Fairhaven district—	
Fairhaven Gold Dredging Co. (2)	Candle Creek.
Kougarok district—	
Behring Dredging Corporation	Kougarok River.
Koyuk district—	
Dime Creek Dredging Co	Dime Creek.
Nome district—	
Dexter Creek Dredging Co	Dexter Creek.
Dry Creek Dredging Co	Dry Creek.
Hammon Consolidated Gold Fields	Wonder Creek.
Hammon Consolidated Gold Fields (3)	On or near Little Creek.

Seward Peninsula—Continued.
Solomon district—
Iversen & Johnson........................ Big Hurrah Creek.
Lomen Reindeer & Trading Corporation..... Solomon River.
Shovel Creek Dredge Co................... Shovel Creek.
Yukon Basin:
Circle district—
C. J. Berry Dredging Co.................. Mastodon Creek.
Fairbanks district—
Chatham Gold Dredging Co................. Cleary Creek.
Fairbanks Gold Dredging Co. (2).......... Fairbanks Creek.
Iditarod district—
North American Dredge Co................. Otter Creek.
J. E. Riley Investment Co................ Otter Creek.
Innoko district—
Flume Dredge Co.......................... Yankee Creek.
Flume Dredge Co.......................... Little Creek.
Guinan & Ames Dredging Corporation....... Ganes Creek.
Kuskokwim region:
Mount McKinley district—
Kuskokwim Dredging Co.................... Candle Creek.
Cook Inlet and Susitna region:
Yentna district—
Cache Creek Dredging Co.................. Cache Creek.

One new dredge appears on this list, that of the Flume Dredge Co., on Little Creek, in the Innoko district, but several that appeared in the lists of former years are absent. Most of the changes are on Seward Pensinsula.

The dredges of Alaska produced $1,572,312 in 1925, or more than 48 per cent of the total output of placer gold from the Territory. The production is a slight increase over that of 1924, which was $1,563,361. The following table gives statistics for the period since dredging began in 1903:

Gold produced by dredge mining in Alaska, 1903–1925

Year	Number of dredges operated	Value of gold output	Gravel handled (cubic yards)	Value of gold recovered per cubic yard
1903–1915		$12,431,000		
1916	34	2,679,000	3,900,000	$0.69
1917	36	2,500,000	3,700,000	.68
1918	28	1,425,000	2,490,000	.57
1919	28	1,360,000	1,760,000	.77
1920	22	1,129,932	1,633,861	.69
1921	24	1,582,520	2,799,519	.57
1922	23	1,767,753	3,186,343	.55
1923	25	1,848,596	4,645,053	.40
1924	27	1,563,361	[a] 4,342,667	[a] .36
1925	27	1,572,312	[a] 3,144,624	[a] .50
		29,859,474		

[a] See text (p. 26) for basis of estimate.

The maximum number of dredges in operation in any one year was 36, in 1917. A decided falling off in both total production and number of dredges operating took place in 1918 and continued to 1920, but since then the trend of each item has been upward.

The average length of operating season in 1925 for those dredges which furnished the data was 96 days, but this figure does not represent the length of season in which dredging was possible, as a number of dredges had short seasons due to causes other than weather conditions. The greatest number of operating days reported by any single dredge was 163 days, for the North American dredge on Otter Creek, in the Iditarod district. The J. C. Riley Investment Co.'s dredge and the Cache Creek dredge, in the Cook Inlet-Susitna region, were each operated 153 days. The earliest date on which any dredge worked was in May on Cache Creek, and the latest date November 17 on the Iditarod.

In the foregoing table are given data on the number of cubic yards of gravel handled by the dredges each year and the value of the gold recovered per cubic yard. This table is valuable in the consideration of Alaska's gold resources but is incomplete and of lessened value in so far as operators fail to make returns covering the item of yardage. The information furnished to the Geological Survey by owners or operators of dredges in 1925 includes figures relating to this item of operation for 15 dredges. These 15 dredges, which represent nearly all the districts where dredging is carried on, handled 2,141,165 cubic yards of gravel in 1925 and recovered an average of 50 cents in gold to the cubic yard. On the assumption that 50 cents represents the average gold content of the gravel handled by all Alaskan dredges, the total yardage may be estimated as 3,144,624 cubic yards. This method of estimating was employed in preparing the corresponding table for 1924,[4] and, as explained there, it may involve the use of a figure for value per cubic yard which is a little too small and result in an estimate of total yardage which is correspondingly too high.

Two new dredges were installed in 1925. The Flume Dredge Co. built and put into operation a dredge on Little Creek, in the Innoko district. The Tanana Valley Gold Dredging Co. (Ltd.) launched a dredge on Fish Creek, in the Fairbanks district, but did not complete the installation of the machinery in time to produce gold in 1925. In the Kuskokwim Valley the New York-Alaska Gold Dredging Co. began the construction of a dredge on Bear Creek, in the Tuluksak-Aniak district. This dredge was expected to begin operation in 1926. In addition to these new dredges a number of old dredges were being reconstructed or moved to new dredging ground, and several other dredges were planned for building in 1926. It is reported that in nearly every locality where a new dredge is planned

[4] U. S. Geol. Survey Bull. 783, p. 19, 1925.

the ground has been thoroughly prospected by drilling or otherwise to determine the gold content of the gravel before construction of the dredge has been begun. Such a procedure, although it has sometimes been neglected, represents the exercise of good business sense and will do much to prevent failure and establish confidence among those who are asked to invest their money in dredging enterprises.

COPPER

Copper in quantities sufficient to be of economic value is not so widely distributed in Alaska as gold, but deposits of copper-bearing minerals are known in many places, and some of those which now attract little or no attention will probably become important when transportation is better or the price of copper is sufficiently high. Meantime only those deposits that are especially rich or are most favorably situated with reference to transportation facilities can be exploited with profit. Notwithstanding this fact, Alaska has a considerable copper production.

The total Alaskan production of copper for 1925 was 73,855,298 pounds, valued at $10,361,336. This includes copper from mines that are operated primarily for copper and that from mines where some other metal constitutes the chief product of value. Most of this copper came from the mines of the Kennecott Copper Corporation, including the Mother Lode mine, at Kennecott, in the Chitina Valley, and at Latouche, on Latouche Island, in Prince William Sound. The next largest producer of copper is the Saltchuck mine of the Alaska Palladium Co., near Ketchikan, in southeastern Alaska, and after that the Green Butte mine, on McCarthy Creek near Kennecott. In addition, copper is produced from ores whose principal content is lead and is recovered from the gold placers of Dan and Chititu Creeks, in the Nizina district of Chitina Valley. A small amount was obtained also from gold lodes in the Juneau, Ketchikan, and Sitka districts.

Copper, silver, and gold produced at Alaska copper mines, 1900–1925

Year	Mines operated [a]	Ore mined (tons)	Copper [b]		Silver		Gold	Total value of metals
			Pounds	Value	Fine ounces	Value		
1900-1915	-------	1,232,396	220,773,969	$35,031,225	2,351,726	$1,297,756	$1,059,357	$37,388,338
1916	18	617,264	119,654,839	29,484,291	1,207,121	794,286	188,977	30,467,554
1917	17	659,957	88,793,400	24,240,598	1,041,153	857,911	265,900	25,364,409
1918	17	722,047	69,224,951	17,098,563	719,391	719,391	107,635	17,925,589
1919	8	492,644	47,220,771	8,783,063	488,034	546,598	63,795	9,393,456
1920	8	766,095	70,435,363	12,960,106	682,033	743,416	18,868	13,722,390
1921	6	477,121	57,011,597	7,354,496	544,311	544,311	11,689	7,910,496
1922	5	581,384	77,967,819	10,525,655	623,518	623,518	15,069	11,164,242
1923	6	731,168	85,920,645	12,630,335	715,040	586,333	33,633	13,250,301
1924	5	761,779	74,074,207	9,703,721	572,078	383,292	13,341	10,100,354
1925	5	860,023	73,855,298	10,361,336	596,607	412,131	32,778	10,506,245
	-------	7,901,878	984,932,859	178,173,389	9,541,012	7,508,943	1,811,042	187,493,374

[a] Properties producing less than $1,000 are not counted as mines but are considered prospects.
[b] Includes also slight amount from other sources.

The table shows a decrease of 218,909 pounds of copper for 1925, compared with the production of 1924, but an increase in value amounting to $657,615, due entirely to the higher price received for copper in 1925. The figures given for the value are based almost wholly on the actual selling price of the Alaska copper and not on the average price of copper (14.2 cents) throughout the United States for the year. A cargo of copper ore from Latouche which was salvaged from the motor boat *Kennecott* in 1925 is not included in the table, as that production was included in a previous report.

The ore shipped from Kennecott to the smelter is taken from four contiguous mines—the Bonanza, Jumbo, Erie, and Mother Lode, which are all operated under one management, although the Mother Lode is organized as a separate company. As shown by the annual statements [5] made to the stockholders, the Mother Lode mine produced somewhat more ore in 1925 than any one of the other associated mines. From the same source it is learned that the ore mined from the Mother Lode amounted to 156,309 tons, averaging 10.38 per cent of copper and 1.68 ounces of silver to the ton. The ore from Kennecott is largely high-grade copper sulphide and carbonate containing silver but practically no gold.

The mine of the Kennecott Copper Corporation at Latouche produces low-grade copper-iron sulphide ore of a character wholly different from that at Kennecott. A caving system of mining is used, and a steady output at low cost has been maintained for a number of years. No high-grade ore is obtained.

Mining operations at the Green Butte mine, on McCarthy Creek, a few miles east of Kennecott, are regarded as prospecting or development work, but a large force of men are employed, and regular shipments of high-grade ore are made to the smelter. The ore resembles that at Kennecott and occurs in similar relation to the limestone and underlying greenstone. Mining was discontinued during part of the winter of 1924–25 but was resumed in May. The incline has now reached the 700-foot level, and it was reported that development work would be discontinued in the winter of 1925–26, while more powerful machinery was being installed.

Copper is obtained from the Saltchuck mine, on Kasaan Bay, Prince of Wales Island, as an associate of the platinum group of metals, particularly palladium, which makes up the chief product of the mine. Originally this deposit was opened for its copper, but it was later found that the copper is subordinate in value to the palladium, although copper is an abundant constituent of the ore and makes up a considerable part of its value.

The copper obtained from lead ores is relatively small in quantity and comes chiefly from the Hyder district, in southeastern Alaska.

[5] Kennecott Copper Corporation Eleventh Ann. Rept., for 1925; Mother Lode Coalition Mines Co. Seventh Ann. Rept., for 1925.

A little copper is also obtained from the sluice boxes of placer mines on Dan and Chititu Creeks. Formerly it was thrown away, and only in recent years, after the construction of the Copper River & Northwestern Railway made transportation easier, has it been saved. A little copper is obtained from gold lodes in southeastern Alaska, and a further small quantity is reported by the smelters as scrap and salvage.

Prospecting for copper has not been encouraged by the price of the metal during the last few years. Many copper prospects in southeastern Alaska, the Copper River Valley, and Prince William Sound have been patented or have had no work done on them other than the assessment work necessary to hold them, and there seems to be no reason to expect any large addition to the copper production in the near future.

SILVER AND LEAD

Most of the silver produced in Alaska has been associated either with gold in gold lodes and placers or with copper in copper mines and was, in fact, a by-product. Most of the lead was derived from lodes that were mined primarily for the gold they contained. This condition was changed somewhat in 1925, for an increasing amount of silver and lead now comes from mines in which these two metals are the most valuable product. The following table shows the quantity and value of silver and lead recovered from mining operations classified according to the most valuable metal produced:

Silver and lead produced in Alaska in 1925

Source	Silver		Lead	
	Ounces	Value	Pounds	Value
Gold lodes	67, 186	$46, 445	1, 298, 256	$116, 243
Gold placers:				
Dredges	11, 728	8, 139		
Others	12, 416	8, 617		
Silver-lead lodes	10, 322	7, 163	279, 645	24, 328
Copper lodes	596, 607	412, 131		
	698, 259	482, 495	1, 577, 901	140, 571

In this table for the first time are listed silver and lead from silver-lead lodes. The silver from gold lodes was produced by 20 mines and a few prospects, that from gold placers by about 506 mines, and that from copper lodes by 5 mines. Lead from lodes other than lead-silver lodes was produced by 5 mines. Silver and lead were produced from 5 mines where they are the chief valuable metals. Much the greater part of the silver produced in Alaska comes from copper mines. Most of the lead is taken from the gold mines of the Alaska

Juneau Gold Mining Co. at Juneau, which, as will be seen from the table on page 9, compiled from the annual report of the company to its stockholders, yielded 1,288,974 pounds in 1925.

Lead produced in Alaska, 1892–1925

Year	Tons	Value	Year	Tons	Value	Year	Tons	Value
1892	30	$2,400	1904	30	$2,580	1916	820	$113,160
1893	40	3,040	1905	30	2,620	1917	852	146,584
1894	35	2,310	1906	30	3,420	1918	564	80,088
1895	20	1,320	1907	30	3,180	1919	687	72,822
1896	30	1,800	1908	40	3,360	1920	875	140,000
1897	30	2,160	1909	69	5,934	1921	759	68,279
1898	30	2,240	1910	75	6,600	1922	377	41,477
1899	35	3,150	1911	51	4,590	1923	410	57,400
1900	40	3,440	1912	45	4,050	1924	631	100,899
1901	40	3,440	1913	6	528	1925	789	140,571
1902	30	2,460	1914	28	1,344			
1903	30	2,520	1915	437	41,118		8,025	1,070,884

Silver-lead ores are attracting attention in several parts of Alaska. The most prominent district is that around Hyder, at the head of Portland Canal, in southeastern Alaska. Other districts include mines or prospects at Chomly, near Ketchikan; the Lake claims, near Wrangell; a new silver-lead prospect near Skagway; and the Alpha mine, in the Kantishna district.

In the Hyder district the new mill at the Riverside mine began production early in the year and made a run of about two months, producing a galena concentrate carrying silver and gold. The property then lay idle for several months pending arrangements for its operation by a new company, but a small additional production was made in the later part of the year. In the Texas Creek area a test shipment of 10 tons of lead ore, with some silver and gold, was made by Carlson & Hewitt from the Homestake prospect to the smelter at Selby. A test shipment of 1 ton of complex silver-lead-zinc-copper ore was made by Hummel, Blasher & Moss from a newly discovered deposit on the south branch of Chickamin Glacier. McDonald & Cronholm shipped a test lot of 20 tons of high-grade lead ore carrying gold and silver from another newly discovered deposit, on the Cantu group, near the foot of Salmon Glacier.

Native gold is associated with the lead ore in several veins in the district, and some exceedingly rich specimens of free gold were found in connection with narrow quartz stringers in a rock cut for the new portion of the Salmon River road near Sixmile. It is probable that with more extensive development native gold will be found in other veins already discovered. Exploration was continued on the Daly Alaska property, and a little native silver was found. Development work is being vigorously prosecuted on the Mountain View property under the direction of Arthur Moe. A small shoot with a considerable percentage of the tungsten mineral scheelite, identified by A. F. Buddington, was discovered in a vein on this property. Grains of scheelite were later noted in other veins. Assessment work was kept up on practically all the other properties in the district, and several new prospects were located in the Texas Creek area. A prospecting tunnel is being driven across a sparsely metallized band in a limestone and schist belt within the coast range batholith on the Commonwealth group of claims, about 13 miles down Portland Canal from Hyder.

A recent geologic survey of the Hyder district by Buddington[6] has shown that there are present near Hyder two batholiths that differ in age and in significance with respect to ore deposits. Metalliferous veins have been found in the rock of the older batholith, but as yet no mineral deposits of commercial importance have been found in the younger batholith. The older batholith consists of granodiorite and is widely exposed on Texas Creek. The rock of the younger batholith along the southern border of the older batholith and in the vicinity of Hyder is quartz monzonite and in the vicinity of Munro Glacier is granodiorite. The older granodiorite has a dull gray color and a slightly banded structure, thus contrasting with the pink or mottled white, more massive rock of the quartz monzonite and the granodiorite near Munro Glacier. Dikes of granodiorite porphyry connected with the quartz monzonite and the granodiorite of Munro Glacier cut both the older granodiorite and the ore veins connected with it. The southern portion of the older granodiorite near the contact with the quartz monzonite is mashed and rendered schistose through the thrust exerted upon it by the intrusion of the younger batholith. The southern boundary of the older granodiorite lies at an elevation of about 4,800 feet on the southern slope of Mount Dolly and extends in general a little north of true west, crossing Salmon River just below the mouth of Fish Creek and thence passing through the head of Thumb Creek and the head of the West Fork of Texas Creek. On the West Fork of Texas Creek, west of Casey Glacier and Ibex Creek, the older granodiorite plunges under a roof of tuffaceous graywacke and slate, disappearing beneath the surface at the head of the West Fork, with the exception of several upward bulges that are exposed where the Texas Glacier joins the Chickamin Glacier and both north and west of the locality where the Chickamin Glacier makes a turn from north to west. Quartz veins with shoots of lead ore, carrying moderate quantities of silver and low to moderate quantities of gold, are found within the batholith and also in the adjoining or overlying country rock, but commonly near the contact between the two. Veins also occur, however, within the older granodiorite at considerable distance from

[6] Buddington, A. F., Geology of the Salmon River area, Hyder district, Alaska (in preparation).

the contact with the sediments. Nearly 50 veins of the type described have been discovered in the older granodiorite and are being prospected.

TIN

Stream tin or cassiterite has been found in the concentrates from the sluice boxes of gold placers in several parts of Alaska. Tin has been mined from its original bedrock source in the Port Clarence district of Seward Peninsula and is recovered from placer deposits in that district and also from placer deposits near Tofty, in the Hot Springs district of Tanana Valley. These two districts are at present the source of all the tin reported from Alaska. Placer mining has been carried on primarily for tin in the Port Clarence district, but in the Hot Springs district the mining is done primarily for gold and tin is a by-product.

The production of tin ore for 1925 was 22.2 tons, which contained 13.8 tons of metallic tin, valued at $15,980. This production is an increase over that of 1924, which in turn was an increase over that of 1923, but it is considerably less than the production for the years 1912 to 1917, when the output of metallic tin reached 139 tons in 1916 and fell below 100 tons only in 1913.

Tin produced in Alaska, 1902–1925

Year	Ore (tons)	Metal (tons)	Value	Year	Ore (tons)	Metal (tons)	Value
1902	25	15	$8,000	1915	167	102	$78,846
1903	41	25	14,000	1916	232	139	121,000
1904	23	14	8,000	1917	171	100	123,300
1905	10	6	4,000	1918	104.5	68	118,000
1906	57	34	38,640	1919	86	56	73,400
1907	37.5	22	16,752	1920	26	16	16,112
1908	42.5	25	15,180	1921	7	4	2,400
1909	19	11	7,638	1922	2.3	1.4	912
1910	16.5	10	8,335	1923	3	1.9	1,623
1911	92.5	61	52,798	1924	11	7	7,028
1912	194	130	119,600	1925	22.2	13.8	15,980
1913	98	50	44,103				
1914	157.5	104	66,560		1,645.5	1,016.1	962,207

The tin credited to the Port Clarence district in 1925 is reported as having been shipped in that year. It seems probable that some of this tin was mined in 1924 and held over till 1925 for shipment, as there is reason for believing that less tin was mined than was shipped.

PLATINUM METALS

Platinum and palladium belong to a group of six metals of which platinum is the most important and consequently gives its name to the group. These metals commonly occur together, so that where one member of the group is found one or more of the others may be expected. Most of the platinum of Alaska is obtained from one lode mine and from several widely separated placer mines where it is associated in subordinate amount with gold. Platinum was long practically unknown and almost unsuspected in Alaska, but the experience of recent years has shown it to be widely distributed, although for the most part in small amount.

The principal producer of platinum metals in Alaska is the Saltchuck mine of the Alaska Palladium Co., on Kasaan Peninsula near Ketchikan. Ore from this mine yields palladium, platinum, copper, gold, and silver, but the value of the ore lies chiefly in the platinum metals, especially palladium. The output of palladium and platinum from the Saltchuck mine made up so large a proportion of the total output of platinum metals from Alaska in 1925 that the amount *can not be stated without disclosing confidential information.* Therefore in this as in the last bulletin of this series the palladium output of the Saltchuck mine is included in the table "Miscellaneous minerals" on page 6 and the copper, gold, and silver are included in the tables on pages 8, 27, and 29.

In 1924 a total of 28 ounces of platinum, valued at $2,594, was recovered from the gravel of placer mines on Dime Creek, on Seward Peninsula near the head of Norton Bay; Slate Creek, in the Chistochina district, Copper River Basin; Granite Creek, in the Ruby district; and Metal Creek, on Kenai Peninsula. Platinum has also been produced in small amount from the Marshall district, on the lower Yukon; from Boob Creek, in the Tolstoi district; from the Cache Creek district, of Susitna Valley; and from beach gravel on Kodiak Island. The quantity of platinum reported by placer-mine operators in 1925 was less than half that reported in 1924, but, inasmuch as platinum was probably produced, as in previous years, in some districts from which no reports were received, it is probable that the amount reported is less than the actual production; nevertheless a decrease in production is evident.

QUICKSILVER

Quicksilver was produced at two localities in Alaska in 1925, and the value is included in the table of "Miscellaneous minerals" on page 6. A large increase in output for 1925 as compared with 1924 is reported.

The largest production was made in the Iditarod district, 22 miles from the Kuskokwim, between the river and Flat. The ore is cinnabar and occurs at a contact of sandstone and an intrusive igneous rock. That mined in 1925 came from the outcrop, but an adit was started to cut the ore body at depth. Quicksilver was also obtained at Napamute, lower on the Kuskokwim, and 10 tons of ore, which had not been retorted when the report was made, was mined from a new deposit on the south side of the river.

Both the localities mentioned have been known for tneir cinnabar deposits for many years. Attempts have been made to put different deposits on a producing basis, and a somewhat irregular production of mercury has resulted. At this time the interest in quicksilver has increased, and steps are being taken to reopen properties that have been lying idle.

COAL

Alaska produced 82,868 tons of coal in 1925, nearly 17 per cent less than the production of 1924, which was 99,663 tons. The value of the coal produced in 1925 may be stated as approximately $404,600. This value can not be determined with accuracy, for it is based mainly on the contract prices of large lots, but considerable coal was sold in small lots in local markets at prices of which no record is available.

Most of the coal was mined in the Matanuska and Healy River fields, both of which are reached by the Alaska Railroad and are thus provided with the transportation facilities necessary to place the coal in a market. A little subbituminous coal is mined by the Eskimos on the shores of Wainwright Inlet, on the Arctic coast southwest of Point Barrow. Some coal is obtained from lignite deposits on Chicago Creek, tributary to Kugruk River in the northeastern part of Seward Peninsula, and is used locally by the placer miners, principally those of Candle Creek. A little coal is also mined at Bluff Point, on Kenai Peninsula, for use of the local canneries in Cook Inlet. The coal from these localities, however, is only a fraction of 1 per cent of the production of the Matanuska and Healy fields. Most of the coal mined on Healy and Matanuska Rivers is consumed by the Alaska Railroad, but a part is used locally, and some is shipped to Alaskan coast towns. The Healy River coal is a lower-grade coal and is produced in smaller quantity than the higher-grade bituminous coal of the Matanuska field.

The valuation given for coal produced in Alaska in 1925 is based in part on the prices paid by the Alaska Railroad for coal furnished under contract from the Matanuska and Healy River fields. In the fiscal year 1925 the railroad bought 57,284 tons of coal of all grades from all fields at an average price of $5.279. The contract prices for Matanuska coal during the later part of the fiscal year 1926 were, run of mine, $4.44; steam, $3.95; for Healy River coal, lump, $4.25; nut, $4; chestnut, $2.68; pea, $1; run of mine, $3.50.

Alaskan coal has to compete with the coal of outside mines whose market is already established, and although the Territory is capable of supplying from its own resources the coal needed for its own use it has not yet been able to close its market to the outside producers. In 1925 nearly 53 per cent of the coal used in Alaska came from outside sources. The showing for Alaska coal is even less favorable than in 1924, for the domestic production was reduced while the quantity of coal imported increased.

Coal produced and consumed in Alaska, 1880–1925

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
	794,854	4,545,097	1,094,010	1,532,396	3,404,095

[a] Compiled from Monthly Summary of Foreign Commerce of the United States, 1905–1925, Bureau of Foreign and Domestic Commerce. No figures on imports before 1899 are available.

In spite of the fact that less coal was mined in Alaska in 1925 than in 1924, an increased use of local coal is anticipated, and steps have been taken in both the Matanuska and the Healy River fields to meet the increased demand. In the Matanuska field the two largest producers are the Evan Jones Coal Co. on Eska Creek and the Premier Coal Mining Co. on Moose Creek. The Evan Jones Co. did a large amount of development work. A long tunnel was driven from the south limb of the anticline, on which mining has been done heretofore, to the north limb, where bad air made it necessary to extend an air course over 1,000 feet long to the surface. Mining was interrupted during May, June, and July. The Premier Coal Mining Co. was in operation almost throughout the year but was closed temporarily as a result of legal difficulties. During the year a branch of the Alaska Railroad was extended up Moose Creek to the property of the Alaska Matanuska Coal Co., which has been equipped with new machinery and put on a producing basis. The Rawson property had no production, and the Alaska Bituminous Coal Co. ceased operations in May. Ross Heckey produced a small quantity of semibituminous coal for the railroad and for blacksmith use. Permits for prospecting the anthracite of the upper Matanuska were issued, but little work was done.

The Healy River Coal Corporation, at Suntrana, was able to operate continuously in 1925, owing to the construction of a new steel railroad bridge across Nenana River. The company has now equipped its mine with the most modern apparatus for producing coal. Electric underground haulage was installed, making this the first coal mine in Alaska to be thus equipped. A modern tipple with facilities for screening and sizing coal was built. Improvements were made in the power plant and camp facilities, and a schoolhouse and recreation hall were constructed. In the mine a crosscut entry was driven to the last or sixth bed, where mining has since been carried on. The Suntrana mine is the chief coal producer of this field, although R. F. Roth did some tunneling on beds 9 miles above the mouth of Healy River which are thought to be the same beds as those met in the Suntrana mine. A few loads of coal from this place were brought down Healy River on the ice.

No coal was produced in the Bering River field except possibly a little that may have been taken out for local use. Interest in this field is not lacking, however. It is reported that the Alaska Anthracite Railroad has been taken over by a new company and will be equipped for handling coal. The part of this road already built is stated to be in fair condition, although some of the bridges are out, and it has not been in recent use. It will be necessary to build coal bunkers on Controller Bay and an extension of the landward end of the road to reach the mines which it is proposed to open.

PETROLEUM

The petroleum production of Alaska is small and comes entirely from the Katalla field, on the south coast a short distance east of the mouth of Copper River, where it is obtained from 16 shallow wells on patented claims belonging to the Chilkat Oil Co. This company operates a refinery at Katalla and disposes of its gasoline and distillate in the local market, principally at Cordova, where a selling station is maintained. Extensive improvements for increasing the yield and quality of products and decreasing the cost of production were made to the plant in 1924 and resulted in increased output in 1925. According to the annual statement of the company to its stockholders[7] the production for 1925 was 7,963 barrels. The prices received in Cordova were 17 cents a gallon for gasoline and 13 cents for distillate. Two wells were drilled in 1925. One reached a depth of 1,160 feet and had an initial production of 3½ barrels a day from three oil-bearing strata. The other was drilled to 1,760 feet but yielded only half a barrel a day. The gasoline-extraction plant was operated approximately 200 days but was closed most of the time in January, February, and March because of extremely cold weather.

Large quantities of petroleum products, such as gasoline, distillate, fuel oil, and lubricating oil, are used in Alaska by the fishing boats and other water craft along the coast, the canneries, the mines of the

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[7] Chilkat Oil Co. Eighth Ann. Rept.

Kennecott Corporation, the Copper River & Northwestern Railway, and other consumers. Most of this oil must be imported from outside sources, as the domestic production is wholly insufficient to meet the demand.

Petroleum products shipped to Alaska from other parts of the United States, 1905–1925, in gallons [a]

Year	Heavy oils, including crude oil, gas oil, residuum, etc.	Gasoline, including all lighter products of distillation	Illuminating oil	Lubricating oil
1905	2,715,974	713,496	627,391	83,319
1906	2,688,940	580,978	568,033	83,992
1907	9,104,300	636,881	510,145	100,145
1908	11,891,375	939,424	566,598	94,542
1909	14,119,102	746,930	531,727	85,687
1910	19,143,091	788,154	620,972	104,512
1911	20,878,843	1,238,865	423,750	100,141
1912	15,523,555	2,736,739	672,176	154,565
1913	15,682,412	1,735,658	661,656	150,918
1914	18,601,384	2,878,723	731,146	191,876
1915	16,910,012	2,413,962	513,075	271,981
1916	23,555,811	2,844,801	732,369	373,046
1917	23,971,114	3,256,870	750,238	465,693
1918	24,379,566	1,086,852	382,186	362,413
1919	18,784,013	1,007,073	3,515,746	977,703
1920	21,981,569	1,764,302	887,942	412,107
1921	9,209,102	1,403,683	2,021,033	232,784
1922	15,441,542	1,436,050	2,095,675	345,400
1923	12,285,808	4,882,015	473,826	454,090
1924	14,412,120	5,554,859	566,431	506,364
1925	16,270,746	6,993,500	562,844	580,321
	327,550,379	45,639,815	18,414,959	6,131,599

[a] Compiled from Monthly Summary of Foreign Commerce of the United States, 1905 to 1925, Bureau of Foreign and Domestic Commerce.

The efforts that are being made to establish new productive oil fields in Alaska did not meet with success in 1925. No new oil pools were tapped, and no new prospects of promise were reported. Drilling operations on the Pearl Creek dome, near Kanatak, on Alaska Peninsula, have so far met with disappointment. The Standard Oil Co. drilled three holes. Two of these are shallow, but the third reached a depth of 5,400 feet without striking oil in sufficient quantity to be of value. The deep hole caved near the bottom, drilling was stopped, and the hole was abandoned. Since then the machinery has been removed and hauled to Kanatak, but not before the holes had been stopped in a manner to comply with the leasing laws. The Associated Oil Co. drilled intermittently on the Finnigan claims of the same field without success.

In the Yakataga field no drilling has been done, but preparations for drilling were made. During the summer of 1925 the General Petroleum Co. landed machinery and a drilling rig at Yakutat, from which it was taken on scows to Icy Bay and unloaded on the beach. Tractors were provided to haul this equipment from the beach to the drilling site, but before they had delivered their freight at its destination the storms and bad weather of early winter put an end to the work until sometime in 1926, when the drill rig is to be installed.

A drill rig was landed at Chickaloon, Matanuska Valley, on the Lars Netland coal-lease area, but was not set up in 1925.

No development was undertaken in the Iniskin Bay field, on the west side of Cook Inlet, but geologic surveys were made by oil geologists representing companies interested in that field, and surveys for land subdivision were carried on by the General Land Office.

The search for oil in naval petroleum reserve No. 4, in northern Alaska, was continued in 1925 by members of the Geological Survey. A party of four men, including one topographer and one geologist, made the winter trip by dog sled from Nenana to that part of the Arctic slope including the headwaters of Colville River and carried on topographic and geologic surveys. One of the chief results of the work, aside from the mapping of new territory, is the delimiting of the area in which petroleum may be expected to be present. A short account of the work is given in another part of this report.

STRUCTURAL MATERIALS

Marble and gypsum are the principal structural materials that have been shipped out of Alaska. Both these materials are present in southeastern Alaska, and because of their convenient situation with reference to water transportation may readily be placed on the Pacific coast market.

Most of the marble is produced from the quarries of the Vermont Marble Co. at Tokeen, on Marble Island, at the north end of Prince of Wales Island. This company was active in 1925 and employed a force of men which is said to have been larger than has been employed before. Such a force would indicate an increasing demand for Alaska marble. Since 1904 the output of marble has steadily grown, but the number of companies producing marble has always been small. The value of the marble produced in Alaska since 1901 is $2,629,214.

Gypsum has been produced on the east coast of Chichagof Island each year since 1906. The mine was closed in December, 1923, and was not reopened 'till August, 1924, when it was taken over by the Standard Gypsum Co. This company made plans for a mill and for developing the mine, but being unable to make satisfactory arrangements regarding royalties with the owners, it finally gave up the mine and removed its equipment. In consequence no production of gypsum in 1925 is reported.

OTHER MINERALS

In some years a number of minerals other than those already mentioned have been produced and marketed from Alaskan sources. This was especially true during the war, when an unusual demand for many of the less common metals arose and the market price was so high as to encourage the production of such metals, even in remote regions of high mining costs. These metals include antimony, chromium, molybdenum, and tungsten. None of them were shipped from Alaska in 1925, although some may have been produced.

ADMINISTRATIVE REPORT

By Fred H. Moffit

This administrative report relates to the fiscal year 1925–26 and therefore involves the field work of more than one calendar year.

Since April 1, 1925, the work of the Alaskan branch has been in charge of Philip S. Smith, chief Alaskan geologist, who at the time of this writing (July, 1926) has been in Alaska since February, continuing the investigation of naval petroleum reserve No. 4 which was begun in 1923. During his absence from Washington S. R. Capps acted as chief Alaskan geologist until May 21, when he also left the Washington office for field work in Alaska and Fred H. Moffit assumed temporarily the duties of the position.

The work of the Alaskan branch was expanded at the beginning of the fiscal year 1926 by the transfer to it of certain functions which had been previously exercised by the Bureau of Mines but which, when that bureau was transferred to the Department of Commerce, were turned over to the Geological Survey. The new duties devolving on the Alaskan branch include the supervision of the production of coal and oil on public lands under the mineral leasing acts. The supervision of leased mineral lands under this new arrangement is administered in cooperation with the conservation branch of the Geological Survey, which performs the necessary Washington office functions and advises the Alaskan branch with respect to the general conduct of work in the field. The following persons connected with the work of the Bureau of Mines in Alaska and resident in the Territory were transferred to the Alaskan branch on July 1, 1925: B. D. Stewart, supervising mining engineer; J. J. Corey, coal-mining assistant; J. G. Shepard, metal-mining assistant; H. H. Townsend, associate mining engineer; Ilona M. Grover, junior clerk.

The local office at Anchorage, Alaska, formerly maintained by the Bureau of Mines was taken over by the Geological Survey.

Systematic investigation of the mineral resources and geology of Alaska and the mapping of its topographic features by the Geological Survey began in 1898 and have continued uninterruptedly to the present time. A number of special investigations, however, were made by men from the Geological Survey before that time. Their work was not conducted by the division of Alaskan mineral resources and in part was directed by organizations wholly outside the Geological Survey. Such work, as well as the work of other Government organizations now active in Alaska, is not included in the following summary of surveys so far made.

Areas surveyed by Geological Survey in Alaska, 1898–1926, in square miles

Fiscal year	Areas covered by geologic surveys			Areas covered by 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)	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)
1898–1925	75,500	140,720	5,847	55,980	180,650	4,066
1926	----------	13,785	130	----------	9,500	----------
	75,500	154,505	5,977	55,980	190,150	4,066
Percentage of total area of Alaska	40.2			42.6		

Some explanation of this table is required. In the course of work that began when Alaska was an almost unknown country and that has extended over a period of 28 years some parts of the Territory were covered first by exploratory surveys in which only the most prominent features of the country could be noted. Later more careful reconnaissance surveys of large areas were made, and finally in some small areas where the mining industry required it, detailed maps of still larger scale were made. Where such surveys overlap and an area has been mapped on two or more scales only the most recent and largest-scale maps are included in the table, so that there is no duplication of areas on different scales. It results, therefore, that the area surveyed from 1898 to 1925, as given in the table, is not identical with the area reported in the corresponding table of the report for the fiscal year 1925, as the totals given in that table are here corrected by amounts corresponding to the areas resurveyed in the field season of 1925. As the areas where surveys are made are determined largely by the needs of the mining industry, it results that the areas mapped geologically and those mapped topographically are in large measure the same.

The table shows that at this time a little more than two-fifths of Alaska, or more than 235,000 square miles out of a total of 586,400 square miles, is mapped both topographically and geologically in an exploratory, reconnaissance, or detailed way. The area thus surveyed on the reconnaissance scale (1:250,000) is nearly twice as great as that of the other two scales combined, and the area surveyed in detail is only 2.5 per cent of the total area surveyed both topographically and geologically. In considering these figures it must be borne in mind that however necessary and valuable the exploratory and other less exact surveys were at the time they were made, the resulting maps must eventually be replaced by better maps of at least the standard of accuracy of the present-day reconnaissance surveys, and in important districts, if the needs of Alaska are to be met, some surveys of the still more detailed kind will be required, both for the mining industry and for the development of water power and other resources.

The work of the Geological Survey in Alaska, however, does not consist solely in making geologic and topographic maps. It includes the collection of mineral statistics and the making of special investigations relating to supplies of coal, petroleum, platinum, chromium, and other mineral resources, as well as of such metals as gold, silver, and copper. For several years the Geological Survey conducted an investigation of the water resources of Alaska to determine the supply of water available for placer mining and for the development of power, but these investigations were discontinued because of lack of funds. More recently certain work formerly carried on by the Bureau of Mines has been transferred to the Geological Survey, as noted above.

The publications of the fiscal year consist of a report on the progress of investigations in Alaska in 1923 (Bulletin 773), the administrative report and a report on the mineral industry of Alaska in 1924 (Bulletin 783–A), and "Mesozoic stratigraphy of Alaska," by G. C. Martin (Bulletin 776).

The funds available and used in part for the conduct of the work of the Survey in Alaska in the fiscal year 1926 include proceeds of an appropriation of $72,000 for 1925–26 carried in the Interior Department act and made available March 3, 1925, and of an appropriation of $50,000 for 1926–27 contained in the Interior Department act, available May 10, 1926. In addition to these sums, appropriated directly for expenditure by the Geological Survey, $22,000 was transferred to the Geological Survey from the appropriation of $33,000 for the work of the Bureau of Mines in Alaska, contained in the Interior Department act for the fiscal year 1926, at the time of the transfer of certain activities formerly conducted by the Bureau of Mines when it was a part of the Interior Department, and $12,300 remained from funds amounting to $75,000 made available to the Survey by the Department of the Navy for investigation of naval petroleum reserve No. 4, in northern Alaska, and expended in part in the fiscal years 1924 and 1925. All these funds except the appropriation for 1926–27 were available for use at the beginning of the fiscal year 1926. Their use has been accounted for in accordance with the law and the regulations of the Treasury Department, but some analysis of the expenditures from other viewpoints may be of interest.

The following statements give in round numbers the amounts that were expended for the principal uses to which the funds were applied in the fiscal year 1926. Without taking into consideration the work for the Navy Department and that transferred from the Bureau of Mines, the amount expended in starting parties into the field in the spring of 1925, before the beginning of the fiscal year 1926, is offset by the amount used to start the parties at the end of the fiscal year 1926, so that the funds used for the fiscal year 1926 were $72,000, the amount of the appropriation for that year. The funds expended in supervising the leasing of mineral lands and for the work in naval petroleum reserve No. 4 will be analyzed separately.

Expenditures from funds directly appropriated for the Geological Survey's work in Alaska, fiscal year 1926

Branch administration	$5,500
Other technical salaries	21,450
Branch clerical and drafting salaries	5,900
Service rendered by other Survey units, including editing, duplicating-machine service, accounting, and other services	5,800
Office expenses, stationery, telegrams, photography, and other expenses	2,300
Field expenses	31,050
	72,000

The sums contained in the items "Other technical salaries" and "Field expenses," plus $1,500 of the item for "Branch clerical and drafting salaries," were expended for surveys and investigations in progress in the fiscal year 1926 as follows:

General investigations	$1,875
Geologic surveys	33,800
Topographic surveys	16,425
Statistics of mineral production	1,900
	54,000

In this table it is impossible to show accurately the distribution of expenses between geologic and topographic surveys. Four of the field parties contributing to these two items in the table were combined topographic and geologic parties, for which the larger part of the cost might properly be charged to the topographic work. It has seemed best, however, to conform with the practice of former years and divide the cost of these four parties equally, or approximately so, between the two kinds of surveys.

The geographic distribution of the work reported in the last table, together with the approximate amount devoted to each district, is as follows:

Approximate cost and distribution of work by geographic divisions for the fiscal year 1926

General investigations	$1,875
Southeastern Alaska	6,950
Prince William Sound	6,600
Matanuska region	1,675
Southwestern Alaska	6,525
Skwentna-Kuskokwim region	5,675
McKinley region	4,100
Upper Yukon and Sheenjek regions	10,525
Northern Alaska	8,175
Statistics of mineral production (including $1,500 for clerical salaries)	1,900
	54,000

In the season of 1925, which included the later part of the fiscal year 1925 and the beginning of the fiscal year 1926, eight parties were engaged in geologic or topographic investigations or both in Alaska. This number includes all those connected with the Alaskan branch exclusive of those resident in Alaska, except two persons who are engaged in clerical duties in the Washington office and one whose time throughout the year is given to the preparation of maps. On the average nearly one-half the time of those engaged in field work is spent in investigations away from Washington, and the remainder of the year, including the winter season, when field work is impracticable or impossible, is devoted to the preparation for publication of information collected in the field, to conferences, committee work, and the answering of correspondence—things which would be done unsatisfactorily and at a great disadvantage if attempted away from the facilities of the Washington office.

A brief account of the field work of each member of the branch is given below for the season 1925, together with the assignment of field parties for 1926 and a statement of the activities of those whose time is all given to the work of the Washington office. Field parties in Alaska are usually out of touch with mail and telegraph communication for weeks or months at a time. It is therefore often impossible to learn the progress of the work till the return of the men in the fall, and consequently until that time it is also impossible to make any accurate statement of what was accomplished during the fiscal year.

Philip S. Smith, chief Alaskan geologist, was detained in Washington by administrative duties connected with the Alaskan work until July 12, when he left for Alaska. He spent about a week in visiting the field party in charge of A. F. Buddington at Hyder, in southeastern Alaska, and an equal time with the party under Fred H. Moffit on Prince William Sound. Most of his field season, however, was spent in Juneau, Anchorage, and Fairbanks, and in the Matanuska and Nenana coal fields in consultation with Messrs.

Stewart and Corey concerning plans for carrying on the work transferred from the Bureau of Mines and in studying the coal-mining situation. After returning from Alaska Mr. Smith was engaged in the Washington office until February 8, 1926, when he left to continue the investigation of naval petroleum reserve No. 4.

In the Washington office Miss Lucy M. Graves acted as chief clerk throughout the period covered by this report. Miss Erma C. Nichols devoted a considerable part of her time to the collection and coordination of mineral statistics. Mrs. Marion E. Maclean was engaged in general clerical work from the time of her connection with the branch (October 5, 1925) until June 16, 1926, when she was transferred to the topographic branch. John B. Torbert was engaged throughout the year in the preparation and drafting of Alaskan maps.

Two parties were at work in southeastern Alaska. A. F. Buddington made a reconnaissance of the west coast of Dall Island and spent the later part of the season of 1925 in detailed geologic surveys in the Hyder district, at the head of Portland Canal, adjacent to one of the active Canadian silver-lead camps. The results of this work are now being prepared for publication. R. K. Lynt was detailed to accompany a party of surveyors from the General Land Office who were carrying on subdivisional surveys in the vicinity of Wrangell Narrows, where he made a detailed topographic map. On February 8, 1926, Mr. Lynt was transferred from the Alaskan branch to the topographic branch.

Fred H. Moffit continued the investigation of the copper and other metalliferous deposits of Prince William Sound, one of the important copper-producing districts of Alaska, which has also produced considerable gold and gives promise of more. About 450 square miles of territory on the west side of the sound was mapped geologically. At the end of the season Mr. Moffit visited the Chitina Valley to collect data on mining.

K. K. Landes made a reconnaissance geologic survey of an area of about 335 square miles between Matanuska River and Knik River. A separate paper in this volume gives the more important results of the work.

R. H. Sargent, topographer, and R. S. Knappen, geologist, made topographic and geologic surveys of 3,000 square miles on the Alaska Peninsula. The surveys extended the full width of the peninsula from Aniakchak Crater to a point 25 miles west of the Chignik Lakes, where another crater of great size was found. The primary object of the surveys was to assist in developing the oil resources of the region, and the work of 1925 completed a series of surveys planned to cover the prospective oil-bearing portion of the peninsula. Mr.

Knappen has in preparation a report on the geology of the district for future publication.

Mr. Sargent was detailed as special representative of the Geological Survey to accompany a party organized by the Bureau of Aeronautics of the Department of the Navy to carry on aerial photographic surveys in southeastern Alaska and left Washington to join the party at Ketchikan in May, 1926. This cooperative work, undertaken at the request of the Survey, is the first attempt to make use of the aero-photographic method of mapping in Alaska. Field work began in the vicinity of Ketchikan and was to be extended northward as rapidly as weather conditions would permit, with the intent to cover as much of southeastern Alaska as possible during the season.

S. R. Capps in 1925 carried on a reconnaissance geologic survey on the northwest side of the Alaska Range in the Toklat-Tonzona district of the Mount McKinley region, covering an area of 2,000 square miles. This work was in part a resurvey on a larger scale of exploratory surveys made by A. H. Brooks and D. L. Reaburn in 1902. A report giving the results of the work is printed elsewhere in this bulletin. Mr. Capps, with K. W. Trimble, topographer, left Washington in May, 1926, to conduct geologic and topographic surveys in a hitherto unmapped district that includes the headwaters of Skwentna River and the South Fork of Kuskokwim River.

J. B. Mertie, jr., made a geologic survey along the Yukon between the international boundary and Circle and at the end of the field season of 1925 spent a week in the vicinity of Fairbanks collecting statistics on mineral production. The survey on the Yukon covered 1,500 square miles and was in part a resurvey on a larger scale of a district covered by earlier exploratory surveys. This expedition had for its object the correlation of field observations and material already in hand. A report on this district has been submitted for publication as a separate bulletin. In May, 1926, Mr. Mertie, with J. O. Kilmartin, topographer, left Washington to conduct geologic and topographic surveys in the valley of Sheenjek River, which heads in the Brooks Range north of Yukon River and joins Porcupine River about 20 miles above Fort Yukon. This area had not previously been mapped.

Gerald FitzGerald, topographer, and W. R. Smith, geologist, left Washington in February, 1925, to extend the surveys already made in naval petroleum reserve No. 4, northern Alaska. They went by dog team from Nenana down the Yukon to Norton Sound and thence north to Kotzebue, where they obtained supplies for the summer. They then completed their winter trip up the Noatak and across the divide, arriving on the Arctic slope before the spring break-up. Their field work began late in April and resulted in exploratory and reconnaissance surveys covering 6,500 square miles of territory, principally in the headwater region of Colville River and some of the northern tributaries of the Noatak.

In February, 1926, Philip S. Smith, chief Alaskan geologist, and Gerald FitzGerald left Washington to continue geologic and topographic surveys in the region between the headwaters of the Colville and the Arctic coast on the northwest. They traveled in the same manner and over the same route as the expedition of 1925 to Kotzebue and thence up the coast to Kivalina, where surveys of the unsurveyed area to the north were begun. After the later part of March the party was out of mail and telegraph communication with the Washington office during the remainder of the fiscal year.

W. R. Smith resigned in February, 1926, to take employment with an oil company in Mexico.

The sum available for use in the fiscal year 1926 from the funds transferred to the Geological Survey by the Department of the Navy was expended as is shown in the following table:

Allocation of funds for surveys in naval petroleum reserve No. 4, northern Alaska

Administration	$1, 375
Technical salaries	5, 750
Clerical and drafting salaries	1, 700
Field expenses	3, 475
	12, 300

The members of the Alaskan branch who were transferred from the Bureau of Mines to the Geological Survey at the beginning of the fiscal year are stationed at Anchorage and Juneau. Their time is occupied with matters relating to the leasing of public lands and the issuing of permits for prospecting under the leasing acts and to the general development of the Alaskan mining industry. Their work involves frequent journeys by the field men to the mining districts throughout the Territory.

The funds for this work were transferred to the Geological Survey from the appropriation for the Bureau of Mines and amounted to $22,000 for the fiscal year 1926. The use of this fund is explained in the following table:

Expenditures from funds transferred to the Geological Survey from the appropriation for the work of the Bureau of Mines in Alaska

Administration (including services rendered by other Geological Survey units, accounting, etc.)	$540
Technical salaries	13, 425
Clerical salaries	1, 500
Field expenses	6, 095
Budget reserve	440
	22, 000

In the preceding table the item "Administration" covers the charges against the appropriation for work done in the Washington office by different units of the Geological Survey and not the salaries of administrative officers in Alaska. The work of supervising the leasing of mineral lands in Alaska, under the general direction of the chief Alaskan geologist, is in charge of B. D. Stewart, supervising mining engineer, who resides in the Territory. The work done during the year included the following activities:

B. D. Stewart spent the major part of his time in the routine supervisory and administrative work of the office, in conferences with officials of the Federal Government and of the Territory, and in the preparation of official reports.

John J. Corey, coal-mining assistant, inspected coal mines in different parts of Alaska, particularly in the Bering River, Matanuska, and Nenana River districts, and consulted with operators concerning methods and plans for mining and marketing Alaskan coal.

John J. Shepard, metal-mining assistant, inspected metal mines in southern and southeastern Alaska and made reports on prospects and properties.

Harry H. Townsend, associate mining engineer, was employed from the beginning of the fiscal year to January 15, 1926. His time was given to the examination of metal prospects and mines and the preparation of reports on them.

Mrs. Ilona M. Grover handled the clerical work of the Anchorage office and gave special attention to supplying the requests for publications of the Geological Survey in Alaska.

N. L. Wimmler, mining engineer, and F. W. Holzheimer, associate mining engineer, were not assigned to field work till late in June, 1926, near the end of the fiscal year.

GEOLOGY OF THE KNIK-MATANUSKA DISTRICT

By Kenneth K. Landes

INTRODUCTION

Location and area.—The area described in this report lies between Knik and Matanuska Rivers in south-central Alaska. These rivers flow westward and converge as they enter Knik Arm, a branch of Cook Inlet. Owing to this convergence the region studied has a triangular outline. It is bounded on the east by a line drawn from Kings Mountain, on the south bank of Matanuska River, to the Knik Glacier. Each leg of the triangle is approximately 25 miles in length, and the area included within it is about 335 square miles. (See pl. 1.)

Most of the region is mountainous, and only the edges are readily accessible. The Alaska Railroad crosses the extreme western apex, and a branch line runs from Matanuska station eastward along the north bank of Matanuska River to Chickaloon. Both rivers are difficult to ford. Cables span the Matanuska at Palmer and at the mouth of Chickaloon River. It is quite possible to line a boat up Knik River from the railroad bridge. A trail leads across the flat from the Palmer cable crossing to the north bank of the Knik and up that river to Metal Creek. Save for a few ranchers close by the Palmer cable crossing and a placer miner here and there on Metal Creek the region is uninhabited.

Earlier surveys and present investigation.—The area covered by the present investigation had not been geologically explored. Some earlier surveys in regions to the south, north, and northeast crossed the border of the area for short distances. In 1906 Paige and Knopf[1] mapped the geology of portions of the Knik and Matanuska Valleys on a reconnaissance scale. Topographers in the same party mapped as much of the drainage into the two rivers as was visible from the valley floor.

In 1910 Martin and Katz[2] mapped in detail the geology of the lower Matanuska Valley. Their investigation was almost entirely

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, 1907.

[2] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

confined to the north side of the river. The preceding year R. H. Sargent, topographer, prepared a base map which covered that area and also part of the area south of the river.

Capps [3] in 1915 mapped the geology of the region south of Knik River.

In connection with a geologic survey of the upper Matanuska Valley in 1924, Capps,[4] assisted by the writer, mapped on a reconnaissance scale the geology of the south flank of the Matanuska Valley from Gravel Creek as far west as Kings Mountain.

The present investigation was carried on during the summer of 1925 by the writer, accompanied by Alex Liska, of Anchorage. Knik River was ascended by boat, and the Matanuska Valley was reached by the Chickaloon branch of the Alaska Railroad. Matanuska River was crossed by boat and at Palmer by cable. Camps were made on the banks of the two rivers at the mouths of the larger tributaries. The extreme ruggedness of the region necessitated back packing up the tributaries, where side camps were established.

The base map used for plotting the areal geology is a portion of the topographic map of the region traversed by the Alaska Railroad. This particular part was a compilation derived largely from the topographic surveys previously mentioned. It was incomplete, as the work was done near tide level, and much of the topography toward the interior of the area was hidden from view, so that the center of the area was entirely unmapped. A few topographic corrections and additions were made in the field. Owing to the character of the base map and the difficulties of travel in the region, the field work was necessarily of a reconnaissance nature.

At the end of the season a hasty trip was made along the railroad from Knik River to Eklutna and south of Anchorage between Potter and Indian in order to make a further study of the greenstone series. The results of this investigation are included in the present report.

PHYSIOGRAPHY

CHIEF FEATURES

The two chief physiographic features of this district are the mountains and the flats. Between them on the south flank of the Matanuska Valley lies a high terrace.

The mountains form a spur of the Chugach Range. They are strongly dissected, and the peaks along the divide range in elevation from 6,000 feet toward the west to more than 8,000 feet at the east-

[3] Capps, S. R., The Turnagain-Knik region, Alaska: U. S. Geol. Survey Bull. 642, pp. 147–194, 1916.

[4] Capps, S. R., Geology of the upper Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 791, 1927.

ern boundary. They continue to increase in elevation east of the area studied and probably reach more than 14,000 feet along the divide between Cook Inlet and Prince William Sound. The higher peaks are snow-covered and where tapped by the headwaters of the larger streams contain small glaciers.

Both Matanuska and Knik Rivers follow braided courses over extensive sand and gravel flood plains. In times of high water these flats are inundated. The flats range in width from 2½ miles on the Knik down to half a mile and less on the Matanuska. In several places Matanuska River passes through canyons where the velocity of the water has prevented the deposition of any flood-plain material whatever.

Alongside and about 10 feet above these present-day flood plains there is a flat extending from the western extremity of the mountain range to the point of junction of the two rivers. This is a level surface save for a row of sand dunes bordering Knik River and a few isolated hills of bedrock rising above the plain. This low terrace, like the modern flood plains, is composed of river-deposited sand and gravel. At one time Matanuska and Knik Rivers flowed at a higher elevation. Serious overloading, undoubtedly caused by the vast amount of material supplied to the streams by the many valley glaciers then existent, necessitated much deposition. At the confluence of the two rivers an extensive flood plain resulted. The present buttes rising above the flat were islands of resistant bedrock. With a further recession of the glaciers less material was supplied to the rivers, and they started to erode again. Each stream deepened its channel, leaving a part of the old flood plain as a low terrace. This valley deepening continued until the gradient was so reduced that the rivers could no longer cope with the load supplied by tributaries and glaciers and were forced once again to build up a flood plain.

The terrace on the south flank of the Matanuska Valley is best shown in the vicinity of the Wolverine Lakes, where it stands about 200 feet above the river. This height decreases upstream, and the terrace finally blends with the valley floor at the foot of the Matanuska Glacier. It is discontinuous, being interrupted at some places by tributary stream valleys and at others pinching out altogether where the main valley narrows. Its surface is rough in comparison with that of the lower terrace, small ridges, hills, and depressions being common features. Bedrock is exposed in the hills and along the stream valleys. It is covered in most places, however, by a veneer of unconsolidated soil, sand, and gravel. These deposits are thick enough in places to conceal the bedrock completely.

The surface of this terrace represents the valley floor left by the receding glacier. In its earlier advance the glacier carved out a

U-shaped valley. The floor of this valley was somewhat irregular, owing to the difference in hardness of the several kinds of bedrock encountered by the glacier. During its recession the glacier and the streams running off from it deposited drift irregularly over the valley floor. The resulting comparatively flat surface, created by the glacier through a combination of erosion and deposition, was made into a terrace by the postglacial activity of Matanuska River. Since the glacier receded this powerful stream has deepened its channel 200 feet below the bottom of the U-shaped valley at its western extremity. The amount of postglacial deepening decreases upstream, and at the foot of the glacier there is none.

Except where swampy the two terraces are densely forested. The trees decrease in number toward the mountains and disappear altogether at the timber line, about 2,000 feet above sea level. Game, consisting of mountain sheep, brown and black bear, ptarmigan, and grouse, is plentiful in the mountains. Ducks are common on the lakes and swamps of the flats. Trout are rare, owing to the fact that most of the streams head in glaciers and are therefore muddy.

DRAINAGE

All the surface run-off in the Knik-Matanuska region finds its way into one or the other of the two rivers. The major tributaries of the Matanuska are Carpenter and Wolverine Creeks; those of the Knik are Metal, Friday, and Jim Creeks. Owing to their large size and great velocity none of these streams can be forded on foot except where they distribute themselves on their fans or near their headwaters.

The major tributary valleys likewise contained glaciers in the past and with the exception of Jim Creek still contain small remnants of these glaciers at their heads. The tributary glaciers, however, were much smaller than the main valley glaciers and were therefore unable to erode their valleys to anywhere near the depth reached by the Knik and Matanuska Glaciers. When these glaciers receded the tributary valleys were left hanging several hundred feet up on the side of the main valley. Postglacial erosion by the tributary streams has resulted in the formation of terraces and canyons. Many of the canyons are very deep adjacent to the main valley, and most of them are impassable.

Drainage from the southwest flank of the mountain spur is conducted across the low terrace flats by a number of sloughs that empty into Knik River. The flats here are thickly covered with swamps and shallow lakes. The hanging valley of Jim Creek or the mountains near by may be reached only by boat up lower Jim Creek and tributary sloughs. The poor drainage on the flats in this vicinity is due to a belt of sand dunes parallel and adjacent to the north bank of the Knik, which has dammed up the normal drainage. Many of these dunes are over 60 feet in height. They are caused by strong down-valley winds, which pick up sand from the river flood plain and pile it up in dunes along the river bends. This wind results from the atmospheric movements caused by the presence of cool air overlying the glacier and hot air in the lower valley, a condition which exists on almost every midsummer afternoon. Sandstorms prevail while this difference in temperature is in effect.

The Jim Creek slough has been able to keep its channel open through the dune belt and into Knik River. This slough and those tributary to it meander greatly and have in times past flooded their banks, building up natural levees as they did so. The presence of these dikelike banks several feet high separating the sloughs from the swamps prevents direct drainage from one into the other and thus furnishes an added reason for the swampy condition between Knik River and the mountain front.

DESCRIPTIVE GEOLOGY

PRINCIPAL FEATURES

Rocks in great variety crop out in the region between Knik and Matanuska Rivers. (See pl. 1.) Metamorphic rocks predominate over unmetamorphosed sediments, and igneous rocks are intermediate in abundance. The general trend of the formations is southwest, parallel to Matanuska River and to the axis of the Chugach Range. The formations decrease in age from south to north.

The metamorphic slate and graywacke in the upper Knik Valley are assumed to be the oldest rocks in the region. Immediately to the northeast of them lies the greenstone formation, consisting of an enormous series of chloritized and epidotized lavas and associated rocks. Into this formation is intruded a small batholith of diorite, the long axis of which likewise runs southwest. The greenstone and diorite form the backbone of the mountain range in the area under discussion. On the south flank of the Matanuska Valley next above the greenstone lies the Cretaceous sedimentary series. Tertiary sediments crop out in a band in the terrace east of Wolverine Creek and in the neighborhood of Kings Mountain.

Kings Mountain is an intrusive plug of rhyolite. Acidic dikes radiate from this mountain into the sedimentary series. Other acidic dikes, probably offshoots from the diorite, penetrate the greenstone. Basic dikes cut the Cretaceous and Tertiary rocks between Carpenter and Wolverine Creeks.

Glacial gravel is prominent on the high terrace and in several of the tributary valleys where the smaller glaciers deposited lateral and recessional moraines. More recent alluvium makes up the low terrace west of the mountain range, and considerable sand and gravel has been deposited by Matanuska and Knik Rivers on their present-day flood plains.

As no fossils were found in the metamorphic rocks their exact age is a matter of considerable doubt. The unmetamorphosed sedimentary rocks are continuations of the same series from the north side of Matanuska River, where Martin and Katz[5] worked out the age relations in detail.

SLATE AND GRAYWACKE

Distribution.—Interbedded slate and graywacke crop out on the north flank of the valley of Knik River east of Wolf Point, a prominent rock cliff rising from the water's edge about 3 miles above the mouth of Friday Creek. The contact with the greenstone at this point bears N. 60° E., a trend which carries it diagonally across the mountains forming the north wall of the valley. Thus the area of exposure of the metamorphic series increases greatly toward the east. Just how far east of the area studied it extends is not known. The morainal débris about the foot of the Knik Glacier and on the ice itself is composed exclusively of the same material. It would appear that the slate and graywacke extended at least as far as the divide separating the Knik River drainage from that flowing into Prince William Sound. The presence of this same series was also noted south of Anchorage, in the vicinity of Indian.

Character.—The commoner of the two varieties of rock is the graywacke. It ranges in color from gray to black and usually cleaves parallel to the bedding. A tendency toward schistosity was noted in some specimens. The grain is fine enough to give the rock a dense compact appearance but without that excessive fineness necessary to the production of a slaty cleavage. At P. R. Strong's camp, at Indian, the graywacke is cut by minute quartz veins. Here it has suffered considerable faulting, and the gouge along the fault planes contains disseminated specks of chalcopyrite.

In the thin section this rock is seen to consist of minerals and rock fragments of a size too large for it to be called a slate or argillite. Because of the size and the diversity of material contained the rock is known as graywacke. The mineral grains seen under the microscope are largely quartz and feldspar, present in widely varying proportions. Mica is another common constituent. The rock fragments were derived from the breaking up of a fine-grained rock, perhaps a lava. Organic material is usually present. Great irregularity of size and shape of the grains is a characteristic feature.

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[5] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

The graywacke belonging to this series shows definite metamorphism, which distinguishes it from similar rocks of later age. In many specimens the larger mineral and rock grains form augen about which the mica plates bend. Where the grain is more uniform metamorphism has produced a less noticeable parallelism of minerals. The quartz grains invariably show strain effects. Later alteration has kaolinized the feldspars. Some of the biotite has been converted to chlorite. A mass or vein of calcite here and there completes the list of secondary products.

The slates are dark greenish-gray. They are rarely conformable to the overlying and underlying beds of graywacke. The stresses and strains which the rocks of the region have had to withstand in times past found many of the slate layers incompetent. These layers are consequently crumpled, although no such results were noted in the graywacke. Some slipping took place between the layers, producing smooth and shiny surfaces. The green color is undoubtedly due to secondary chlorite formed during the crumpling.

Many thin quartz veins are found in the slate. Most of them are interbedded, although a few cut across the bedding at a low angle. Where the slate is crumpled the quartz veins follow its twists and turns. A great many such thin white veins, all parallel to one another and highly contorted, give the rock a gneissic appearance when worn smooth.

Structure.—No rock older than the slate and graywacke has been found in this area. The source of supply of the clastic material that makes up the series remains in doubt, along with its thickness and its structural relations to the underlying rock. At the contact with the greenstone at Wolf Point the slate and graywacke strike N. 60° E. and dip 30° N. Only minor fluctuations from this structure reading were noted above Wolf Point and in the canyon of Metal Creek.

Age and correlation.—Owing to the dearth of fossils a definite age can not be assigned to this series. It continues south of Knik River into the region studied by Capps,[6] who indicates it on the map as "Mesozoic, possibly some Paleozoic." Mendenhall[7] in 1898 named the slate and graywacke the Sunrise "series" (now called Sunrise group). Similar rocks appearing in the Prince William Sound region have been divided into the Valdez and Orca groups. Positive age identification of this extensive group of rocks must await the discovery of diagnostic fossils.

[6] Capps, S. R., The Turnagain-Knik region, Alaska: U. S. Geol. Survey Bull. 642, pp. 147–194, 1916.

[7] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 305–307, 1900.

GREENSTONE

Distribution.—The rocks in the greenstone formation are mainly of volcanic origin, although interbedded sediments appear in a few localities. The igneous rocks occur both in flows and sills and as tuffs, breccias, and agglomerates. They are mainly intermediate in chemical composition, although in places rhyolites predominate. The entire volcanic series has been subjected to regional metamorphism. The ferromagnesian minerals have been altered to chlorite and, with feldspar, to epidote. These two secondary minerals are green, and their presence in abundance in the rocks gives the formation its name. The rhyolites present here and there in the volcanic series are lean in ferromagnesian minerals and so remained unaffected by this alteration and have kept their original white or gray color.

In the region between Knik and Matanuska Rivers the greenstone is by far the most prominent formation. It crops out in a belt about 14 miles wide, which trends southwest throughout the area. Within this belt lies the long, narrow outcrop of the diorite batholith. The two formations together make up most of the mountainous part of the region. To the west a few greenstone buttes rise abruptly above the gravel flats. The same formation crops out along the railroad track south of Knik River between the bridge and Eklutna and between Potter and Indian.

Character.—The intermediate volcanic rocks that constitute the major part of the greenstone formation exhibit wide variations in texture. On the south flank of the Matanuska Valley, between the Cretaceous sediments and the diorite, the rock is a tuff, consisting of small green angular fragments. South of the diorite batholith and in the valley of the Knik the rocks are severely altered, having a green or yellowish-green color and a much more homogeneous texture. Some of these rocks are greasy in luster; others are dull. Thin ramifying calcite veins are practically everywhere present, but secondary quartz is uncommon, except in the vicinity of sulphide mineral veins. Adjacent to deposits of chalcopyrite near the headwaters of Jim Creek and of sphalerite and galena on the scarp between Eklutna and Peters Creeks the greenstone country rock is extensively silicified.

South of Anchorage, between Potter and Indian, slate inclusions in a green matrix are exceedingly common. They range from a very small size to 6 inches or more in length and are so abundant in places as to constitute 75 per cent of the rock. Quartz veins under an inch in thickness traverse these agglomerates irregularly.

Microscopic examination shows that both the fragmental and the massive rocks have a similar mineral composition, and they are therefore grouped together in one formation. When the volcanism was explosive in character the clastic rocks were produced. Less violent eruption resulted in the extrusion of lavas. The minerals vary widely in size of grain, owing to differences in rates of cooling. At two widely separated localities the rock is large grained, like a granite. Here the cooling must have been slow, as in a large feeder dike or other intrusive body, where the magma was well insulated from the surface. The fragments in the tuff on the south flank of the Matanuska Valley and many of those in the agglomerate exposed between Potter and Indian were derived from a fine-grained lava rock containing a few small phenocrysts in a cryptocrystalline groundmass. Most of the greenstones represent an intermediate phase between the large-grained deep-seated rocks and the fine-grained lavas. Here the texture is porphyritic, but the phenocrysts are numerous and large, and the minerals in the matrix itself are by no means minute. These rocks crystallized either in thick flows or in sills between the flows, where cooling was slower than at the surface.

The primary mineral composition is fairly constant despite the textural variations. Feldspar is by far the commonest mineral. It is usually albite, but microcline and orthoclase appear locally in minor amounts. Primary quartz is less common, rarely appearing in the porphyritic rocks as phenocrysts and usually forming but a small part of the groundmass. The ferromagnesian minerals have almost everywhere been completely altered. A few remnants of biotite and hornblende attest to the presence of these minerals, but in amounts subordinate to the feldspar. Magnetite was the only other primary mineral recognized.

In composition and texture these rocks are soda trachyte porphyries. They verge with increased quartz on dacite porphyry and with increased size of grain on syenite porphyry.

From 30 to 90 per cent of the original volcanic rock has undergone alteration. The commonest secondary minerals are epidote and chlorite; hence the green color of the altered rock. Both of these minerals were derived from ferromagnesian minerals. Considerable epidote was also derived from feldspar through a reaction between that mineral and biotite or hornblende.[8]

Other secondary products, present in varying abundance, are calcite, quartz, and kaolin. Calcite veins were seen in almost every thin section studied, and many of them are thick enough to be visible in the hand specimen. Much of the albite has been partly replaced by calcite. The lime for both the veins and the replacement deposits was probably obtained locally from feldspar and ferromagnesian

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[8] Clarke, F. W., The data of geochemistry, 5th ed.: U. S. Geol. Survey Bull. 770, p. 609, 1924.

minerals. Secondary quartz appears with the vein calcite and has also replaced a large part of the country rock adjacent to the sulphide veins previously mentioned. Ground-water activity has caused a partial alteration of feldspar into kaolin.

The origin of the greenstone involves several stages. In the first place the lava was blown and poured out over the surface of the land, eventually accumulating to considerable depth. Later this mass of igneous material was subjected to regional metamorphism. Hot waters circulated through the lava and tuff, changing biotite to chlorite, feldspar to epidote, etc. These changes took place without the importation of new material from outside the greenstone. Metamorphism was not accompanied by severe pressure, otherwise the shale and limestone within the greenstone series would have been altered. Here and there ascending metal-bearing solutions introduced silica and calcite into the surrounding rock. Calcite, with some quartz, was also deposited in veins and replacement bodies by carbonated waters that were present during the metamorphism and by ground waters that have been active since that time.

Interbedded with the trachytic rocks are a few layers of rhyolite. They are usually unimportant quantitatively, but on the scarp facing Knik Arm between Eklutna and Peters Creeks they reach considerable thickness. The rhyolite is white or light gray and contains quartz and orthoclase phenocrysts. The thin section shows that these minerals constitute most of the groundmass also. The only other mineral of importance present is muscovite. Ferromagnesian minerals are lacking. In texture the rhyolite ranges between a fine and a coarse porphyritic phase. Alteration has been largely confined to kaolinization of the feldspar. Small amounts of vein calcite may also be present. Silicification is dominant near the lead-zinc veins on the scarp above Knik Arm. The rhyolite was undoubtedly extruded at the same time as the trachyte and has undergone the same subsequent history, but owing to the absence of ferromagnesian minerals no chloritization or epidotization took place. The acidic rocks have therefore retained their light color.

The igneous activity that produced the trachyte and rhyolite was interrupted at times by periods of quiescence and submergence, as shown by the presence of sedimentary rocks here and there within the greenstone formation. Among these sediments shale predominates. It covers a considerable area between the canyon mouth and the forks of Friday Creek. It is dark gray and in places verges upon slate but is nowhere truly slaty. Near the mouth of Friday Creek knots of greenstone as much as 4 inches across occur within the slaty shale. Perhaps these were volcanic bombs that were thrown into the sea, joining on the sea floor the much finer material deposited by inflowing rivers.

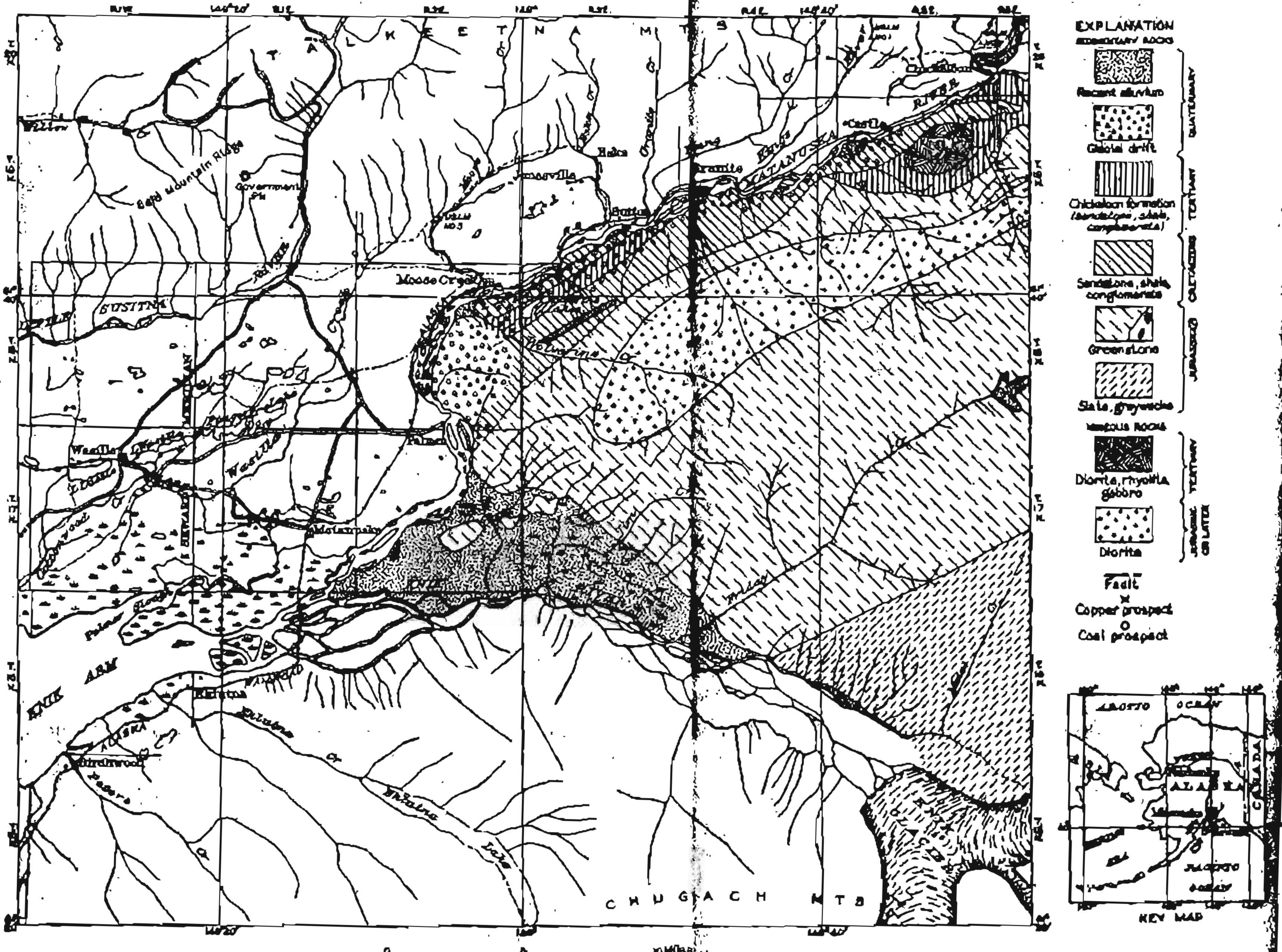
In a terrace at the mouth of Friday Creek and between Potter and Rainbow graywacke beds were found. In the Friday Creek locality the rock consists of subangular and generally small grains of feldspar, quartz, and rock fragments. The feldspar grains were severely kaolinized, and the rock itself was chloritized to some degree. The graywacke occurring west of Rainbow is interbedded with greenstone agglomerate and was derived from that rock. It is greenish gray to black and contains partly rounded grains of greenstone material.

Conglomerates are rare in the greenstone formation. Toward the headwaters of Carpenter Creek a massive conglomerate containing very jagged and irregular fragments as much as 3 feet across is exposed. A 1-foot bed was noted on Friday Creek interbedded with shale.

In the vicinity of Potter there is a limestone bed which likewise lies within the greenstone formation. This limestone is a gray, finely crystalline rock, irregularly crossed by narrow white veins. Under the microscope the veins are seen to consist of large calcite crystals, and the gray groundmass contains very fine crystals of the same mineral. The limestone grades on one wall into a massive rock of great hardness, composed of fine-grained white quartz crystals stained yellow on the surface by limonite. In thin section this rock is seen to consist of very fine interlocking quartz crystals. Veins containing much larger quartz crystals cross the section, and still later veins of calcite cut both matrix and quartz veins.

The calcite and quartz are probably travertine deposits. Solutions containing at one stage calcium carbonate and at another silica emerged through hot springs to the surface of the ground and there evaporated, depositing these minerals as they did so. Hot springs are common in regions of volcanic activity. Later ground-water activity produced the veins noted in the two deposits.

Structure.—The greenstone formation overlies the slate and graywacke metamorphic series. At Wolf Point the slate and graywacke dip under the greenstone at an angle of 30°. The strike is N. 60° E. Reliable structure readings on the greenstone itself are impossible, and the shales found here and there within the formation must be utilized for that purpose. The nearest shale to the slate and graywacke contact lies in the valley of Friday Creek. Close by the forks of this creek the sediments strike N. 70° E. and dip 40° N., but along the west side of the valley below the forks they dip at low angles. Evidently the greenstone formation is folded here into an asymmetrical syncline. The eastern limb is steep and is roughly conformable to the underlying metamorphic series. The western limb is gentle. The presence of the shale along the axis of the syncline accounts for the large area of its outcrop.



GEOLOGIC MAP OF THE KNIK-MATANUSKA DISTRICT

On the north side of the range, between the diorite batholith and the Cretaceous sediments, the greenstone dips northwest and strikes northeast. Variable dips given by shales found between that locality and Friday Creek indicate the presence of several fluctuations of structure. Evidently the greenstone formation repeats itself, in part at least, between its contacts, and therefore no measurement of its thickness can be made.

Because of the generally massive structure of the rock, faults are difficult to recognize. The only faults of importance noted are on Carpenter Creek. A short distance south of the contact between greenstone and Tertiary rocks a 100-foot bed of conglomerate followed by several hundred feet of shale crosses the creek. These sediments dip fairly steeply to the south, whereas the adjoining greenstone supposedly dips to the north. Probably a pair of strike faults allows the repetition of Tertiary sediments at this point.

Age and correlation.—No fossils were found by the writer within the greenstone formation. From its position it is evidently later than the metamorphic rocks and pre-Cretaceous. Martin and Katz [9] mapped this series east of Kings Mountain and called it Lower Jurassic. Their evidence was based on fossils collected from similar rocks exposed elsewhere in the Matanuska Valley. The greenstone formation also crosses Knik River to the south, extending into the territory mapped by Capps,[10] who refers to Jurassic or possibly Cretaceous fossils found in the underlying slate and graywacke and concludes that the greenstone is Mesozoic. Heretofore the greenstone of Knik River and the volcanic rocks of the upper Matanuska Vally have been considered separate series, but the field work of the summer of 1925, coupled with microscopic examination of the rocks involved, leads to the conclusion that they belong in the same formation. In that case the age is probably early Jurassic. The fossils of questionable age occurring in the underlying slate and graywacke in the Turnagain-Knik district must belong to even earlier Jurassic time.

CRETACEOUS ROCKS

Distribution.—The Cretaceous sedimentary rocks appearing in the Knik-Matanuska region consist of sandstone, shale, and conglomerate. They crop out in a belt south of and parallel to Matanuska River, underlying most of the high terrace. In the vicinity of the Wolverine Lakes Cretaceous rock laps up on the mountain range itself, owing to the presence there of a hard basal conglomerate. Farther east, where this conglomerate is lacking, the line of

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[9] Martin, G. C., and Katz, F. J., op. cit., pp. 29–32.

[10] Capps, S. R., The Turnagain-Knik region, Alaska: U. S. Geol. Survey Bull. 642, p. 164, 1916.

demarkation between plateau and scarp likewise marks the contact between sediments and volcanic rocks.

Character.—The Cretaceous sandstones vary considerably in appearance but not in composition. In color they may be either gray or green, but the green is more common. Some are fine grained and very dense; others are medium grained. They may be so massive as to conceal the bedding. In places the sandstone is sufficiently hard to form scarps that rise above the terrace surface. Microscopic examination shows that not over 15 per cent of the grains are quartz. The rest are mainly feldspar and rock fragments. They are exceedingly angular and evidently traveled but a short distance. Chlorite is common, both in the cement and replacing the grains. Calcite and kaolin are other abundant secondary minerals. The rock fragments are very suggestive of the greenstone in appearance. In all likelihood when these sediments were being deposited greenstone near by was being eroded, and most of the clastic material was derived from that source.

The shale members are thicker and more abundant than the sandstones but are less prominent topographically owing to their inferior hardness. They are black and on exposure break into small, jagged fragments.

Conglomerate is rare save on the scarp south of Wolverine Lakes, where it reaches considerable thickness. The pebbles in this conglomerate are subangular to almost spherical. They range in size from 2 millimeters to 2 centimeters and were derived from a fine-grained greenish metamorphic rock, probably the greenstone. Limonite forms the cement and gives the entire rock a brownish-yellow color.

Structure.—The sedimentary rocks form an asymmetrical syncline whose axis approximately parallels the mountain range. The conglomerate adjacent to the greenstone contact dips steeply to the north, but the sandstone and shale on the south bank of the Matanuska dip gently to the south. No exposure of the actual contact between greenstone and sediments was found, but it would appear from the position of the Cretaceous rocks near the contact that the two formations are roughly conformable.

One large fault wholly within the Cretaceous was noted. The canyon of Matanuska River east of Moose Creek marks the course of this fault for a little over 2 miles. On the north bank of the river the sediments dip steeply to the north; on the south bank they have a mild southerly dip. At the upper end of the canyon the river bends sharply to the north, but the fault, still marked by a conspicuous depression, continues eastward and is rejoined by the river a short distance below Sutton. From that point eastward and from the lower end of the canyon westward the fault disappears under a mantle of drift and alluvium.

Age and correlation.—The Cretaceous rocks in the region south of the Matanuska are continuations of much more extensive exposures of the same sediments on the north side of the river. Martin and Katz [11] have worked out the geology of this region in detail and from definite fossil evidence have concluded that these rocks are of Upper Cretaceous age.

TERTIARY ROCKS

Distribution.—The Tertiary sedimentary rocks in the region between Knik and Matanuska Rivers lie in two small patches on the south flank of the Matanuska Valley. One of these is the westward extension of the Tertiary rocks of Coal Creek. These rocks cross from Carbon Creek to Carpenter Creek in a belt between Kings Mountain and the main range. Their lesser resistance has resulted in the presence of a low divide between the two creeks which isolates Kings Mountain from the mountains to the south. But this patch of Tertiary rocks pinches out between greenstone and Cretaceous rocks within a short distance beyond Carpenter Creek.

The other Tertiary sedimentary outcrop is long and narrow. It projects across from the north side of Matanuska River near Granite Creek, extends southwestward, and disappears under a thick veneer of glacial gravel west of Wolverine Creek.

Character.—The Tertiary sedimentary rocks that crop out in this area belong to the Chickaloon formation and include sandstone, shale, and a small amount of conglomerate. Coal is present at several horizons within the series. The distinction between the Chickaloon formation and the underlying Cretaceous rocks in places may be very difficult to make out. Where the Chickaloon occurs in an alternating series of sandstone and shale beds 1 to 2 feet thick there is no difficulty, for the Cretaceous strata, so far as known, do not possess exactly that habit. Where more massive strata occur and fossil evidence is lacking it is necessary to fall back on a less definite set of criteria.[12] The presence of coal is considered to be proof of Tertiary age.

The usual sandstone of the Chickaloon is a loosely cemented "salt and pepper" aggregate of partly decomposed and angular grains. It may be green and fine grained, however, and no megascopic difference can be noted between such rock and the Cretaceous sandstones. Under the microscope the Tertiary sandstone, like the Cretaceous, is seen to be deficient in quartz and high in rock fragments. But the presence of many fairly fresh feldspar grains, besides the usual

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[11] Martin, G. C., and Katz, F. J., op. cit., pp. 34–39.
[12] Idem, p. 36.

greenstone fragments, leads to the belief that a granitic body was likewise being eroded when the Tertiary sediments were deposited. This body, probably one of the several diorite batholiths known to exist in the Matanuska region, had not yet been uncovered in Cretaceous time.

The shales of the Chickaloon formation are generally soft and gray, but where much organic material is present they are black. Very thin coaly streaks are common, and thicker coal beds appear in places. These are described in the section on economic geology.

Conglomerate is exposed in several places along lower Wolverine Creek. One bed is 15 feet thick. It forms a low ridge and a constriction in the stream channel, owing to its superior hardness. Other smaller beds were noted. The pebbles are generally small and subangular.

Structure.—The Tertiary tract in the vicinity of lower Carpenter Creek was probably faulted into its present position. The dips in that area are northward and would carry the rocks under the Cretaceous unless an abrupt reversal took place. Cretaceous rocks are entirely missing between the Tertiary and the greenstone to the south, but their absence may be due to erosion.

The second Tertiary tract owes its presence to the local rock structure. The sedimentary rocks are here folded into a syncline along the axis of which the Tertiary beds crop out. These beds dip rather steeply and may even be overturned for a short distance on the south flank of the syncline.

Age and correlation.—The Tertiary sedimentary rocks south of Matanuska River continue across to the north side of the river, where they crop out much more extensively. They belong to the Chickaloon formation, within which are found the Matanuska Valley coals. Martin and Katz [13] describe the flora and fauna of this formation and conclude that it is probably Eocene.

IGNEOUS ROCKS

DIORITE

A belt of diorite from 1¼ to 3½ miles wide appears wholly within the greenstone, on the south flank of the Matanuska Valley. It trends southwest and forms many of the mountains on the north side of the range. Its contact with the greenstone usually passes through a notch where it crosses a divide between creeks.

The diorite body is batholithic in form, as is shown by the irregularity and nonconformity of its contact with the greenstone, by the downward divergence of its walls, and by the presence of dikes in

[13] Martin, G. C., and Katz, F. J., op. cit., pp. 49–52.

the greenstone that are believed to be offsprings of the diorite mass. A few xenoliths of greenstone in diorite were also found.

In the hand specimen the diorite of Matanuska Valley is characterized by a granitic texture, with half the grains white plagioclase and the other half greenish-black hornblende. Adjacent to the greenstone contact on upper Carpenter Creek the diorite is gneissoid, probably as a result of slight movement while the magma was crystallizing.

In thin section the diorite is seen to consist almost exclusively of soda feldspar and hornblende, in about equal proportions. Quartz is present in maximum proportions of 5 per cent, except in the gneissic phase, where it is more abundant. Biotite, apatite, and pyrite are very minor accessories. The feldspar grains are only slightly kaolinized, a condition which accounts for the fresh appearance of the rock as a whole. Chlorite ranges from a trace in the majority of sections to several per cent in the gneiss, but it nowhere approaches the proportion present in the greenstone, although the diorite has a much greater ferromagnesian content than the original volcanic rocks of that series. Obviously chloritization and epidotization preceded batholithic intrusion, or the diorite would also have succumbed to this alteration.

In age the diorite is later than the greenstone and therefore probably post-Jurassic. Diorite porphyry sills intruded into Cretaceous and Tertiary sediments in the Matanuska Valley are described by Martin and Katz.[14] If these are offshoots of the batholith, the diorite must be likewise post-Chickaloon.

RHYOLITE OF KINGS MOUNTAIN

Kings Mountain is a prominent peak lying just south of Matanuska River between Carpenter and Carbon Creeks. It is offset from the main range and owes its isolation to its girdle of less resistant Cretaceous and Tertiary sedimentary rocks. The rock forming the core of the mountain is rhyolite. It filled the neck of an old volcano whose outlines have been completely destroyed by erosion. But the igneous plug remains and assumes a mountainous form owing to its superior hardness.

Several periods of activity marked the life of this volcano, as is attested by the presence of more than one type of rhyolite about the flanks of Kings Mountain. The mountain itself, although prevailingly light colored, exhibits various tints of yellow and red where an abundance of iron is present.

The rhyolite most typical of Kings Mountain is slightly porphyritic, with phenocrysts of quartz and orthoclase. The groundmass

[14] Martin, G. C., and Katz, F. J., op. cit., pp. 56–61.

is dark gray and very dense, but microscopic examination proves it to be entirely holocrystalline. Accessory minerals, visible only in thin section, are biotite, muscovite, and apatite. They are all very subordinate to the quartz and orthoclase. Later calcite is fairly common. A small amount of black chalcedony was present in one specimen. Limonite may or may not be present.

A very much darker rock with quartz and calcitized orthoclase phenocrysts was found well up on the side of Kings Mountain, in contact with the rhyolite just described. It proved to be also a rhyolite with the same mineral composition except for the presence of small black opaque grains. These are nonmagnetic and have a hexagonal outline suggestive of ilmenite. They constitute about 20 per cent of the rock and undoubtedly are the cause of its dark color.

A large number of rhyolite dikes radiate from Kings Mountain into the sedimentary rocks on the west. Owing to their superior hardness they form narrow ridges rising above the general level of the region. They represent offshoots of the main igneous body into the country rock.

The rhyolite in the dikes differs considerably in appearance from the rhyolites of Kings Mountain. It is white and dense and covered with little specks of red iron oxide. Study of thin sections shows the rock to be fine-grained but holocrystalline, with quartz and orthoclase the principal minerals and muscovite and hematite secondary. The presence of hematite in rhyolites is unusual.

As the rhyolite plug and associated dikes are intruded into Cretaceous and Chickaloon (probably Eocene) sediments they must be subsequent to these sediments in age. They probably belong to a late Tertiary epoch.

ACIDIC DIKES

Innumerable dikes of alaskite cut the greenstone in the neighborhood of the diorite batholith, with which they are undoubtedly genetically related. In the hand specimen this rock is white and dense, but the thin section shows its granitic texture. Quartz and feldspar in almost equal proportions are the sole primary minerals. The secondary minerals, calcite and kaolin, are present in small amounts—the calcite in thin veins, the kaolin partly replacing feldspar.

A dike of similar origin but of slightly different composition was observed just north of the diorite contact on Carpenter Creek. This rock is likewise granitic and contains no black minerals, but it carries from 10 to 15 per cent of muscovite. The dominant minerals are microcline and quartz.

Numerous rhyolite dikes, probably continuations of those about Kings Mountain, cut through the sedimentary rocks that crop out on lower Carpenter Creek. All are porphyritic, with quartz and feldspar phenocrysts. The groundmass is gray or green and in most of the dikes is composed of fine crystals, but in one dike the crystals attain fair size. Minerals accessory to the quartz and feldspar are magnetite and biotite. The biotite is usually chloritized. Later veins of quartz are locally present. Calcite appears in veins and replacing feldspar. These dikes are of post-Chickaloon age. One of them completely truncates a coal seam exposed in the canyon of Carpenter Creek.

INTERMEDIATE AND BASIC DIKES

A few intermediate dikes traverse the sediments and the greenstone on the south flank of the Matanuska Valley. Where intruded into the stratified rocks, as in the vicinity of the Wolverine Lakes and on lower Carpenter Creek, these dikes rise above the general topographic surface as long, narrow ridges. The intermediate rocks are dark gray or green and contain scattered phenocrysts of plagioclase feldspar. Microscopic examination shows chloritized biotite to be the only other primary mineral present in any considerable quantity. Magnetite and the secondary minerals calcite and chlorite may or may not be present.

The only dike of sufficient size to warrant representation on the geologic map is a dike of gabbro which crops out on the mountain side south of the Wolverine Lakes. The rock is dark green and consists largely of fair-sized plagioclase crystals with lesser amounts of fayalite. Some chlorite is likewise present.

Half a dozen basic sills are intruded into the coal-bearing Tertiary rocks on lower Carpenter Creek. They range in thickness from 4 to 20 feet and dip with the strata, to the northeast. The rock in the sills is dark colored and usually very finely crystalline. Plagioclase is the most abundant mineral constituent; magnetite is subordinate. Varying amounts of chlorite and kaolin are also present. In one slide the feldspar was seen to be strongly calcitized.

Most of the intermediate and basic igneous rock bodies are intrusive into the Chickaloon formation and therefore must be of post-Chickaloon age. The few that cut the Cretaceous and greenstone formations may very well be post-Chickaloon also, but their age can not be proved. It appears that there was during middle or late Tertiary time an epoch of igneous activity which produced the Kings Mountain plug and the many dikes and sills on the south flank of the Matanuska Valley.

GLACIAL DEPOSITS

Glacial deposits may occur in any part of the area that was covered by glacial ice. On the geologic map accompanying this report such deposits are shown only where they reach sufficient thickness to seriously obscure the bedrock geology; likewise in the following paragraphs only those localities are described where glacial materials are abundant.

Sand and gravel deposited by the Matanuska Glacier cover most of the high terrace north of the mountain range. The thickness of the mantle ranges from a knife-edge where a hogback of stratified rock or a dike projects through it to over 100 feet where drift has filled in a low place in the preglacial surface. The glacial deposits are rudely or not at all stratified. The gravel, which predominates, consists of fairly coarse subangular boulders.

At the western extremity of the mountain range drift deposits lap up on the mountain side to an elevation of 800 feet. They were deposited by the Matanuska and Knik Glaciers where these two bodies of ice expanded and met on reaching the confluence of their separate valleys.

Small morainal deposits, both lateral and recessional, are common in all the tributary valleys. In the valley of Wolverine Creek lateral moraines were found along the sides of the valley at an elevation of 2,900 feet. At the foot of each glacier still existent in the region there is considerable coarse drift.

RECENT ALLUVIAL DEPOSITS

The low terrace lying between Matanuska and Knik Rivers west of the main range is composed of river-deposited sand and gravel. The north side of the terrace is well drained, and the land is suitable for agriculture.

The two main rivers are running over extensive flood plains of sand and gravel which they themselves have formed in recent time.

ECONOMIC GEOLOGY

COPPER

A copper deposit of promise, lying wholly within the greenstone formation, is exposed in a tributary draw near the headwaters of Jim Creek. The vein crops out on the north side of the valley several hundred feet above the creek bed and 4,150 feet above the sea. It was discovered and located by Joe Conroy and P. Marion in 1906.

The strike of the vein is N. 80° W., and the dip practically vertical. The course of the ore deposit may be traced by its gossan for a few hundred feet to the east, where it crosses the divide to upper Wolverine Creek. To the west talus slides obscure the outcrop, but the locators report picking it up again in the next two draws.

The vein is badly sheeted. Evidently the ascending solutions depositing the ore minerals followed the path of least resistance through a shear zone in the greenstone. Deep-seated portions of the slowly crystallizing diorite batholith which undoubtedly underlies this rock may have been the source of the ascending waters.

The vein itself averages about a foot in width. It consists of an intermixture of massive chalcopyrite and pyrrhotite. In the hand specimen the chalcopyrite appears to predominate, and gangue minerals, if present at all, are subordinate. A shallow gossan 4 to 8 feet wide marks the outcrop of the vein.

Microscopic examination of a polished section of the ore shows the presence in a fine intergrowth of approximately equal amounts of chalcopyrite and pyrrhotite. These two minerals constitute about 80 per cent of the section. Sphalerite is the only other ore mineral present, composing about 15 per cent of the total. It occurs in scattered aggregates of small irregular masses. The only gangue mineral appearing in this section is calcite, which occurs in short veins and constitutes the remaining 5 per cent of the mineral content.

Samples taken from the 1-foot vein of massive sulphides assayed as follows: Copper, 15.08 per cent; zinc, 2.95 per cent; silver, 1.75 ounces to the ton; gold, trace.

The south wall of the sulphide vein for a distance of 12 or 15 inches consists of light-colored dense rock cut by minute veins of arsenopyrite. Study of thin sections shows this to be greenstone country rock largely replaced by quartz and calcite introduced by the ore-bringing solutions. It assayed 0.41 ounce of silver to the ton and 0.04 per cent of copper.

About 50 feet lower down the side of the valley lies the top of a 200-foot series of slates. Even these are cut and partly replaced by fine quartz veins, probably of the same generation as the ore minerals. At 500 feet above the sulphide vein a dike of alaskite, another offshoot from the diorite batholith, crops out.

The chief difficulty with developing this ore deposit would lie in its inaccessibility. The flats between Knik River and the mountains can be crossed at present only by boat. From the mouth of the Jim Creek Canyon to the prospect there is a climb of 4,000 feet. Until the floor of the hanging valley above the canyon is reached it is necessary to climb steep rock slopes—an impossible feat for a pack train. Tramming seems to be the only feasible method for transporting the ore down out of the mountains. However, in spite of these handicaps to development, it appears that this deposit is well worth further prospecting.

The presence of copper float has been reported from upper Wolverine and Carpenter Creeks, but the ore has not yet been found in place.

LEAD AND ZINC

The claims of W. S. Myers, near Eklutna, were examined toward the end of the season. This property lies at an elevation of 1,500 feet in a slight draw in the face of the cliff between Eklutna and Peters Creeks. The country rock is greenstone with a considerable amount of associated rhyolite. It has undergone extensive silicification in the neighborhood of the mineral deposits.

At one point the country rock is impregnated through a vertical zone about 3 feet wide with scattered crystals and small masses of arsenopyrite, pyrite, sphalerite, and galena. At a slightly lower elevation the country rock is cut by a distinct vein less than 2 inches in width containing calcite with scattered bits of sphalerite, galena, and chalcopyrite. About 6 inches of slightly mineralized rusty gouge lies on each side of the vein.

At neither of these points are there sufficient base-metal minerals exposed to encourage development work.

GOLD PLACERS

Desultory gold-placer operations have been carried on along Metal Creek for the last 20 years. The stream bed has been staked for the first 10 miles, but many of the claims have been allowed to lapse. No figures are available for the total production from this creek, but it probably does not exceed a few thousand dollars.

Metal Creek is a turbulent stream occupying a steep-walled hanging valley to a point near its mouth, where it drops down through a canyon into Knik River. Above the canyon it runs over a narrow flood plain, consisting in part of huge boulders. It is too large and too swift to ford during the summer. There are several small streams tributary to lower Metal Creek that are available for sluicing or developing power.

The gold lies on the bedrock well below high-water mark. It is difficult of access except during periods of low water in the fall, when prospectors have had some success "sniping." Sluicing has been done on a group of claims about 8 miles above the mouth of the creek.

Colors can be panned anywhere along lower Metal Creek. The gold is reported to become increasingly coarse upstream. The country rock is slate and graywacke near the mouth of the creek and greenstone farther up. Granite (diorite?) is reported to be the country rock toward the headwaters. The gold found in the bed of Metal Creek probably came from lode deposits in or near the granite.

COAL

A 3-foot bed of coal crops out on the west side of Carpenter Creek in the tract of Chickaloon rocks about half a mile south of Matanuska River. A prospect tunnel 20 feet long has been driven into the seam about 30 feet above the creek bed.

The coal bed strikes N. 75° W. and dips 17° N. It is interbedded with carbonaceous shale. At 20 feet below the portal of the tunnel lies a 4-foot basic sill, one of several that are intruded into the Chickaloon sediments in this vicinity. A rhyolite porphyry dike about 20 feet thick completely truncates the bed of coal between the portal and the top of the hill.

The coal itself is clean and shiny, but movements suffered since its formation have slickensided it and made it somewhat friable. This particular coal bed gives little promise of future value owing to its character and its relation to the igneous intrusive, but there may be in the vicinity other seams of better quality and more favorable location.

A well dug on the fur farm of Bailes & Keily, between the Wolverine Lakes, encountered a few fragments of coal on the bedrock surface. This coal is dirty and broken and is traversed by narrow stringers of calcite.

A coal outcrop has been reported on the south bank of Matanuska River across from Granite Creek, but it was not found by the writer. It is quite possible that coal exists in the narrow belt of Chickaloon rocks that extends westward from the mouth of Granite Creek, but at almost all points these sediments underlie high terrace gravel and thus are difficult to prospect.

THE TOKLAT-TONZONA RIVER REGION

By Stephen R. Capps

INTRODUCTION

LOCATION AND GENERAL CHARACTER

The region here considered lies on the northwest flank of the Alaska Range and extends from the headwaters of the main Toklat River southwestward to the head of Tonzona River, an air-line distance of about 100 miles. In this region the Alaska Range rises abruptly from the lowlands on the northwest. The lowlands are of mild relief, are covered by marshes interspersed through areas of timber, and have few rock exposures. The difficulties of summer travel by pack train in these lowlands are so great and the geologic results to be obtained there are so meager that they have so far received little attention from the geologist. The Alaska Range, by contrast, is in this region practically devoid of timber, rock exposures are excellent, and travel by pack train along the front of the range is easy. Yet the mountain mass is extremely rugged, and all the larger valleys are occupied by great glaciers that push well out toward the mountain front and bar ready access to the higher parts of the mountains. These conditions leave a belt some 15 to 25 miles wide in which the geologic results to be obtained justify the expenditure of time and effort necessary to examine it at present.

The region discussed in this report (pl. 2) lies between parallels 62° 40′ and 63° 25′ north latitude and meridians 149° 50′ and 152° 40′ west longitude and comprises an area of about 2,000 square miles. Toklat River, at the east edge of the region, is about 48 miles west of McKinley Park station on the Alaska Railroad. Most of the area lies within the borders of the Mount McKinley National Park.

PREVIOUS SURVEYS

Until the completion of the Alaska Railroad from Seward to Fairbanks, in 1923, the region on the north flank of the Alaska Range, in the vicinity of Mount McKinley, was difficult of access and was visited by comparatively few persons. Most of those who entered this area were prospectors, hunters, and trappers, who worked southward from the Kantishna mining district, but in general these men left no permanent record of their discoveries. Since 1902 our only accurate knowledge of the region on the northwest slope of the Alaska Range west of Muldrow Glacier has been derived from Brooks's monumental exploration in that year, during which instrumental topographic surveys and systematic geologic observations were carried from Cook Inlet to Rampart by way of Rainy Pass, the north flank of the range, and Nenana River.[1] Although Brooks's expedition brought out an astonishing amount of geologic information from the region traversed, nevertheless it made only a hasty exploration in which the difficulties of long and rapid marches consumed much of the energy of Brooks and his assistants. Later work in other parts of the range has added greatly to our knowledge of the geologic history of this province. Prindle, in 1906, visited the Bonnifield and Kantishna mining districts,[2] and Moffit[3] and Capps[4] have studied adjacent areas, each of these investigations throwing additional light on the stratigraphy and structure of the range.

Several mountaineering expeditions, organized for climbing Mount McKinley, have visited this region and have been followed by publication of narrative accounts of the expeditions and descriptions of the regions traversed.[5] These expeditions have added considerably to our knowledge of the geography of the immediate vicinity of Mount McKinley and have supplied scattered notes on the geology, but none of them was accompanied by a trained geologist, and no areal geologic mapping was attempted.

PRESENT INVESTIGATION

The expedition that gathered the material for this report was organized in 1925 for the purpose of carrying a reconnaissance geologic survey from Toklat River southwestward along the face of the Alaska Range to connect with earlier surveys by the writer in the Toklat and Kantishna districts and to review in greater detail a part of the area visited by Brooks in his hasty explorations in 1902.

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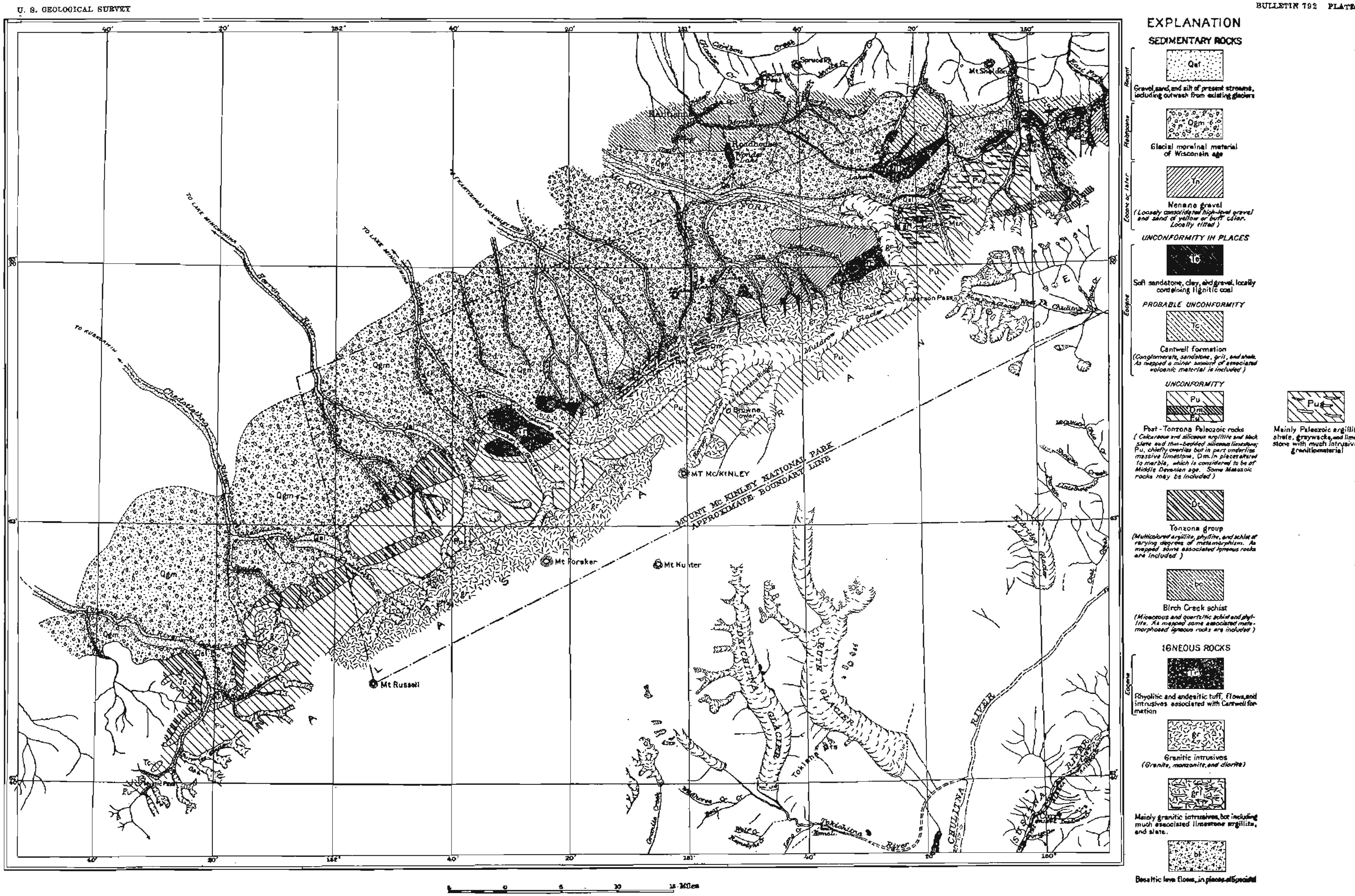
[1] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, 1911.

[2] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, pp. 205–226, 1907.

[3] Moffit, F. H., The Broad Pass region, Alaska: U. S. Geol. Survey Bull. 608, 1915.

[4] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, 1912; The Yentna district: U. S. Geol. Survey Bull. 534, 1913; The Kantishna region, Alaska: U. S. Geol. Survey Bull. 687, 1919; Mineral resources of the upper Chulitna region: U. S. Geol. Survey Bull. 692, pp. 207–232, 1919.

[5] Dunn, Robert, The shameless diary of an explorer, Outing Publishing Co., 1907. Cook, F. A., The top of the continent, Doubleday, Page & Co., 1908. Browne, Belmore, The conquest of Mount McKinley, G. P. Putnam's Sons, 1913. Stuck, Hudson, The ascent of Denali, Chas. Scribner's Sons, 1914.



GEOLOGIC MAP OF THE TOKLAT-TONZONA REGION

A short visit was made to the Kantishna mining district at the end of the field season. The party consisted of S. R. Capps, geologist, and two camp hands, Elmer Larson and M. L. Eckart, to both of whom the writer wishes to express his thanks for faithful service. Seven pack horses were used to transport the necessary supplies and equipment. The party left the railroad at McKinley Park station on June 14 and returned to the starting point on September 4. No topographic mapping was attempted, the original topographic map made by D. L. Reaburn, of the Brooks expedition, being used as a base. To this map certain additions were made from sketches by the writer, consisting principally in extending the headward portions of streams and glaciers into areas not seen by Reaburn. Although these sketches were only roughly controlled by compass readings, they nevertheless give a general idea of the drainage in areas which until now have remained blank on published maps.

The writer here wishes to acknowledge courtesies extended by Harry Karstens, of the National Park Service, Thomas A. Marquam, of the McKinley Park Transportation Co., O. M. Grant, of Copper Mountain, and the miners of the Kantishna district, whose hospitality was unfailing.

GEOGRAPHY

DRAINAGE

The region here described lies along the northwest flank of the highest portion of the Alaska Range, and as large areas in the range are above the level of perpetual snow, the main valley heads on both flanks are occupied by glaciers. The crest of the range lies much nearer the northwest than the southeast edge of the range, and this configuration has led to the development of many short parallel valleys descending the northwest slope of the range, each occupied by a small separate glacier, in contrast to the elaborately branching valleys of the Susitna slope, where many smaller ice tongues converge into major trunk glaciers. Muldrow Glacier, which drains the northeast slopes of Mount McKinley, differs conspicuously from both these forms, for it occupies a valley that trends parallel to the axis of the range and receives a number of large tributary ice streams. Muldrow Glacier has a total length of about 44 miles and with its tributaries covers an area of at least 75 square miles. It therefore ranks among the largest half dozen glaciers of the Alaska Range. The other principal glaciers of the region, including Hanna, Straightaway, Foraker, Herron, and Chedotlothna Glaciers, range in length from 11 to 14 miles, and there are a large number of smaller, unnamed glaciers from 8 miles to 1 or 2 miles long.

All the larger streams within this area head in the glaciers of the Alaska Range and therefore are supplied in large part by waters flowing from the melting ice fields. As a consequence the volume of stream discharge is extremely variable, being lowest in the winter and greatest on the long warm days of summer or during warm rains, when the melting of the glaciers and snow fields is most rapid. In the winter stage of low flow the streams run clear, being fed mainly by springs. In summer, by contrast, when the glacial discharge is active, the streams are turbid from a heavy load of gravel, sand, and silt.

As a consequence of the heavy load of glacial débris which they carry and of their great daily and seasonal variation in volume the glacial streams tend to build up extensive valley-floor deposits of gravel and sand, and they generally flow over these deposits in many braided channels. These glacial-outwash deposits consist of coarse boulders near the glaciers, but their materials become progressively finer downstream, and as a result the valley flats narrow, and there is less tendency for the streams to break into smaller channels.

About three-fourths of the area here described lies within the drainage basin of Kantishna River. Toklat River and Stony Creek, its tributary, drain directly to the Kantishna around the east side of the Kantishna Hills. McKinley Fork, the largest tributary of the Kantishna, heads in Muldrow Glacier and is also fed by Clearwater Creek, Muddy River, and Birch Creek. In the area here described McKinley Fork flows in a multitude of channels over a wide gravel flat, and though the total volume of water discharged is considerable, the stream is not navigable even for small power boats. By proper care in choosing a ford it may be crossed on foot between the mouth of Clearwater Creek and Muldrow Glacier in all but extremely high stages of flood. North of the area here shown (pl. 2) this river flows in a northerly direction around the west base of the Kantishna Hills and below the settlement of Roosevelt is navigable in summer for boats of moderate draft.

Foraker, Herron, Chedotlothna, and Tonzona Rivers are supplied mainly by glacial waters, and all have the characteristics of glacial streams, though none of them discharge so much water as McKinley Fork. Foraker and Herron Rivers flow northward to Lake Minchumina and thence drain to the Kantishna. Chedotlothna and Tonzona Rivers are headward tributaries of the Kuskokwim. All these streams can be forded on horseback in ordinary summer stages, but all are large and swift enough to make fording on foot dangerous except during times of low water.

RELIEF

KANTISHNA-KUSKOKWIM LOWLAND

The Alaska Range is bordered on its northern and western flanks by a great lowland of varying width that extends for practically the entire length of the range—from the international boundary on the east to and beyond the great bend of the Kuskokwim on the southwest. This lowland, in the region here described, is occupied by the headward tributaries of Kantishna and Kuskokwim Rivers. It is a great structural depression in which a large quantity of detritus, derived mainly from erosion of the Alaska Range, has been deposited, and its prevailing surface forms are the result of stream and glacial aggradation, with here and there isolated groups or ranges of hard-rock hills rising above the general level of the plain. This lowland has been little studied except around its borders, for the marshy character of the ground, the thick timber and brush, and the many rivers that cross it render summer travel difficult. It is believed likely, however, that at some earlier time, perhaps early in the Pleistocene, it was a single great river basin, drained by a stream that followed the general course of the Tanana to about the mouth of the present Kantishna and thence swung to the southwest across the present divide and into the basin now occupied by the upper Kuskokwim.

The Kantishna-Kuskokwim lowland has in general an altitude of less than 1,000 feet, though in this area its margin along the mountains ranges from 1,600 to 3,000 feet above sea level. This high margin is crossed by many streams that drain radially from the highlands. Farther out in the lowland these streams unite into larger rivers which converge into the Kantishna or the Kuskokwim. The divide between the basins of these great rivers is said to lie between Herron and Chedotlothna Rivers, though from the mountains one's eye can not follow the rivers far enough to determine their final course, and the course of the drainage lines in that unsurveyed area has been wrongly shown on many published maps. The most trustworthy information obtainable is that Chedotlothna River is the easternmost tributary of the Kuskokwim, and that Herron and Foraker Rivers flow to Lake Minchumina and thence to the Kantishna.

ALASKA RANGE

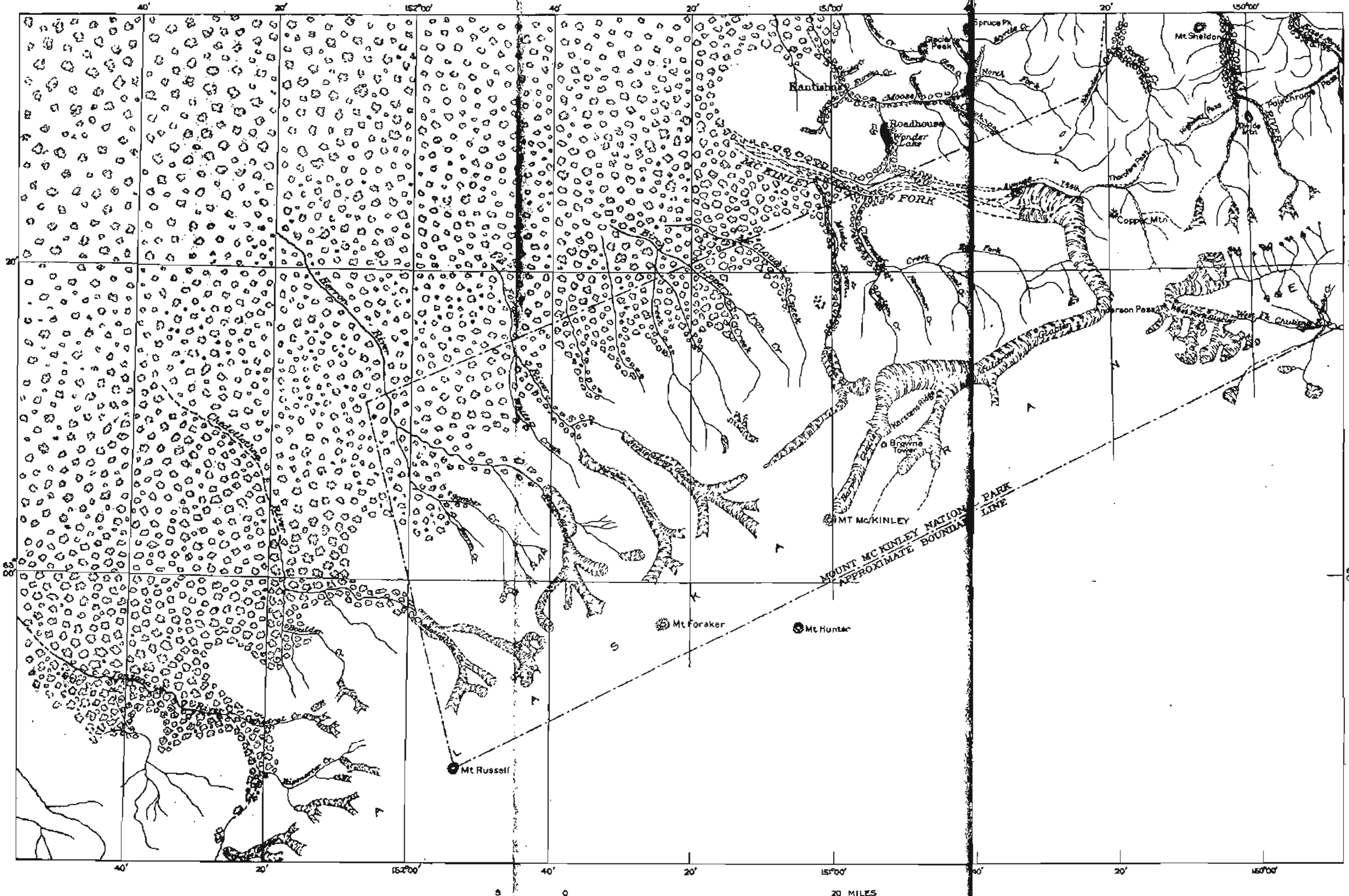
The region between Muldrow Glacier and Tonzona River is noteworthy because, although in this stretch the Alaska Range reaches its greatest height, the mountains rise abruptly from the lowland on the north without any intermediate belt of foothills. Between Muldrow

Glacier and the railroad along Nenana River and, in fact, as far eastward as Delta River the main range is bordered on the north by a considerable foothill belt, and foothills are developed also southwest of Tonzona River. These outlying hills have been described elsewhere.[6] Groups of isolated hills rise above the lowland level, but their structure has not been studied, and it is doubtful if they are structurally and geologically related to the Alaska Range. At any rate they are so separated from it by intervening lowlands that they would not be considered to belong to the Alaska Range geographically. The abrupt front of the range, which rises from the moraine-covered edge of the lowland, is probably the result of both folding and faulting. The nearly straight line of the mountain front suggests a great fault scarp, but the fault could not be directly observed, and the steep dip of the sedimentary beds, in many places as high as 90°, is evidence that in the uplift of the mountain mass a sharp flexure of the rocks took place. The relative importance of faulting and folding in determining the abrupt front of the range has not been determined.

The Alaska Range forms one of the major geographic features of the continent, culminating in Mount McKinley, the loftiest mountain in North America, with an altitude of 20,300 feet. The part of the Alaska Range here under consideration lies at the crown of the great arch described by the axis of the range. At Mount McKinley the axial direction of the range is northeast, and as the range approaches the headwaters of Toklat River it veers to east. Southwest of the mountain the range swings southward and approaches a due south trend at its south end. In this area the range is from 30 to 50 miles wide, but its crest, as roughly indicated by a line drawn through Mounts McKinley, Foraker, and Russell, lies at an average distance of only 12 miles from the Kuskokwim-Kantishna lowland and is therefore much nearer to the northwest than to the southeast border of the range. The abrupt rise from the lowlands on the northwest to the crest of the range gives this magnificent mountain chain an aspect that for sheer steepness and for scenic grandeur can scarcely be matched elsewhere. From places on Hanna Glacier the slopes of Mount McKinley rise from 5,000 to more than 20,000 feet in a horizontal distance of less than 5 miles. The limit of perpetual snow here lies at an altitude of about 7,000 feet, so that the higher parts of the range are concealed by a permanent mantle of ice and snow except on cliffs that are too steep to afford lodgment for it.

All the larger valleys that head back against the crest of the range are occupied by glaciers that push well down toward the mountain

[6] Capps, S. R., The Kantishna region, Alaska: U. S. Geol. Survey Bull. 687, pp. 13–14, 1919; The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, p. 12, 1912.



SKETCH MAP SHOWING DISTRIBUTION OF TIMBER IN THE TOKLAT-TONZONA REGION front. Muldrow Glacier extends several miles out into the lowland belt, but in the other valleys the ice tongues reach only to the face of the range. The steep slopes of the main range and the glacier-filled valleys make access to the higher mountains difficult, and few persons have penetrated the range more than a short distance. A number of well-equipped mountaineering expeditions have attempted to ascend Mount McKinley, and although at least three parties have reached the higher slopes only a single expedition[7] succeeded in ascending its highest peak. Mounts Foraker, Hunter, and Russell, magnificent peaks of the first magnitude, are as yet unscaled, and a considerable area in the heart of the range is still entirely unexplored.

CLIMATE

No accurate weather records have been taken in this immediate area, but it is known that the climate here is much like that of the general region on the north slope of the Alaska Range. In interior Alaska in general the summers are moderate and the winters cold. The annual precipitation is light, ranging in the Tanana Valley between 8 and 19 inches and averaging about 11 inches, though in the mountains it is doubtless higher. The mean annual temperature at Fairbanks is about 25°, with a range between 86° and −65° F. Along the flank of the Alaska Range the weather is influenced by local conditions. During most of the time in the summer the higher peaks of the range are in clouds, and local showers are frequent. In winter the snowfall is considerable in the mountains but is light north of the range.

VEGETATION

In this region the Alaska Range proper in practically devoid of trees. Timber grows up to altitudes of 2,000 to 2,800 feet and reaches its greatest altitude along the main river valleys, as shown in Plate 3. The entire Kantishna-Kuskokwim lowland below an altitude of about 2,000 feet contains timber, though by no means in a solid stand, for the lowland contains many marshy tracts in which the trees are scattered and scrubby. The principal trees are spruce, cottonwood, birch, and larch, none of which reach large size. Spruce trees exceptionally reach a diameter of 2 feet at the base, but they average much smaller and yield little clear lumber. It is therefore apparent that this timber has value only for rather local uses.

Along the immediate base of the Alaska Range timber for camping purposes is available in only half a dozen of the larger valleys, and the main dependence of the Geological Survey expedition for fuel was on willows and brush. A few miles northwest of the route

[7] Stuck, Hudson, The ascent of Denali, Chas. Scribner's Sons, 1914.

traveled, however, timber is abundant. Small cottonwood trees are locally and willow bushes generally to be found above the highest spruce timber. For any mining operations that may be undertaken in this part of the range it will be necessary to haul wood for fuel and for structural uses for some distance.

Grass is found generally throughout the region, though the traveler will often find it necessary to select his camp site with the problem of horse feed in mind, for there are considerable areas where forage is scarce. The principal forage plants are redtop, "bunch grass," and at a few places "pea vine," a vetch that grows locally on the gravel bars of the streams. Stock can subsist on the local vegetation only between June 1 and September 15, for after the first heavy frosts the grasses lose most of their nutritive value. The region contains several wild edible berries, including currants, raspberries, and blueberries. The blueberries are especially abundant and grow best above timber line at altitudes of 2,000 to 2,800 feet.

Little agriculture has been attempted in the region here described. On Wonder Lake and on Friday Creek, in the Kantishna mining district, gardens have been cultivated successfully at altitudes of 1,600 to 1,800 feet. No doubt similar success with quickly maturing crops could be obtained elsewhere in equally favorable places, but in general the agricultural possibilities of the area along the foot of the Alaska Range are small, though no doubt stock could be grazed there during the summer.

GAME

The northern slope of the Alaska Range from Nenana River westward is notable for the abundance of big game. From McKinley Park station on the Alaska Railroad to Muldrow Glacier the white bighorn sheep abound, and hundreds may be counted on a single day. Between Muldrow Glacier and Tonzona River they are much less numerous, but southwest of the Tonzona they are again plentiful. The entire region is a summer feeding ground for great herds of caribou, which on hot days climb high on the mountains and glaciers to escape the heat and the insects. Moose are much less numerous but are frequently seen in the timbered and brushy valleys. Grizzly bears range throughout the mountains, and black bears in the timbered lowlands. Rabbits and ptarmigan are at times very numerous, but they vary in abundance from year to year. Some fur-bearing animals occur, notably fox, lynx, mink, and marten. Much of the area here described lies within the limits of the Mount McKinley National Park, where hunting and trapping are forbidden.

This part of Alaska is poorly supplied with fish. Most of the streams, being glacier-fed, are turbid in the summer, and fish avoid them. Streams that are clear contain grayling but not in great abundance. Wonder Lake contains trout, but that is the only locality in this area where trout are known to occur. So far as known, the salmon, which each year migrate up Kuskokwim and Tanana Rivers to spawn, do not come to the headward reaches of these streams.

POPULATION, TRAILS, AND TRANSPORTATION

Except for some 30 miners in the Kantishna district, two prospectors at Copper Mountain, and one on Carlson Creek, this region is unpopulated. A few prospectors visit the area from time to time, and an occasional hunting party crosses it on the way to hunting grounds outside the park. Even the natives rarely visit it, as their villages are in the lowlands along streams from which they can obtain fish. West of Muldrow Glacier and south of McKinley Fork there is a single prospector who may be considered a permanent resident. There are no well-marked trails except those of the wild animals. Travelers to this region in summer come either by trail from the railroad at McKinley Park or up Kantishna River by boat to Roosevelt, some 20 miles north of Kantishna post office, and thence overland. A good wagon road is now under construction westward from McKinley Park station, and some 20 miles was completed by the end of 1925. From the end of the road a good trail for pack horses leads by way of Igloo Creek and Polychrome, Highway, and Thorofare Passes around the end of Muldrow Glacier past Wonder Lake to Kantishna post office. Eventually this trail will be superseded by the extension of the wagon road now being built.

In spite of the entire absence of man-made trails southwest of McKinley Fork, travel by pack train in summer presents no serious difficulties. By following close to the northwest face of the range, generally above timber line, the traveler finds an open country with solid footing for horses and little obstruction from trees or brush. Here, too, the torrential glacier streams, which below unite to form deep rivers, are small enough to be forded on horseback except in flood stages. They are, however, large enough to be difficult and dangerous to cross on foot during the summer.

The Alaska Range itself is high and rugged, and travel into its higher parts and up the glacier-filled valleys, where no fuel for camping is to be found, requires alpine equipment. The lowland below an altitude of 2,000 feet, by contrast, is in general timbered and marshy and is crossed by many rivers too large to ford but too swift and shallow to be navigable except by poling boat or canoe, so that it is to be avoided in summer. In winter, when the streams and marshes are frozen, travel by dog sled is feasible anywhere except in the higher parts of the range.

GEOLOGY

GENERAL OUTLINE

The surface distribution of the rock formations of this area, in so far as they have been differentiated, is shown on the accompanying geologic map. (Pl. 2.) The geologic field work on which this map is based has all been of reconnaissance character, a large area being covered during a short field season, so that it has been possible to outline the geologic units only approximately. Even when the position of the formational boundaries was accurately determined in the field it was often impossible to record the details, for the base map used was made in a hasty exploratory trip in 1902, and no time was available to the topographer for refined mapping of the details of surface form. An additional difficulty confronts the geologist working in this region because of the scarcity of fossils from which the age of the sedimentary beds may be accurately determined, and so likewise the age of the igneous rocks is difficult to determine through their relations to sedimentary beds of known age. The only recognizable organic remains found in any of the rocks during the present investigation were some fragmentary leaf imprints from the Cantwell formation on Tonzona River. No fossil shells were seen. It has therefore been necessary to leave the question of the age of the rocks largely unsettled, though correlations are suggested with beds of similar lithology and known age elsewhere. The tentative age assignments here given are subject to change or modification as fuller information is obtained, and it is certain that some assemblages of beds here grouped together will later be subdivided.

The geologic subdivisions shown on the accompanying map have already been described in reports on this and contiguous areas, and elaborate descriptions are unwarranted here. In the following pages a brief description of each subdivision is given, with reference to more complete published descriptions.

As shown on the geologic map (pl. 2) the pre-Tertiary rocks are divided into eight units, each of which is distinguished by a separate pattern. Each of two of these units is a combination of two others; one is an assemblage in which igneous rocks predominate but which includes also considerable sedimentary material, and the other is a similar assemblage in which the sedimentary beds predominate over igneous rocks. The same sedimentary rocks where comparatively free of intrusive materials are shown by a separate pattern, as are the intrusive rocks where they contain only minor amounts of included sediments.

The oldest formation is undoubtedly the Birch Creek schist, which occurs in this area only along the valley of Moose Creek in the Kantishna mining district. The schists of this formation are unfossiliferous, and their age has not been definitely determined, but from their association elsewhere with fossiliferous sedimentary beds it is known that they antedate the Ordovician period, and they may be of pre-Cambrian age. The rocks that appear to be next younger than the Birch Creek schist are a group of schists and phyllites, grading toward the southwest into less metamorphic argillites. This group, which is known as the Tonzona group, has so far yielded no fossils, but from certain relations Brooks[8] tentatively assigned it to the Lower Devonian or the Silurian, and definite information is still lacking upon which to make a more precise age determination. A third pre-Tertiary group of sediments constitutes the major element of the north flank of the Alaska Range. It is composed dominantly of black blocky argillite and graywacke, with some black slate, some thin-bedded limestone, locally siliceous, and calcareous shale and argillite, all more or less intimately intruded by dioritic rocks. The age of these sediments is not accurately known, but from their association with a massive limestone that elsewhere has yielded Middle Devonian fossils these rocks are known to be in part, at least, of Paleozoic age, and the group probably includes beds some of which are older and some younger than the limestone. It is possible, moreover, that some Mesozoic black argillites and slates are also included in the group as here mapped. Certain massive limestones that occur in the Toklat Basin and near Hanna Glacier are shown by a separate symbol on the map. (Pl. 2.) These limestones are highly metamorphosed and recrystallized, so that any fossils they may have once contained have been destroyed, but they lie along a belt that extends eastward to Nenana River in which limestones with similar lithologic relations have yielded Middle Devonian fossils. The limestones separately mapped in this report are believed to be also of Middle Devonian age.

In addition to the above-mentioned pre-Tertiary sedimentary rocks there are in the Toklat Basin certain areas of greenstone that are probably Mesozoic, and in the Alaska Range large areas of intrusive granitic rocks, mainly diorite. These granitic materials were probably intruded in Jurassic time. They cut the older sediments and in places are so intimately intruded in them that it is impossible to separate them on a map of the scale of Plate 2. In such places they are shown either as areas composed mainly of granitic rocks with some included sediments or as mainly sedimentary rocks with considerable intrusive material.

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[8] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, pp. 73–76, 1911.

The Tertiary rocks are here divided into three formations, the oldest of which is the Cantwell formation. This formation is composed mainly of conglomerate, sandstone, and shale and is associated and in part interbedded with some intrusive and extrusive igneous materials composed mainly of volcanic flows and tuffs. Fossil plant remains reported from the Cantwell formation indicate that it is of early Tertiary age. It is succeeded, probably unconformably, by lignite-bearing sandstone and shale such as occur at intervals along the entire northern face of the Alaska Range. These beds are to be correlated with the lignite-bearing beds of the Nenana coal field, which have been determined to be of Eocene age. Above the lignite-bearing Eocene beds is a thick series of high gravel deposits that in this area have been differentiated only in Polychrome and Thorofare Passes and in the basin of Clearwater Creek. These deposits, the Nenana gravel, are believed by the writer to be of Tertiary age, though younger than the coal-bearing formation. They have so far yielded no fossils. The Quaternary deposits as mapped in this region include two broad groups of materials; the older comprises the widespread mantle of glacial drift that generally marks the southeast margin of the lowlands and was deposited by the glaciers during a time when they were expanded much beyond their present size, and the younger consists of the present stream deposits, including the gravel, sand, and silt of the present flood plains of the streams. These younger deposits, to be sure, are largely the outwash of glacier-fed streams and are therefore mainly of glaciofluvial origin. Other Quaternary deposits, including accumulations of talus and older terrace gravel, are of small areal extent and have not been differentiated on the geologic map.

The following table gives the stratigraphic sequence for this district in so far as it is now known.

Quaternary: Gravel, sand, and silt of present streams; talus accumulations; peat and impure organic deposits, or muck; soils and rock disintegration products in place; deposits of existing glaciers; terrace and bench gravels, some of glacio-fluvial origin; morainal deposits, mainly of Wisconsin age, but possibly including some of pre-Wisconsin age.

Tertiary:

- Nenana gravel (loosely consolidated elevated gravel and sand, yellow or buff, locally tilted).
- Lignite-bearing formation (generally light-colored soft sandstone, clay, and gravel, little indurated, locally containing lignite). Contains Eocene plants. Locally associated with sediments are lava and tuff.
- Cantwell formation (generally dark-colored, indurated conglomerate, grit, sandstone, and shale, with some carbonaceous material). Generally classified as Eocene, although there seems to the writer a possibility that the deposits may be Upper Cretaceous. Associated with the formation are dikes and considerable thicknesses of lava and tuff.

Mesozoic (?) (possibly some of the shales and graywacke beds here grouped with the post-Tonzona Paleozoic rocks are of Mesozoic age):

Granitic intrusives, mainly diorite.

Amygdaloidal and ellipsoidal greenstone.

Post-Tonzona Paleozoic rocks:

Argillite, slate, and graywacke, locally calcareous; thin-bedded limestone, locally siliceous; in places intensely intruded by granitic rocks. This group contains some beds that underlie and some that overlie the Middle Devonian limestone and may even contain beds as young as Mesozoic.

Middle Devonian limestone: Massive crystalline limestone beds in Toklat Basin and near Hanna Glacier, everywhere highly metamorphosed.

Paleozoic argillite, phyllite, and schist, varicolored. In general highly metamorphosed to schist. Older than the Middle Devonian limestone.

Devonian or Silurian:

Tonzona group: Multicolored argillite, phyllite, and schist of varying degrees of metamorphism.

Pre-Ordovician: Birch Creek schist (micaceous and quartzitic schist and phyllite).

STRATIGRAPHY

BIRCH CREEK SCHIST

Character and distribution.—The Birch Creek schist appears in the area here under discussion only as a narrow strip along the valley of Moose Creek, in the Kantishna mining district, although it is the prevailing formation in the Kantishna Hills, just north of this area, and forms an important element of the Alaska Range farther east, occupying a continuous belt that extends from McKinley Fork at least as far eastward as Delta River. The Birch Creek schist of this general region has been described by Brooks,[9] Prindle,[10] and Capps.[11] The prevailing phase includes highly contorted fissile mica schist, quartzite schist, and phyllite in shades of green, brown, and gray. Where fresh and little weathered the rocks appear rather massive, but in weathered exposures they break down into thin flakes, the surfaces of which glisten with mica scales. The degree of schistosity is not uniform, the rocks ranging from highly fissile mica schists to rather massive, poorly cleaving quartzitic beds.

The schist is cut by many quartz veins, most of which are gash veins and stringers that follow the foliation of the schist and have been distorted in the general crumpling and folding that the rocks have undergone. These gash veins, lenses, and stringers are commonly little mineralized but are prevailingly of milky-white massive quartz with no visible sulphide minerals, though in places a little pyrite appears in them. In addition to the twisted gash veins that

[9] Brooks, A. H., op. cit., pp. 56–60.

[10] Prindle, L. M., The Bonnifield and Kantishna regions: U. S. Geol. Survey Bull. 314, p. 206, 1907.

[11] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, pp. 20–22, 1912; The Kantishna region, Alaska: U. S. Geol. Survey Bull. 687, pp. 26–29, 1919.

follow the cleavage planes of the schist there are in places later quartz veins that cut across the foliation and are mineralized with sulphides and free gold. Some of these later veins are many feet wide, have been traced for several hundred feet, and have a valuable content of gold, silver, and lead. This group of veins has doubtless supplied most of the placer gold to the streams of the Kantishna district, and two mines have produced a considerable tonnage of ore of high grade. Other veins, probably of the same group, contain large bodies of stibnite. The prevailing mineral association in these veins is arsenopyrite, pyrite, galena, sphalerite, stibnite, tetrahedrite, gold, and silver. The schist itself contains some scattered pyrite but has so far not been found to contain metals in minable amounts.

Structure and thickness.—The Birch Creek schist is believed to have consisted originally of sedimentary materials, including shale, sandstone, and a little limestone. As a result of deep burial and intense folding and crumpling at various times these rocks have been completely recrystallized and metamorphosed into the schists we now see. As a result of the very processes that have developed mica schists from previously unaltered sediments the schists have a highly complex structure. This structure includes larger close folds upon which are superimposed smaller folds and close crumpling and contortion, so that no trustworthy estimate can be made of the original thickness of the beds from which the schists were derived. Furthermore, the schists are the oldest rocks in this region, and their base is nowhere exposed. It can only be said that the Birch Creek schist in the Kantishna district is now at least 2,500 feet thick and is probably much thicker. The structure is highly complex in detail, but in a broad way the strike of the foliation is parallel with the axis of the Alaska Range and its dip is steep.

Age and correlation.—Precise information concerning the age of the Birch Creek schist is still lacking, although the formation has been studied in many parts of Alaska and by many observers. The schist lacks fossils from which its age could be accurately determined, and as it is everywhere the oldest formation in the district in which it is found, nothing concerning its age can be deduced from the character of the underlying rocks. In this general region the rocks next younger than the Birch Creek are the argillite and phyllite of the Tatina group, which is tentatively assigned to the Ordovician. If this assignment is accepted it would make the Birch Creek at least pre-Ordovician. In the Yukon-Tanana region, where the Birch Creek is extensively developed, there is a thick series of sediments, the Tatalina group, that lies beneath Lower Ordovician beds and above the Birch Creek schist. The exact age of the Tatalina is still undermined, but it is in part correlated with rocks that are known to include Middle Cambrian fossils, and its presence between Ordovician rocks and the Birch Creek schist lends strong evidence to the conclusion that the Birch Creek may be of pre-Cambrian age.

TONZONA GROUP

Character and distribution.—A group of rocks that has been called the Tonzona group occurs in considerable areas along the northwest front of the Alaska Range. This group as a whole has been rather fully described by Brooks.[12] In the area here considered rocks of this group have been identified from Foraker Glacier to the basin of Tonzona River. In most of that area they consist of glossy thin-cleaving phyllites and schists in shades of red, green, blue, brown, and black, though west of upper Tonzona River they are less metamorphosed and include varicolored argillites and cherts.

In the belt of these rocks that extends from Foraker Glacier southwestward to and beyond Barren Creek and in the belt that crosses the Chedotlothna Basin the rocks of this group consist largely of phyllite that has a silky sheen along the cleavage planes, though their texture is fine and no individual crystals could be distinguished with the naked eye. Where sufficiently metamorphosed to exhibit a well-developed schistose structure these rocks are easily identified. In places, however, there are large bodies of black argillaceous material, partly altered to slate and phyllite that resemble certain phases of the post-Tonzona Paleozoic rocks described elsewhere in this report, and in these places the separation of the rocks of the Tonzona group, as shown on the accompanying map, is tentative only. On the east side of the Tonzona Basin south of Cathedral Creek there are certain quartzose schists, associated with black glossy phyllites and slates, that may have resulted from the metamorphism of some siliceous igneous rock. Their degree of metamorphism justifies their inclusion with the Tonzona group, especially as similar rocks occur in this group in the Bonnifield and Kantishna regions. West of upper Tonzona River, in the type area from which the group took its name, the rocks of this group are less metamorphosed than in the areas just mentioned and consist mainly of varicolored argillite with considerable chert.

Structure and thickness.—The structure of the Tonzona group in this region is highly complex. The close folding that developed the schistose structure has so complicated the section that no reliable estimate of the thickness of the beds can be made. In general the strike of the schistosity is roughly parallel with the trend of the

[12] Brooks, A. H., op. cit., pp. 73–76.

range, and the dip is usually high. In most places the bedding of the sediments from which the schists were derived can not be determined, though in localities where there is an alternation of schists of various colors the rocks of a single color may be presumed to represent what was originally a single bed or group of beds, and these also have prevailingly steep dips. West of Tonzona River the Tonzona rocks are less highly metamorphosed, and the structure is more easily decipherable. A section studied by Prindle[13] shows steeply dipping clay shale and grit with some limestone, interbedded with or cut by diabase. Faulting is everywhere common, and faults probably played an important part in determining the shape of the present outcrops of this group. It appears that the group must have an actual thickness in places of several thousand feet. No more definite figure can now be given.

Age and correlation.—No fossils have been found in the rocks of the Tonzona group, and its age can therefore be determined only in a general way. Brooks states that although its age is doubtful it is without doubt younger than his Tatina group, which is, in part at least, probably Ordovician. In the area here discussed it seems certain that the Tonzona rocks are older than the other rocks that appear in close association with them. These associated rocks include the Cantwell formation, which is classified as early Tertiary, and a great group of argillites, shales, slates, thin-bedded limy shales and limestones, and massive limestones. As will be shown later, most of the latter assemblage is believed to be of Paleozoic age, and the massive limestones within it are believed to be Middle Devonian. If, then, the conclusion is correct that the Tonzona rocks are older than the associated Paleozoic beds, they are older than Middle Devonian and younger than the part of the Ordovician that is probably represented by the Tatina group. The present evidence is therefore that the Tonzona lies somewhere between Ordovician and Middle Devonian.

POST-TONZONA PALEOZOIC ROCKS

Distribution and character.—The largest single group of rocks shown on the accompanying map (pl. 2) consists of an undifferentiated assemblage that includes blocky black argillite, slate, calcareous argillite, thin-bedded limestone and shale that are locally silicified, and considerable intrusive igneous material. Undoubtedly this group will be subdivided into a number of formations when it can be studied in detail, for it contains several rather distinct lithologic units. The country occupied by this group lies, however, in the high, rugged part of the Alaska Range, much of which is covered by perpetual snow and in which practically all the valleys are occu-

[13] Brooks, A. H., op. cit., fig. 8, p. 74.

pied by glaciers, so that it is difficult of access. The rocks of this group, furthermore, are all dark colored, so that close examination of exposures is necessary to determine their character.

In a general way it may be stated that this group is composed of argillaceous sediments, with minor amounts of coarser beds and with some thin-bedded limestones. These sediments include black blocky argillite and black slate, locally intimately interbedded with graywacke. Elsewhere the slate or argillite is calcareous and is interbedded with thin-bedded limestone. In still other places both argillite and limestone have been strongly silicified, much of the lime having been removed and replaced by secondary silica. Near the contacts with large bodies of intrusive materials all the sediments have been contact-metamorphosed, and the argillite has become a hard, massive, dense rock, filled with secondary minerals and locally mineralized by sulphides, chief of which is pyrite. It is in this group of sediments, at places near the borders of large granitic intrusive masses or where they have been intimately intruded by dikes and sills as offshoots from the larger intrusive masses, that most of the mineral deposits in this region occur. In certain areas, notably that just east of Muldrow Glacier in the vicinity of Copper Mountain, the volume of granitic intrusive rock injected into this group of sediments approaches that of the intruded sediments. Such places are shown on the accompanying geologic map by a conventional pattern. In other places, notably east and west of Hanna Glacier, the intrusive rock predominates in volume over the sediments, although a large amount of sedimentary material is included within the boundaries of the igneous mass. These areas also have been shown by a conventional pattern.

Structure and thickness.—Only the general structural features of this group of rocks have been worked out, but it is known that these beds have been deformed by mountain-building processes during at least two distinct periods and possibly more. One of these periods was probably late in Mesozoic time, and another occurred during middle or late Tertiary time. Each deformation resulted from folding, faulting, and tilting along approximately the present alinement of the Alaska Range. The beds now present a wide range of structure, which runs from steep monoclinal dips to great major folds upon which secondary smaller folds are superposed, the whole having been more or less complicated by faulting and locally by intricate intrusion. In the upper Toklat Basin this group of rocks, including the Middle Devonian limestone, which is in reality a part of the group, although it is mapped separately, dip steeply to the north beneath the Mesozoic greenstones and the Cantwell formation. No older rocks have been recognized in that locality. Farther west, in the basins of Herron and Chedotlothna Glaciers, these rocks overlie the older Tonzona schists but have been infolded with them. Throughout much of their area, in the rugged snow-covered parts of the range, the structure of this group has not been deciphered.

The complex structure of this group of beds renders difficult any estimate of its thickness, and the problem is further complicated by the fact that in no one locality were both the top and bottom of the group observed. Furthermore, there is generally a profound erosional unconformity between these rocks and the next younger formation with which they are in contact, an unknown thickness of the older group having been removed by erosion. Their wide areal distribution, however, and the great vertical relief of mountains composed wholly or in large part of these rocks indicate that the group must be at least 3,000 feet thick, and it may be much thicker.

Age and correlation.—The best definite evidence of the age of this great rock assemblage is that it includes materials that lie both above and below the limestone that has been assigned to the Middle Devonian. Logically this Middle Devonian limestone is a part of this group, but as it is a distinct lithologic unit and in places could be differentiated from the rest of the group it has been shown by a separate pattern on the accompanying geologic map. The beds beneath the limestone are obviously older than it and are younger than the Tonzona group. Probably they are in part of earlier Devonian age, though some may be as old as Silurian. Obviously also the beds that overlie the limestone are younger than it. The next younger formation in this region is the greenstone that on somewhat doubtful grounds is assigned to the Mesozoic. All that can definitely be stated about this group is that it includes rocks both younger and older than the Middle Devonian limestone, and the group as a whole is thought to be mainly of Paleozoic age. It is proper to note, however, that in lithology parts of this group closely resemble a great series of argillite, slate, and graywacke that is extensively developed on the southeast flank of the Alaska Range, in the Susitna Basin, and that is believed to be of Mesozoic age. Possibly a part of the rocks here assigned to the Paleozoic may be of Mesozoic age. No fossils have been found in these rocks, and fossils are likewise almost entirely absent from the Mesozoic slate and graywacke group of the opposite flank of the range. Further field studies will be necessary before the age limits of this rock group can be determined and before a positive statement can be made that it includes only Paleozoic terranes.

Middle Devonian limestone.—At several places in this region, notably at the headwaters of Toklat River and on either side of Hanna Glacier, there are exposures of massive limestone associated with black argillite, slate, and limy argillaceous sediments. In the Toklat Basin the limestone is interbedded with sedimentary rocks, and some small bodies of granitic intrusive material cut the sedimentary series. The limestone does not occur in a continuous band, as might be expected, but is interrupted by faults and has consequently a patchy distribution. Near Hanna Glacier the limestone and associated sediments have been so extensively intruded by granitic material that they now appear only as great lenses or irregular blocks completely inclosed by intrusive rocks. On the accompanying geologic map (pl. 2) the larger masses of limestone are shown in approximately their true position, but the innumerable irregular bodies of argillite, slate, and thin-bedded limestone that are included in the great intrusive mass are indicated only by a conventional pattern, for neither the scale to be used for the map nor the time available permitted their mapping in the field.

Everywhere, whether interbedded with sediments or inclosed by intrusive rocks, this limestone is crystalline and massive. Bedding planes are indistinct or unrecognizable. At the head of the main Toklat Valley the limestone is really a marble in shades of white, gray, or pale pink. Near Hanna Glacier it is gray to white on freshly broken faces, is completely recrystallized, and has much secondary calcite in veinlets and bunches. Weathered surfaces show evidence of some silicification. No trace of fossils was found in either locality.

The massive limestone in the upper Toklat Basin is much faulted and folded, so that its structure is obscure. The general strike of the faulted blocks is approximately parallel to the trend of the range and the dips are commonly steep. Although bedding planes were not observed in this crystalline limestone, the shape and position of the masses indicate a general northward dip of 70° or more. Because of the complex structure, which includes both faults and close folds, no reliable estimate of the thickness of this formation could be made. Here and there the thickness has apparently been increased by duplication through faulting, but certainly the formation has in places a normal thickness of several hundred feet. Near Hanna Glacier blocks and lenses of limestone that certainly are 400 feet or more thick are bordered by intrusive rocks, so that no measure can be given of their original thickness. These lenses, inclosed in diorite, have various orientations but in general strike southwest and dip at high angles.

No direct evidence of the age of this limestone was found in the present investigation. It is, however, certainly younger than the Tonzona phyllites and argillites, described above, and is older than the Cantwell. The best evidence of its age is that obtained by correlation with other limestones found both east and southwest of this area. In the Tonzona Basin Brooks[14] found a limestone that occupies a position in the range similar to that here under discussion and has similar geologic relations, from which Middle Devonian fossils were collected. Likewise Capps[15] found on upper Sanctuary Creek massive limestone that yielded Middle Devonian fossils. Both these localities are along the strike of the limestone here described, and in both places the limestone has similar geologic associations. Furthermore, no other massive limestone of known age occurs on the north flank of the Alaska Range in this region. There thus seems to be ample justification for correlating the limestone in the Toklat Basin and near Hanna Glacier with the Middle Devonian limestones that occur along the same strike both east and west of this region.

CANTWELL FORMATION

Distribution and character.—The Cantwell formation has an extensive areal development in the Toklat Basin and thence eastward to Nenana River. Farther west, in the region here considered, the Cantwell occurs in relatively small, irregular, and more or less isolated areas along the margin of the range, bordered on the southeast by Paleozoic sediments and granitic intrusive masses and on the northwest mainly by later Tertiary materials and glacial deposits. It is entirely possible, however, that the Cantwell formation may occupy considerable areas in the Kantishna-Kuskokwim lowland beneath the glacial materials and the younger Tertiary sediments.

The general characteristics of the Cantwell formation throughout its known extent on the north slope of the Alaska Range have been adequately described by Brooks[16] and Capps[17] and will be summarized here only briefly. The formation consists predominantly of coarse clastic sediments that grade from beds of coarse conglomerate which contain pebbles 6 inches or more in diameter through finer conglomerates and grits to coarse sandstone and thence into shales. Normally the basal part of the formation is composed of coarse conglomerate, and there is a tendency toward fewer coarse beds and more fine sediments higher in the section, though fairly coarse conglomerate beds occur at intervals far above the base of the formation. Above the prevailing coarse basal phase, which locally has a thickness as great as 200 feet, there is commonly an alternation of sandstone, grit, shale, and conglomerate, the individual beds ranging in thickness from a few inches to many feet. Many

[14] Brooks, A. H., op. cit., pp. 77–78.
[15] Capps, S. R., unpublished notes.
[16] Brooks, A. H., op. cit., pp. 78–83.
[17] Capps, S. R., The Kantishna region, Alaska: U. S. Geol. Survey Bull. 687, pp. 37–44, 1919.

of the beds are somewhat lenticular, so that the section differs from place to place. The Cantwell sediments range from light gray in some of the conglomerate and sandstone to dark gray and black in the shale. The beds are well indurated and weather into rugged forms. The conglomerate especially is resistant, yields topographic forms of bold relief, and breaks down into coarse angular talus. The shale is much less resistant to erosion.

The Cantwell sediments were laid down mainly as subaerial lacustrine or estuarine deposits. No fossils have been found in this formation except plant remains, and the absence of all forms of aquatic animals indicates that the formation includes no marine sediments. Associated with the Cantwell formation there are in places abundant volcanic materials, including intrusive dikes and sills as well as lava flows and tuffs, that are in part interbedded with the Cantwell formation. These volcanic rocks, which include rhyolite porphyry flows and tuffs, andesite, and diabase, are in many places highly colored, the colors ranging from white and cream through light shades of pink, red, green, and purple to dark green, brown, red, and black, and they give the striking colors to the mountains of Calico and upper Teklanika Basins, to Polychrome Pass, and to the upper valley of Toklat River.

West of Muldrow Glacier, in the region here under discussion, the Cantwell formation likewise consists of conglomerate, sandstone, and shale, but it is here associated with volcanic tuffs and lavas that in places exceed in thickness the Cantwell sediments.

In the eastern headwaters of Clearwater Creek, just west of Muldrow Glacier, is an area of several square miles occupied by varicolored volcanic rocks, mainly tuffs, but including also intrusive and flow phases. One conspicuous member of this assemblage is a black obsidian that weathers to an opaque green rock. This obsidian also appears at "Green Point," on the east side of Muldrow Glacier some 2 miles south of the Thorofare Creek bar. These volcanic materials overlie typical Cantwell conglomerate, sandstone, and shale. Farther southwest, at the lower ends of Straightaway and Foraker Glaciers, there is another large area in which the basal conglomerate and finer sediments of the Cantwell are overlain by a thick series of tuffs, flows, and intrusive rocks. Still farther southwest, in the basin of Tonzona River, are small isolated areas of Cantwell sediments that are relatively free from volcanic materials.

Structure and thickness.—In general the Cantwell rocks are less severely metamorphosed than either the Tonzona schists or the other Paleozoic sediments with which they are associated. The degree of metamorphism which they underwent depended, however, upon local conditions, and the result differs so greatly from place to place that no broad description is everywhere applicable. East of Broad Pass the formation grades from normal Cantwell sediments to stretched conglomerate and mica schist.[18] In the Toklat Basin the beds, though indurated, are generally found in broad open folds. Locally, however, they are intensely crumpled and plicated. On the headwaters of Clearwater Creek the Cantwell sediments and the associated volcanic materials are of fairly simple structure and are little metamorphosed. Their contact with the granitic rocks on the south is apparently a fault contact, and they are overlain unconformably by either the coal-bearing Tertiary beds, the Nenana gravel, or glacial deposits. In the basins of Straightaway and Foraker Glaciers the dominant structural feature is a great pitching syncline in which the Cantwell sediments lie unconformably upon Tonzona and post-Tonzona Paleozoic rocks and are themselves overlain with apparent conformity by a thick series of the associated volcanic rocks. The irregular outlines of the areas of Cantwell rocks in the Tonzona Basin are the result of faulting and infolding with the older rocks.

Age and correlation.—The only determinable fossils that have been reported from the Cantwell formation consist of a few collections of leaf imprints, although the finer sediments generally contain poorly preserved carbonaceous remains of sticks, twigs, and leaves. Most of these specimens have been determined to be of early Tertiary age. For only one collection was it suggested by the paleontologist that the age might be as old as Upper Cretaceous, but he considered this unlikely. The earliest age assignment for this formation was made by Brooks, in 1902, and his conclusion that the Cantwell formation was of Carboniferous age was based solely on lithologic grounds, for he found no fossils that he thought belonged in this formation.

The uncertainty in regard to the age of the Cantwell involves also the age of the coal-bearing Tertiary beds of the north slope of the Alaska Range. These coal-bearing beds, which have yielded abundant collections of plant remains, have been generally correlated with the Kenai formation of the Cook Inlet region, which is considered to be of Eocene age. Somewhat fragmentary collections from the Cantwell have also been doubtfully referred to the Kenai epoch. Yet on stratigraphic grounds the Cantwell formation is certainly to be considered as older than the coal-bearing Tertiary beds of the north side of the Alaska Range, and it was indurated, deformed, and eroded before the deposition of those beds. It would thus seem evident that either the Cantwell represents an earlier stage of the Eocene than the coal-bearing Tertiary beds, or else it is of Upper Cretaceous age, as has already been suggested. In view of the time interval represented by the deformation and erosion referred to above, it seems to the writer that the Cantwell may be

[18] Moffit, F. H., The Broad Pass region, Alaska: U. S. Geol. Survey Bull. 608, p. 45, 1915.

as old as Upper Cretaceous, though in the lack of conclusive evidence it is here classed as Eocene on the basis of the paleontologic determinations now available.

The volcanic materials associated with the Cantwell formation may be considered of the same general age as the Cantwell, for the surface lavas and tuffs are interbedded with the sediments. In the region here described the main accumulation of the sediments now remaining took place before the chief volcanic activity occurred. Farther east, in the Toklat Basin, the bulk of the volcanic material occurs about in the middle of the Cantwell formation, and the major volcanism was preceded and followed by periods during which sediments were laid down with only a minor admixture of volcanic materials.

TERTIARY COAL-BEARING FORMATION

Character and distribution.—Coal-bearing sediments of Eocene age occur at intervals along the north flank of the Alaska Range from the Kuskokwim Basin to the Alaska-Canada boundary, also on the south side of the range, in the basins of Susitna River and Cook Inlet. In the Cook Inlet region these beds have been called the Kenai formation, and there is little doubt that the coal-bearing Tertiary sediments on the north side of the range are, in part at least, the equivalent of the Kenai, though the exact identity of the two formations has not yet been established, and the sediments on the north slope have as yet received no formation name.

North of the range this formation is best known and reaches its greatest development in the Nenana coal field, where the coals it contains have been mined for several years. Farther west, in the Toklat and Kantishna Basins and on the headwaters of the Kuskokwim, the Tertiary coal-bearing beds occur in small isolated areas on the flanks of the Alaska Range, and although their known surface outcrops are small it is quite possible that they may occupy considerable areas in the great Kantishna-Kuskokwim lowland, concealed beneath a mantle of glacial materials and stream gravel. It is to be expected that a more thorough examination of this region will disclose other outcrops of this formation in addition to those shown on the map (pl. 2).

Most exposures of the Tertiary coal-bearing beds show unconsolidated or only slightly indurated white to cream-colored sand, gray to blue-black clay, and fine conglomerate, with scattered seams and sticks of carbonaceous material and in places with lignite. The lignite is of fair grade, is brown to black, and occurs in beds ranging from an inch or two to 20 feet or more in thickness. In the region here considered this lignite has at present no value for shipment to outside markets, but it has been used locally for domestic purposes and may prove of great value in any mining developments that may take place in the district, especially in localities where wood for fuel is not available.

Occurrences of beds of the coal-bearing formation in Highway Pass and in the pass between Stony Creek and the southeast branch of Moose Creek reveal narrow synclinal basins in which there is an alternation of clay, sand, and gravel containing streaks of carbonaceous material and some considerable beds of a fair grade of lignite. A sloughed bank on the north side of Thorofare Creek, the small stream flowing west from Thorofare Pass, half a mile above its mouth, shows unconsolidated clay and considerable lignite. It is possible that there is at that place a lignite bed of workable thickness.

At the upper main forks of East Fork of Clearwater Creek a mud flow on a steep terrace face shows loose cream-colored sand with fragments of lignite that indicate the presence there of beds of the coal-bearing formation. Likewise on Coal Creek and on a fork of Clearwater Creek between Coal Creek and East Fork there are exposures of this formation. From the East Fork of Coal Creek rises a bluff 75 feet high consisting of tilted and folded beds of sand, shale, and gravel. The sand and shale are unconsolidated, but lenses of the gravel are consolidated so that they weather into coarse angular blocks. At this place there are bunches and beds of lignite as much as 6 inches thick. On the West Fork of Coal Creek several pits have been excavated on the weathered outcrop of a lignite bed. No coal in place was visible at the time of visit, but a large dump at one pit, consisting wholly of weathered fragments of lignite, indicates the presence of a considerable bed of lignite at that place.

No exposures of the coal-bearing Tertiary formation were seen between Coal Creek and Tonzona River, but Brooks [19] mapped two areas farther southwest, between Tonzona and Dillinger Rivers.

Structure and thickness.—The sediments that make up the Tertiary coal-bearing formation were deposited by streams at a time when the area now occupied by the Alaska Range was a region of low relief and of mature drainage, as is indicated by the sediments themselves, which are much finer than those now being carried by streams in the same area. The presence of thick lignite beds indicates that there were long periods during which the accumulation of vegetable remains could go on without being interrupted by the deposition of clastic sediments. The deposition of the coal-bearing formation was terminated by the beginning of growth of the present Alaska Range. The uplift of the mountains steepened the stream gradients, and as a consequence coarse gravel deposits—the

[19] Brooks, A. H., op. cit., pl. 9.

Nenana gravel—were laid down upon the finer coal-bearing sediments, which about this time were tilted and folded. With the continued growth of the range the streams deepened their valleys, and the unconsolidated Tertiary materials were rapidly cut away. Only in places where they were in some manner protected from erosion or where they were folded down below the level of the older hard rocks have the Tertiary sediments remained.

This formation is believed to be generally unconformable upon the underlying rocks. A direct contact between these rocks and the Cantwell has nowhere been observed, but the greater induration of the Cantwell and certain discordances of structure indicate an unconformity. Its structural relations to the younger Nenana gravel are not so well agreed upon. In some places there is a definite recognizable unconformity; in others there appears to be perfect conformity. It is likely that in some places the deposition of the Nenana gravel succeeded that of the coal-bearing formation without interruption, but elsewhere the coal-bearing beds were deformed and eroded before being covered by the Nenana gravel. Certainly the coal-bearing formation was in general involved in the folding, faulting, and uplift of the Alaska Range.

As only isolated bodies of this once widespread formation now remain, and as there is no assurance that the base of the formation at any place was deposited contemporaneously with the base at any other place, it is difficult to estimate the original thickness of the formation. The thickest known remnant is on Healy Creek, east of Nenana River, where a single section shows 1,900 feet of beds. Farther west the remnants of the formation are thinner, and it is doubtful whether in the region here described the formation ever attained so great a thickness. On upper Moose Creek several hundred feet of the formation is exposed. In the basin of Clearwater Creek less than 100 feet was seen at any one locality.

Age and correlation.—The age of the coal-bearing Tertiary formation of the north slope of the Alaska Range has been determined largely from the fossil plants that have been found in it and by correlation with similar beds of known age elsewhere. Plant remains are abundantly present throughout this formation but are commonly found only as lignitized sticks, stems, and imperfect and fragmentary leaf prints. In many places, too, where fairly perfect leaf impressions occur, they are found in incoherent sand and clay that crumble upon digging and are too fragile to be collected for later study and identification. For these reasons the collection of fossil plants from most localities is difficult. At a few places, however, leaf-bearing beds have been found in association with burned-out coal beds, and in the burning of the coal the adjoining clay beds have been baked to a hard, bricklike material, in which the leaf prints are still perfectly preserved. Collections from these places have been identified as definitely of Eocene age and have served to correlate the coal-bearing formation of the north flank of the range with the Eocene deposits of the Susitna Basin and the margins of Cook Inlet. The stratigraphic relations also show that the coal-bearing Tertiary beds are younger than the Cantwell formation and older than the Nenana gravel.

NENANA GRAVEL

Character and distribution.—The Nenana gravel comprises a series of elevated gravel deposits that are widely distributed along the north flank of the Alaska Range. They are extensively developed both immediately east and west of Nenana River, and the deposits in those localities have been described in such detail [20] that a brief summary will suffice here.

The term Nenana gravel has been applied to a thick series of unconsolidated or only loosely cemented material, consisting for the most part of beds of well-rounded, rather coarse gravel, with subordinate beds and lenses of sand. Pebbles the size of cobblestones are common, though there is much finer gravel, and in some places boulders a foot or more in diameter were seen. The pebbles include a wide range of rock types, and the percentage of pebbles of various types differs greatly from place to place. In the aggregate all the older hard-rock formations of the Alaska Range are represented, though, as is to be expected, the harder materials such as quartz, quartzite, conglomerate, and various kinds of igneous rock predominate over the softer and more easily destroyed sedimentary rocks.

A characteristic feature of the Nenana gravel is its yellow or buff color, which indicates that the gravel is old enough to have been rather thoroughly oxidized, whereas the deposits of the last glaciers and of the present streams that in many places overlie the Nenana gravel are gray and little oxidized.

The Nenana gravel, being unconsolidated, yields readily to erosion by glaciers and streams, and the surface forms developed on it by erosion are generally of smooth outlines and gentle slopes, so that good exposures are not common. As a consequence of its smooth surface forms and the mantle of soil and vegetation by which much of it is covered, some areas of this gravel can not be distinguished from certain glacial deposits, and the Nenana gravel may therefore have a wider distribution than is shown on the map.

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[20] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, pp. 30–34, 1912; The Kantishna region, Alaska: U. S. Geol. Survey Bull. 687, pp. 51–57, 1919.

In the region here described the Nenana gravel was distinguished and mapped at only a few places. In the basin of Thorofare Creek, north and northeast of Copper Mountain, there are some small ridges and benches of old gravel that are evidently remnants of what was formerly a much more widespread deposit of this material. The basin of Clearwater Creek has considerable areas of Nenana gravel, as shown on Plate 2, and no doubt this formation has a considerable development farther southwest but is generally concealed beneath the prevalent mantle of glacial materials.

Structure.—That the Nenana gravel is a stream deposit is indicated by the character and composition of its materials and by the distribution of the formation. There is no evidence that this region has been generally submerged since Mesozoic time, as all the Tertiary materials, including the Cantwell formation, the coal-bearing formation, and the Nenana gravel, were laid down by streams during periods when the surface stood above sea level. The prevailing coarseness of the Nenana gravel in contrast to the comparative fineness of the sand and clay of the next older coal-bearing formation indicates a renewed uplift of the Alaska Range after a period of relative quiescence, during which the relief of the region was moderate. It is believed that in this uplift the axial portion of the range was elevated enough to give the northward-flowing streams steep gradients, so that they could transport coarse material, but that the areas now occupied by the gravel were still north of the uplifted area. After the deposition of the gravel, locally to a thickness of nearly 2,000 feet, the uplift of the range became more extended and involved the areas earlier covered by the gravel deposits. The gravel and the underlying coal-bearing beds were raised and warped into folds that lay parallel with the mountain axis. During these later stages of uplift and since the elevation of the range to about its present height and area erosion by streams and glaciers has been active, and the loosely coherent gravel has been deeply dissected. From some areas which it formerly covered it has been entirely removed.

In general the Nenana gravel is believed to lie conformably upon the coal-bearing formation in those sections where both are present. Where the coal-bearing beds are absent the gravel lies unconformably upon some of the older formations. Locally what appears to be normal Nenana gravel is unconformable upon the coal-bearing formation, but this can be explained if the gravel so found is considered to represent not the base of the Nenana formation but some higher portion, for the coal formation in places was doubtless involved in the mountain-building movements and eroded during early Nenana time and was covered with gravel later in the Nenana epoch. Certainly in many localities there is apparent conformity between the coal-bearing beds and the overlying Nenana gravel, even though both have been folded and tilted together. It may be said that in general the Nenana gravel is deformed equally with the coal-bearing formation where both occur.

Age and correlation.—From the facts cited it is shown that the Nenana gravel is younger than the coal-bearing Tertiary (Eocene) and older than any glacial deposits that have been recognized in Alaska. Certainly it is older than the deposits of Wisconsin age, and it is probably also older than the pre-Wisconsin glacial deposits. Brooks,[21] who traversed this region in 1902, grouped this gravel with the glacial deposits and considered them all to be of Pleistocene age. As a result of field studies in 1910, the writer gave this formation its name, and considered it to be of Miocene or Pliocene age.[22] Later studies, conducted through three field seasons and extending from Tonzona River eastward to Delta River, have convinced him that the Nenana gravel antedates by a considerable time all the known glacial deposits of the region and that the gravel was deeply oxidized and extensively eroded before the first recognized Pleistocene ice advance. Furthermore, the conformable relations observed at many places between the coal-bearing Tertiary beds and the gravel and the similarity in the extent of the deformation suffered by these two formations indicate that the gravel deposition began soon after the completion of the coal-bearing series and may well have ended the laying down of those finer sediments. The gravel has yielded no fossils upon which an age determination could be based, but the writer believes it to be certainly of Tertiary age and probably almost as old as the coal-bearing formation.

QUATERNARY DEPOSITS

PREGLACIAL CONDITIONS

The area now occupied by the Alaska Range has been the scene of mountain-building movements at intervals since very early geologic time. Our information concerning the climate of this region during these ancient times is meager, but it is probable that during those periods in which the mountain range stood at a considerable altitude there were glaciers in the higher valleys, as there are to-day, and that in the intervening periods when the mountains had been worn down to moderate or low relief the glaciers disappeared. The plants that flourished in early Eocene time give evidence of a temperate climate. The uplift of the present Alaska Range began in Eocene time and has probably been renewed intermittently to this day.

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[21] Brooks, A. H., op. cit., pp. 108–109.

[22] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, pp. 30–34, 1912.

GLACIAL CONDITIONS

OLDER GLACIATION

In the beginning of Pleistocene time, when the range had reached approximately its present height and area, a progressive change in climate began, which included a gradual lowering of the mean annual temperature and probably also an increase in precipitation. The mountain glaciers began to expand in area and thickness and to push farther down their valleys. Tributary glaciers joined those in the main trunk valleys, and the ice streams pushed outward to and beyond the mountain front and onto the piedmont plain. After this first great encroachment of glacial ice there were several successive withdrawals and readvances of the ice, marking several stages of glaciation during the glacial epoch.

The complete history of early glacial time in Alaska can not yet be written, if ever, for during the last great glacial advance the vigorous ice streams, moving out into the areas that had earlier been glaciated, recarved the valleys and overrode the existing glacial deposits and thus destroyed much of the evidence of earlier ice advances. There is, however, on the north slope of the Alaska Range definite evidence that there was at least one major ice advance in Pleistocene time that took place before the last great advance of which we have such abundant evidence.[23] In the northern United States and in Canada there were several distinct epochs of glaciation separated by periods of ice withdrawal, and it is quite likely that in Alaska also there were at those times corresponding glacial fluctuations. There is little doubt that the last glaciation in Alaska corresponds with the most recent or Wisconsin stage of glaciation in the United States.

LAST GREAT GLACIATION

There is abundant evidence to indicate the vigor and extent of the Alaskan glaciers during their last great advance, and the general distribution of glacial ice at that time is known, though many details still remain to be worked out. For the part of Alaska here considered the most striking feature of this distribution is the great difference in the areal development of the glaciers on the opposite sides of the Alaska Range. On the southern or Pacific slope the entire area between the crest of the Alaska Range and the coast, except a few of the loftiest peaks and mountain ridges, was buried beneath a huge ice field. On the north slope the glaciers pushed outward only a few miles beyond the mountain front, and a great area in the basins of Tanana, Yukon, and Kuskokwim Rivers was not then nor, so far as we know, at any earlier time invaded by glacial ice. This

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[23] Capps, S. R., The Kantishna region, Alaska: U. S. Geol. Survey Bull. 687, pp. 59–60, 1919.

great difference in ice development on opposite sides of the range can not well be accounted for by assuming a difference in the mean annual temperature of the two regions but is almost certainly due to a difference in the precipitation. It is likely that then, as now, the mountain range acted as a barrier to the moisture-laden winds from the Pacific, and that the moisture was chiefly dropped on the south side of the range, so that the interior region had a comparatively arid climate. A further factor favoring the greater development of the glaciers on the south slope is the asymmetrical position of the divide peaks, which lie much closer to the north front than to the south front of the range. The glaciers that were tributary to the Susitna Basin, therefore, had great headward basins in the high mountains, whereas the high portions of northward-draining valleys are in general short and small.

The extent of glaciation on the north flank of the Alaska Range from the Kantishna region eastward to Delta River has already been described.[24] In the region here treated no accurate mapping of the outer edge of the glaciated area has been done, for the ice extended out into the alluvial lowlands, which in summer are marshy and which lie outside the region of principal concern in the present investigation. It is known, however, that Muldrow Glacier, which is much the largest glacier on the north slope of the range, pushed northwestward at least 30 miles beyond its present terminus, overflowed the divide between McKinley Fork and upper Moose Creek, and sent at least small ice lobes both down Moose Creek and into Stony and Boundary Creeks. Wonder Lake lies in a glacial basin excavated by the ice that moved northward into Moose Creek. The outer limits of this glacier on the northwest have not been defined, but it probably terminated in some such way as is indicated on the geologic map. (Pl. 2.)

West of Muldrow Glacier the mountain front, at the time of the last great ice advance, was bordered by a piedmont ice sheet formed by the coalescing of a large number of valley glaciers whose terminal lobes expanded laterally as the ice streams emerged from the confines of the narrow alpine valleys. This piedmont ice sheet extended outward into the lowland for an average distance of 12 or 15 miles from the mountains. The present surface of the area that was covered by this ice sheet is now marked by large and small boulders, by deposits of glacial till, and by many ponds and lakes. The great lowland of Kantishna and Kuskokwim Rivers farther northwest is believed to have escaped glaciation not only during the last great advance but also during previous stages. So far as is known, the area between

[24] Capps, S. R., The Kantishna region, Alaska: U. S. Geol. Survey Bull. 687, pp. 56–64, 1919; The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, pp. 34–39, 1912.

the Alaska Range on the south and the Brooks Range north of the Yukon has never been invaded by a continental ice sheet and has never been occupied by glacial ice except by a few small valley glaciers that formed on the slopes of isolated mountains.

The existing glaciers in the part of the Alaska Range here described show evidence of rather recent retreat and shrinkage. Muldrow Glacier, although still vigorous, nevertheless has an area at its lower end where for several square miles the ice appears to be melting faster than it is replaced by movement from above. Hanna, Foraker, Herron, and Chedotlothna Glaciers are all in retreat. Straightaway Glacier and the many glaciers tributary to Tonzona River show less evidence of recent shrinkage.

From the indications of recent retreat here and elsewhere in Alaska the inference has often been drawn that the Alaskan glaciers are all shrinking and are on their way to complete disappearance. This conclusion is not justified. There is abundant evidence that many glaciers are as large now as they have been at any time for several centuries, and others have shown important recent advances. The vigor of each glacier is largely determined by the conditions of snowfall and of melting within its own basin, and unequal distribution of the snowfall in any year or series of years may cause some glaciers to advance and others to retreat. The terminus of any glacier is likely to oscillate within certain limits over a period that may seem long as measured in the lifetime of a person, but a period of retreat for any given group of glaciers is likely to be followed in time by a period of readvance.

PRESENT STREAM GRAVEL

The gravel deposits along the present streams, indicated on the accompanying map (pl. 2), have been laid down under conditions essentially like those that now exist in this region. These deposits include only those that occupy the flood plains of the present streams and are subject to overflow in times of flood; as a consequence they appear on the map as long, narrow bands that follow the irregular courses of the streams.

Except Clearwater Creek, a headward tributary of McKinley Fork of Kantishna River from the south, all the larger streams head in glaciers and in consequence are heavily charged with sand, gravel, and mud during the summer season of glacial melting. A part of this load of detritus is deposited along the stream flood plains, building up wide flats of bare gravel and sand, through which the streams flow in many branching channels. The coarser gravel and sand is deposited near the glaciers; farther downstream, where the material being transported consists of finer gravel and mud, the rivers deposit less material, have narrower flood plains, and show much less tendency to branch out into many small channels.

IGNEOUS ROCKS

Igneous rocks occupy large areas within this region and are of wide range in both composition and age. Igneous activity has taken place here at intervals from the pre-Ordovician to the Tertiary, and the only formations that do not contain intrusive or extrusive igneous materials are those of late Tertiary, Pleistocene, and Recent age. The oldest igneous rocks that have been recognized are certain basic greenstones and serpentines that are associated with the Birch Creek schist and have been metamorphosed along with the schist. If these rocks were originally lava flows, as appears likely, they were extruded during the laying down of the sediments that are now altered into schist and so are contemporaneous with the schist and of pre-Ordovician age.

The Tonzona group of sediments is associated and in part interbedded with rocks that were originally rhyolites, rhyolite porphyries, and tuffs but now have been altered into schist. These igneous materials are much less abundant in the region here described than they are farther east in the vicinity of Nenana River, where they have received the name Totatlanika schist.

The most intense igneous activity in this region took place during Mesozoic time and resulted in the intrusion of granitic rocks in large volume and in extensive flows of basaltic lava. The exact periods during which these granitic rocks were intruded and the lavas poured out have not been determined, nor has it been positively learned which were the earlier. Both the granitic rocks and the greenstones cut the great series of sediments here classified as post-Tonzona Paleozoic rocks and are certainly younger than the Paleozoic. Correlation with periods of igneous activity elsewhere in Alaska leads to the suggestion that the main period of volcanism represented by the greenstone flows here was probably in early Mesozoic time, whereas the intrusion of the granitic rocks probably occurred in Jurassic time, or even later in the Mesozoic.

Although basic dikes and sills are present here and there throughout this area, in most places their extent is too small to be shown on a map of the scale of Plate 2. In the upper basin of Toklat River, however, and northwest of Thorofare and Highway Passes there are considerable areas of greenstone that shows flow structure and was therefore poured out upon the surface as lava. The greenstone is apparently more than 2,000 feet thick, ranges in color from dark green to dark brown and deep purple, is commonly amygdular, and in places shows ellipsoidal structure. It lies unconformably beneath the Cantwell formation and appears to be unconformable upon the Paleozoic sediments. No fossils have been found in it, and it is here tentatively assigned to the Triassic.

Granitic rocks, including granite, monzonite, and diorite, are important elements in this part of the Alaska Range. (See pl. 2.) They occur in two large and several smaller areas. One area extends from Muldrow Glacier southwestward to Straightaway Glacier in a belt that is 3 to 4 miles wide and is extended northeastward by a number of smaller outliers. In places the northwest boundary of this granitic belt is a nearly straight line that suggests a fault contact. Elsewhere the main intrusive mass includes increasing quantities of sedimentary materials as its edge is approached until locally the sediments predominate, though cut by great quantities of granitic dikes and sills. This is especially true near Copper Mountain and northeast and southwest of Hanna Glacier.

The second large area of granitic rocks extends from the west base of Mount McKinley southwestward to Mount Russell. Although the presence of granitic rocks in this area is definitely known from the morainal material brought down by the glaciers, and although even at a distance of several miles the granitic areas could be distinguished from the dark-colored bordering sediments, nevertheless these rocks lie in the rugged and almost inaccessible portions of the range, and the writer nowhere actually examined them in place. The part of the range in which they occur is largely unmapped, and the boundary between the granitic materials and the Paleozoic sediments, as shown on Plate 2, is an approximation only. It is certain, however, that they extend southwestward beyond the crest of the range and onto the Susitna slope, for the glaciers on that slope carry great quantities of granitic materials on their surfaces. It is probable that the ability of these hard, crystalline rocks to resist erosion is in large part responsible for the great height of the crest-line peaks in this part of the range.

No definite evidence of the age of the granitic intrusions was obtained in this investigation other than that they cut and are therefore younger than the Middle Devonian limestones and are overlain by and are therefore older than the Cantwell formation. Similar granular intrusives occur in places throughout the Alaska Range and in neighboring regions in the Susitna Basin. In the eastern Talkeetna Mountains their stratigraphic relations show that similar granitic rocks cut Lower Jurassic beds and were intruded before late Middle Jurassic time. On the basis of correlation with these intrusives of the eastern Talkeetna Mountains, a correlation that is admittedly open to question, the granitic intrusives of the region here under consideration are tentatively assigned to the late Lower Jurassic or early Middle Jurassic, but they may be in part as young as Upper Cretaceous.

The next notable igneous activity after the intrusion of the granitic rocks took place during Cantwell time. The deposition of the early coarse clastic sediments of the Cantwell formation was interrupted by a period of volcanism during which a thick series of lava flows and of fragmental volcanic material accumulated in this region. In places this material consisted mainly of rhyolite and andesite lava flows. Elsewhere it was composed largely of fragmental material ejected from volcanoes, and this formed thick beds of tuff interbedded at intervals with flows. Just west of Muldrow Glacier, in the headward basin of Clearwater Creek, several thousand feet of varicolored tuff, with some andesite flows in red, brown, pink, and gray and beds of glossy black obsidian, occupies an area of several square miles. Similar rocks also occur along the lower valleys of Foraker and Straightaway Glaciers, farther west. Included in these volcanic materials are minor quantities of sedimentary rock, deposited during the intervals between volcanic outbursts. At a few places dikes and sills cut the Tertiary coal-bearing formation, and some tuffaceous material is present, but in general it may be said that since the Cantwell epoch there has been little igneous activity in this part of the Alaska Range.

ECONOMIC GEOLOGY

No productive mining has so far been done in the region here under discussion, though several lodes carrying silver, gold, lead, and copper have been staked, and some development work has been done. In the Kantishna district, however, just north of this region, placer mining has been conducted on a moderate scale each year since 1905, and the total output of placer gold to the end of 1925 has been about $556,000. Recently considerable attention has been given to the lode deposits of the district. A large number of lodes have been staked on quartz veins carrying silver, gold, and lead and other lodes carrying promising bodies of antimony ore. One group of claims on Friday Creek has yielded a considerable quantity of high-grade silver ore, though no systematic mining has been done. All the lode prospects and mines of the Kantishna district are on veins that cut the Birch Creek schist. The schist in this area occurs only at the northern margin of the Toklat-Tonzona region and has not been found in the Alaska Range south of the Kantishna district. All the prospects now known along the northwest front of the Alaska Range from Muldrow Glacier southwestward to the basin of Tonzona River lie along the margins of granitic intrusive masses, either in the intrusive itself or in the invaded sediments near the granitic rocks. Furthermore, rather close prospecting has failed to disclose the presence of placer gold in encouraging amounts. The absence of placer gold, however, does not necessarily mean that gold-bearing lodes are not present. Glacial erosion during the last period of glaciation was so severe in the mountains that any alluvial deposits that may have contained placer gold must have been removed and scattered, and north of the mountain front the great quantities of glacial débris would have buried any stream-channel deposits that escaped glacial scour. The chance of finding extensive gold placers in this region is rather slight, although it is possible that if preglacial placers existed here small areas of them might have been preserved by some unusual combination of circumstances.

At Copper Mountain, just east of the end of Muldrow Glacier, is a mineralized area that has attracted considerable attention. It was discovered in 1921 by O. M. Grant and F. B. Jiles, who staked 23 claims on the north slope of Copper Mountain between Muldrow Glacier and Thorofare Creek. The country rock consists of a series of calcareous and siliceous argillites and siliceous limestone intimately intruded by granitic dikes and sills, the intrusive material locally equaling or exceeding in volume the intruded sediments. The sedimentary beds are unfossiliferous, and their age is not certainly known, but the best available evidence indicates that they are Paleozoic. The sediments are much altered and silicified, probably as a result of the intrusion of the granitic material. The geology is complex and has not been worked out in detail, but it is known that in addition to the intricate and irregular distribution of the intrusive rocks there has been considerable faulting at more than one period.

The metallic minerals, which were no doubt introduced as a result of the igneous intrusion, include the sulphides of zinc, lead, iron, and copper, with a varying content of gold and silver. The ores have replaced the calcareous sediments and occur as vein fillings in both the sediments and the granitic intrusives. Sphalerite is much the most abundant sulphide and occurs as massive aggregates almost free of other sulphides or gangue, as a mixture in various proportions with galena or with both galena and chalcopyrite. The sphalerite, where unaccompanied by lead or copper sulphides, is said to carry only a minor content of gold and silver. The galena, by contrast, commonly carries much silver, and assays have been obtained that show more than 200 ounces of silver and $6 to $17 in gold to the ton. The outcrops that show the most copper are on the Caribou and Denver claims. Elsewhere the lead and zinc sulphides predominate.

By the fall of 1925 little more than assessment work had been done on these claims, and except one 90-foot tunnel, all the development work consisted of open cuts, trails, and a camp. There is no doubt that Copper Mountain is extensively mineralized, but the work so far done is inadequate to demonstrate whether or not there are sufficiently large bodies of high-grade ore on it to make mining profitable at present.

A group of claims has been staked by John Anderson on the east side of Thorofare Creek, east of Copper Mountain, on what is reported to be a large body of sphalerite with some galena. Assays are said to show mainly zinc and lead, with only minor quantities of the precious metals.

In the region southwest of Muldrow Glacier a number of lode claims have been staked, principally by H. Carlson and "Slim" Averil. As reported by the owners, most of theses claims are on mineralized lodes that lie near the northern margin of the great granitic intrusive mass and are probably of the same mode of origin as the lodes near Copper Mountain. The principal metals are said to be lead, silver, and copper. No one was on these properties at the time the writer visited the region, and as only assessment work has been done on them he was unable to find most of them. It may be said, however, that all along the margin of the granitic intrusive masses there is widespread evidence of mineralization, mostly by iron sulphide, and it seems quite possible that there may be localities where the more valuable sulphides of lead, zinc, and copper, as well as gold and silver, may be present in sufficient quantity to justify the development of mines, if better transportation becomes available. As has already been stated, the region is at present so difficult of access that only very high grade ore could be mined at a profit.

Aside from those on Copper Mountain, the only lode claim in this region on which any considerable development work has been done is the J and K claim, on Boulder Creek, a stream that joins Chedotlothna River from the south, some 10 miles below Chedotlothna Glacier. The J and K claim, staked in July, 1923, by F. B. Jiles, Ed Knudson, and Jo Cators, lies on the east side of Boulder Creek, about half a mile below the glacier in which that stream heads. The mineralized rock on which prospecting was done occurs in a group of sediments that include blocky slate and argillite, as well as thin-bedded siliceous limestone and chert, probably all of Paleozoic age, that occur in a narrow belt bordered on the north by older Tonzona schist and phyllite and on the south by a mass of granitic intrusive rocks. The area of greatest mineralization lies about 250 yards from the contact of the argillite-slate-limestone group with Tonzona schist, and about a quarter of a mile from the granite contact.

The principal development work on this property consists of an open cut 25 feet long, with a 12-foot face, having a 12-foot shaft in its floor at the edge of the stream bars, and a trench on the bench some 30 feet vertically above the shaft and 40 feet west of it. Practically the entire open cut, the shaft, and the trench are in a body of siderite (iron carbonate), and the dump is composed largely of this material. The lode strikes about N. 80° W. and stands almost vertical. In the cut and on the dump the metallic minerals recognized in addition to the abundant siderite are arsenopyrite, pyrrhotite, pyrite, chalcopyrite, sphalerite, galena, malachite, and coatings of manganese oxide. It is reported that the chief encouragement to the owners was a thin vein of galena bearing much silver, but this was apparently all removed in prospecting. Polished sections of the ore examined under the microscope show that the siderite, now much the most abundant of the metallic minerals, was introduced later than the sulphides. Tetrahedrite has been reported from this property, but none was seen in either the hand specimens or the polished sections.

Some 200 feet southwest of the main workings a 10-foot tunnel discloses a zone of sulphides, mainly arsenopyrite, lying parallel to the vertically dipping bedding. The country rock consists of sedimentary beds that show thorough secondary silicification, and a granitic dike 50 feet thick cuts the sediments some 100 feet southeast of the tunnel.

The general conditions of mineralization at this property are strikingly like those at Copper Mountain, except for the presence of abundant siderite and pyrrhotite. What were once presumably calcareous sediments are cut by granitic dikes that have silicified the sediments and introduced a similar suite of sulphides to that generally found near the borders of granitic intrusive rocks in this region.

It is reported that the streak of rich silver-bearing galena on this property pinched out and that the claims have been abandoned by the original stakers.

In the existing situation in regard to transportation to Copper Mountain and to points farther southwest along the Alaska Range only ore of very high grade can be profitably mined and shipped. On a recent shipment of about 30 tons of ore from the Kantishna district to the smelter at San Francisco transportation charges alone were more than $70 a ton. This ore traveled about 20 miles by sled and the rest of the way by river boat, railroad, and steamship. Transportation to Copper Mountain will be improved on the completion of the wagon road from the railroad at McKinley Park station, now under construction by the Alaska Road Commission, but even with a wagon road an expensive haul of some 60 miles to the railroad will remain. Unless considerable bodies of high-grade ore are found or unless supplies of lower-grade ore large enough to justify a branch line of the railroad are developed, the remote situation of this district will impose a severe handicap upon lode mining. With the possible exception of Copper Mountain, the ore reserves of which have not yet been determined, no lode deposits of sufficient size to justify a railroad to this region have yet been found.

GEOLOGIC INVESTIGATIONS IN NORTHERN ALASKA

By Philip S. Smith

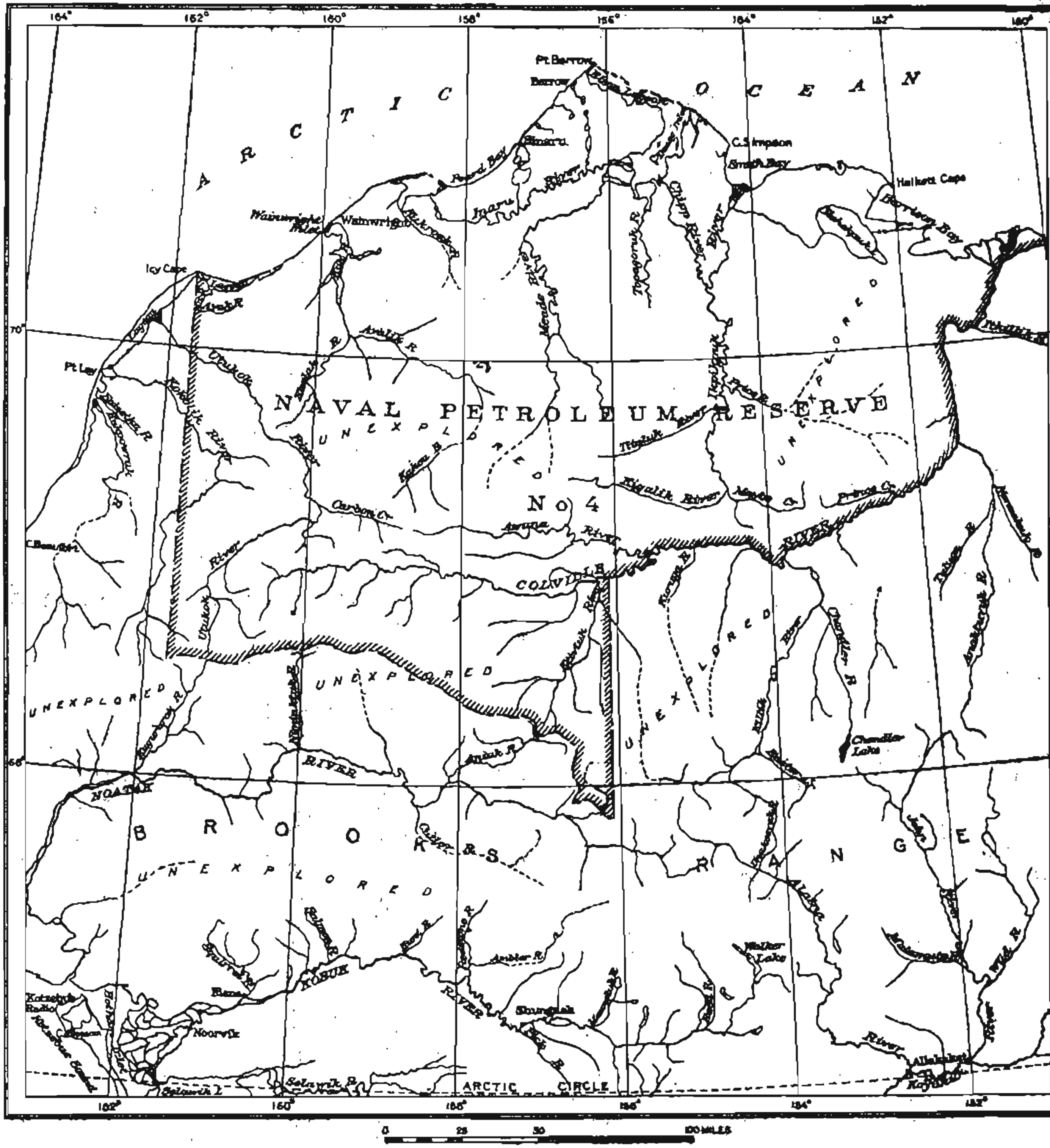
NARRATIVE OF THE EXPEDITION

Geologic investigations in naval petroleum reserve No. 4 were continued in 1925 by a party in charge of Gerald FitzGerald, topographic engineer, with Walter R. Smith, geologist. This party left Washington February 20 and Seattle February 28 and arrived at Nenana, on the Alaska Railroad, March 10. At this place W. R. Blankenship and Fay Delezene, who were to assist in camp duties, joined the party with two dog teams and the necessary equipment for the trail. The party left Nenana March 13 and made the trip along the Nenana-Nome mail trail to the head of Norton Bay and thence to Kotzebue, a distance of about 725 miles, at an average rate of more than 27 miles a day. At Kotzebue necessary supplies and equipment were obtained, as the party would be unable to purchase additional supplies until they returned to the coast in the fall. Several natives and their dog teams were hired to help in freighting some of these supplies into the mountains which form the southern boundary of the reserve and at which the new work of the season was to start.

Leaving Kotzebue on April 15, the party went northward up Noatak River to the Kugururok (see pl. 4), a tributary from the north that enters near longitude 162° W. Topographic surveys were started from landmarks a short distance above Kugururok River, near the canyon of the Noatak, that had been located by C. E. Giffin on an earlier survey, and geologic observations were made so as to tie the new work to that done by Philip S. Smith in 1911.

The party pushed up the Kugururok until the later part of April, when a pass across the mountains was found that led to the drainage basin of the Utukok, a stream on the north side that empties into the Arctic Ocean near Icy Cape. From then on every effort was made to move the camp supplies forward so that they would reach the drainage basin of Colville River before the ice on that stream broke in the spring and at the same time to survey as large a tract of the adjacent territory as possible. Both objects were successfully accomplished. A low pass from the Utukok to the Colville was found, and all supplies placed far enough down the Colville to permit the use of canoes when that stream became free of ice. One of the canoes used by the party had been hauled in from Kotzebue with the other supplies. The second canoe was one that the Geological Survey party under W. T. Foran had been forced to abandon on the Utukok the previous year, when they encountered unexpectedly difficult and long portages.

The ice on the Colville broke so that a canoe was used on May 30, the same date that Killik River, the tributary of the Colville on which the expedition of 1924 made its winter headquarters, had broken the year before. With the opening of the river dog-team work ceased for a while, and the party worked downstream, making numerous back-packing trips into the country 20 miles or more from the river and thus widely extending the area covered by the surveys. On one of these side trips the headwaters of Kaksu River were mapped. This stream is possibly one of the heads of Meade River, but its position is such that it may turn and enter the Ketik or Avalik, which flows into the Kuk, so that further exploration will be required before its true course can be fully determined. During these trips north of the Colville more of the basin of Awuna River, whose lower part was ascended by one of the parties of the expedition of 1924, was mapped. In this way and dropping successively downstream, the party descended the Colville to Etivluk River, a tributary from the south which enters the Colville near longitude 156° and whose lower course was traversed by the Survey party in 1924. At this point, which was reached July 12, junction was made with the surveys of 1924, which had covered most of the eastern part of the basin of the Colville as far east as its tributary the Anaktuvuk. The party under FitzGerald therefore turned southward, ascending the Etivluk and mapping the country on both sides of the stream. During this upstream journey dogs were used with good effect hauling on the tow lines of the boats. By July 25 the party had reached a portion of the stream so small that each day it seemed likely that only a little more progress could be made with the boats. The rainy weather, however, kept the stream at a good stage of water, and by the occasional use of a shovel to widen out narrow points in the channel, the boats were successfully worked upstream. Above the camp of July 27 the stream was little more than a gully cut through the turf, just wide enough for the canoes to pass through and with very little current. This character continued for several miles, to a point 3 miles above the camp of July 28, where the stream was found to issue from a lake about 1½ miles in diameter. This lake proved to be situated almost precisely on the divide between the Colville and



SKETCH MAP OF NORTHWESTERN ALASKA

the Noatak, and a portage of about 1,000 yards from its south end brought the party to a stream tributary to Aniuk River, which flows into the Noatak a little west of longitude 158°. The Aniuk was followed down without much difficulty to its mouth, which was reached August 11 and where the surveys were tied with those made in 1911 by Philip S. Smith and C. E. Giffin.

The party quickly dropped down the Noatak, making practically no stop except for camp at night, and arrived at Kotzebue August 22. Here connection was made with the *Boxer*, and through the courtesy of the Bureau of Education the party was taken to Nome, where, after less than a day's delay, it obtained passage on one of the boats running between Nome and Seattle.

Throughout the region north of the Noatak spruce and other large trees are entirely absent. In fact, the most northern spruce in the region was seen on the Kugururok near latitude 68°, and no spruce was found on the Noatak or any of its northern tributaries east of the Nimiuktuk. In the valleys north of the mountains willows grow at sufficiently close intervals so that with care they can be relied on as a source of camp fuel for small parties of travelers. The area more remote from the streams is covered with grass, lichens, moss, and prostrate bushes. Flowers are nearly everywhere abundant.

Game was found abundantly in the northern part of the area traversed. In the mountains are sheep, and in the plateaus and lowlands north of them caribou was the main source of meat. Fish, principally grayling, were caught in the Colville and Noatak and many of their tributaries. Doubtless they live in many of the other streams, but these were the only ones that were traversed during the season of open water. Birds were also abundant—ptarmigan in the higher country and water birds, such as geese and ducks, in the lower country. Only one bear was seen, and signs of bear were not at all common. Some red fox live in the region, but they did not appear to be nearly as numerous as in the similar region to the east. Natives from the Noatak often go into the Utukok for trapping.

No people live in the region traversed by the party in 1925 after leaving Noatak Mission, on lower Noatak River. Signs of former human visitation were seen at a number of places, but they were made by nomadic parties on trapping expeditions or traveling through the country and did not seem to indicate very long sojourn at any single locality.

TOPOGRAPHIC RESULTS

As a result of these explorations an area of about 6,500 square miles of hitherto unknown country was mapped with the degree of accuracy required by reconnaissance exploratory standards. A much larger area was observed so that its general aspects are known at least sufficiently well to be of considerable assistance in planning further work in the region. Although in general the work is counted as of exploratory standard, most of it was really done in much greater detail. In effect practically all of the topographic work was executed by plane-table and micrometer-traverse methods on a field scale of 1:180,000, though the map which is in course of preparation is being drawn up for publication on a scale of 1:500,000. At frequent intervals during the work observations for latitude and azimuth were made with a transit. When computed these observations coincided with the positions determined by the other methods very closely. The position of the mouth of the Aniuk as determined by this survey coincided so closely with that previously determined by Giffin that probably few points are more than a mile out of position east and west and probably not as much as that north and south. During the winter the novel expedient was used of making the micrometer bases of snow, and placing a colored piece of cloth on the face toward the point from which the next observation back on these bases was to be made. This expedient was resorted to because it was necessary to make signals in a region where timber is entirely absent and where even good-sized bushes are extremely rare, except in the valley bottoms near the streams. It may be of interest to note that a number of the low station marks made of brush and used as micrometer bases by the party that surveyed the Noatak in 1911 were still standing. Elevations were determined throughout the area surveyed, and the relief was sketched with 200-foot contours. The same major topographic division was noted in this region as had been reported in the country farther east—namely, a mountain mass whose higher peaks rise to heights of 4,000 to 5,000 feet above the sea and a rolling plateau country north of the mountains whose summits are usually not much more than 2,000 feet high. The streams have carved rather deep, narrow valleys in the mountains, some of which have evidently been the sites of glaciers in the past, although no glaciers exist there now. In the plateau region the streams flow in beds sunk several hundred feet below the uplands, but the slopes are fairly smooth, and rocky ledges usually crop out only close to the valley floor or on the summits of the ridges.

GEOLOGIC RESULTS

The principal geologic result of the expedition was the recognition and delimitation of rocks belonging to four major geologic divisions—the Mississippian, the Triassic, the Lower Cretaceous, and the Upper Cretaceous. These rocks were found to coincide in general character and relation with rocks of the same age seen by the parties in 1923 and 1924. The Mississippian rocks form most of the higher hills north of the Noatak. They consist of considerably indurated and deformed slates and sandstones overlain by several thousand feet of massive limestone locally called the Lisburne limestone. Overlying this series is a considerable thickness of chert of Triassic age. The cherts are varied in color, some being nearly pure white and others black, green, or red. The alternation of colors in some of the bluffs makes noteworthy and striking landmarks.

No Jurassic rocks were recognized in the area traversed by the party in 1925 and none had been found by the party that surveyed adjacent parts of the reserve in 1924. Overlying the chert but at many places in faulted relation with it are sandstones and shales which are regarded as of Lower Cretaceous age. These rocks are as a rule considerably folded and almost everywhere stand at high angles. They are thoroughly indurated and consist of a monotonous succession of alternating layers of sandstone and shale that disclose no readily recognizable key horizons over any considerable distance. As a consequence it was impossible to make any precise measure of their thickness, but they are several thousand feet thick. Near or at the base of the rocks of this system is a conglomerate which in places has pebbles 6 or 8 inches in diameter but which is usually much finer or is a coarse grit.

Overlying the Lower Cretaceous rocks is a thick series of sandstones and shales which, according to W. R. Smith, are considerably less intensely deformed than the Lower Cretaceous and which at few places in the area studied by him stand at angles higher than 30°. This conclusion is somewhat at variance with the observations of the parties in 1924 and of F. C. Schrader in 1901 on similar rocks, and if it proves to be correct it will be of great stratigraphic significance in throwing light on the age of some of the mountain building and serve as a means of identifying in the field these two formations, which lithologically are practically indistinguishable and can now be separated surely only in places where fossils are found. The Upper Cretaceous rocks contain numerous beds of coal interstratified with the shales and sandstones. Some of the beds are several feet thick, and most of them consist of subbituminous or bituminous coal of good quality. The Upper Cretaceous rocks are everywhere more or less folded, so that anticlines and synclines having their axes trending in general east and west are common. The folding appears to be progressively less and less intense as traced northward from this front of the mountains.

No igneous rocks of the granitic type in place were recognized in the area surveyed. Some boulders and pebbles of granite are present in the unconsolidated deposits on the Aniuk and on the

Etivluk, even as far as its junction with the Colville. According to the interpretation advanced by W. R. Smith, these fragments were probably derived from granitic masses south of the Noatak and transported northward by ancient glaciers and then reworked by the modern streams. Although this interpretation must as yet be regarded as only an interesting suggestion, it has economic significance because most of the known metallic mineral deposits of value in this part of Alaska seem to have a rather close association with igneous intrusive rocks, and if intrusives are not present in this region the probability of finding deposits of valuable metallic minerals here is regarded as not great.

No extensive deposits of unconsolidated sand and gravel were recorded in the area surveyed. The largest bodies of continuous unconsolidated deposits apparently were outwash material from the ancient glaciers. These, however, are more or less confined to the valleys of the larger streams and to their more or less immediate vicinity. So far as evidence is available, it shows that the mountains have at no time in the past been covered by ice caps but were the seat of local valley glaciers that flowed down the former valleys and then, on reaching the limit of the mountains, debouched into small piedmont lobes. No evidence of recent incursion of the sea was found in the area traversed by the party in 1925, and there is no reason to believe that in recent geologic time there were broad movements of depression that resulted in lowering the inland part of the reserve sufficiently to place it at or below sea level.

DATA RELATING TO PETROLEUM

The main object of the expedition was to determine the probability of extensive deposits of oil in this region, and other lines of geologic investigation were subordinated to this end. Until the whole investigation is completed no comprehensive analysis of all the data bearing on the problem will be attempted, and even then probably no public report will be issued until the Government's policy regarding the administration of this tract has been formulated. The more or less obvious results of the work, however, are of such general interest that it has been the practice to make a report of some of the current information in the knowledge that some of the suggestions may require material modification in the light of more complete study or data and that proof of the commercial value of any oil fields that may be discovered can be determined only by actual tests with the drill.

From direct observation the expedition of 1925 furnished few or no additional data to prove the occurrence of petroleum in the region. It has been incontrovertibly shown that petroleum does occur in this reserve, for it is found seeping from the ground near Cape Simpson, on the Arctic coast. The observations made during 1925 have materially delimited the area in which there are rocks similar to those that are supposed to occur near these seepages.

Nothing was observed that tends to modify the opinion already expressed by other geologists that the possible oil-bearing rocks are of Mesozoic age and occur entirely north of the Brooks Range. Although the party of 1925 found some of these Mesozoic rocks infolded or infaulted in the general mountain area that on earlier maps had been indicated as dominantly Paleozoic, these small Mesozoic areas did not appear at all promising structurally for yielding any quantity of oil. No rocks capable of furnishing oil in notable quantity, such as the oil shale obtained in 1924 from the Etivluk, were recognized in other parts of the area traversed in 1925, so that the determination of the stratigraphic limits of the oil deposits is still in doubt. The observations made in 1925, however, corroborate the opinion heretofore expressed that in the large area of Mesozoic rocks structural features competent to trap any oil that may have been produced are widespread. In fact, several large anticlines of great length and considerable closure are shown on the field maps of the geologist. As already stated, the geologist in the party of 1925 has expressed the belief that there was a period of notable deformation between the Upper and Lower Cretaceous, as a result of which the rocks of the earlier period stand at high angles and are considerably more broken and dislocated, therefore not affording as good structure for the retention of any oil that may have originated in or below them.

The work done in 1925 has not solved the question that was raised earlier as to whether certain of the rocks heretofore called Jurassic are in reality different from the rocks which in this area appear to be a continuation of them but which contain Cretaceous fossils. However, the work brought to light additional presumptive evidence that the two may be the same, because, although nearly continuous sections were observed in both the eastern and the western parts of the area, no rocks containing Jurassic fossils were recognized, though Triassic, Lower Cretaceous, and Upper Cretaceous rocks were readily identified. Especial emphasis was placed on the search for Jurassic rocks, as it was realized that the petroleum in the Cook Inlet-Alaska Peninsula region and Katalla-Yakataga region, which contain the only other well-known, definitely proved seepages of oil in Alaska, probably comes from rocks of this age. It was therefore long supposed that these rocks were to be especially sought, but from all the observations so far made the conclusion is suggested that either the Jurassic rocks are not the source of the oil in northern Alaska or, if they are, only a small part of the reserve is likely to be underlain by them within a depth that can reasonably be reached by the drill.

The opinion has already been expressed that unless a very large supply of oil can be demonstrated the development will be so costly that, for practical purposes, the area can not be regarded as a potential source of oil in the near future. The facts at hand are by no means adequate to determine this point, and probably the matter can not be settled without drilling. The recommendation made two years ago that test drilling be done in the vicinity of the oil seepages near Cape Simpson is therefore renewed. It should be distinctly understood, however, that such drilling is not to be undertaken with the aim of producing oil but to prospect and afford geologic data regarding the conditions. A light prospecting drill rig and the necessary crew could be sent during the open season by water within a mile or two of the seepages, so that transportation would not be difficult. The first test holes need not be more than a few hundred feet deep, but the cuttings from them should be carefully examined by a geologist attached to the party, who can then give advice as to the best places to continue prospecting with the drill. When not required to examine the cuttings from the drill the geologist could probably make excursions into the region within a radius of 50 to 75 miles of these seepages for the purpose of gathering more data regarding surface conditions. After the drill has supplied the required geologic data regarding the occurrence of oil in the seepages near Cape Simpson, probably additional field reconnaissances and surveys should be made of those areas where the examinations already made have indicated analogous conditions. In this way drilling and geologic examinations could supplement each other and give data unavailable from either source alone.

If drilling is not undertaken there are still areas that have not been traversed and that might afford definite evidence of oil and thus well repay the cost of cruising them on that chance, as well as supplementing the geologic data already procured. Among these areas where additional reconnaissances of this sort are most needed are the tract lying 50 to 100 miles from the coast and extending in a northeasterly direction between the surveys of 1923 and those of 1925 and another area between the Ikpikpuk and the lower part of Colville River, including Tasekpuk Lake and adjacent country. Plans are already in progress for the survey of the first of these areas, and the field surveys were made during 1926. Although the results can not be expected to compare with those that might be obtained if drill logs were available, these scouting trips should greatly supplement present knowledge of the general geologic conditions of this part of northern Alaska.

DATA RELATING TO OTHER MINERAL RESOURCES

The explorations conducted by the FitzGerald-Smith party in 1925 were mostly south of the areas in which the coal-bearing rocks noted by the parties of 1923 and 1924 occur, and very little of the coal-bearing series with the thicker coal beds was seen. The rocks near the Colville and north of it are the same as those seen by Foran on the Utukok, Epizetka, Kuk, Kaolak, and Kukpowruk, so that little doubt is felt that similar coals also occur in the rocks somewhat higher in the section and somewhat north of the area surveyed in 1925. Some coal was seen, but it is mostly in thin seams and not of commercial thickness, though it appears to be of the same quality as the subbituminous coals characteristic of the Upper Cretaceous.

A small exposure of coal was also visited on the Kugururok about 4 or 5 miles above its junction with the Noatak. Possibly this is one of the later Tertiary coals that occupy small isolated basins of no great areal extent and of little commercial importance unless coal is needed locally, such as occur above Squirrel River and at a few other points along the Kobuk.

As has already been stated, the investigations of 1925 were focused on the search for oil, so that relatively little attention was paid to other minerals, and on the whole areas that might contain gold or copper were avoided, as they would hold little chance of being oil bearing. In spite of this condition, however, the gravels were panned at a number of places, and colors of gold were found in some. Practically no tests of the gravels of the Kugururok or the Utukok were made, as the winter conditions that prevailed while the party was in the valleys of these streams made such tests difficult and impracticable in the time available. On the tributary of the Colville named Storm Creek a pan of gravel showed several small bright colors. This stream lies near the contact of the Upper and Lower Cretaceous rocks, but the deposit through which it has cut its course may represent a Tertiary concentration that formed a high bench of outwash from the hills, later re-sorted by the present stream. Some colors of gold were also found in pans taken at intervals down the Colville and in the lower part of the Etivluk north of the limestone. Farther up the Etivluk, although several tests were made, no colors of gold were seen, and on Fay Creek, which at the time appeared to have a good grade and other favorable physical characters, panning tests failed to disclose any gold. Southward from the limestones on the Etivluk to the vicinity of Flora Creek, the large tributary of the Aniuk from the east, no colors of gold were found, though the gravels were panned at several places. South of Flora Creek, however, a pan taken from a high bar showed a number of small colors, and from thence downstream a few colors could be obtained at many places as far as the junction with the Noatak. In spite of the finding of some colors in areas underlain by rocks of Cretaceous age, however, it is believed that they are not promising areas to prospect. Neither are the areas that derived their deposits from the areas occupied solely by the Lisburne limestone. On the other hand, the somewhat metamorphosed rocks of the Noatak sandstone, which forms the country rock toward the southern face of the mountains north of the Noatak, or any of the older schists that may crop out in the region are well worth careful examination.

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SELECTED LIST OF SURVEY PUBLICATIONS ON ALASKA

[Arranged geographically]

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

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

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

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

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

GENERAL

REPORTS

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper 45, 1906, 327 pp.

Alaska coal and its utilization. Bulletin 442-J, reprinted 1914. 10 cents.

Mineral industry of Alaska in 1924, by Philip S. Smith. In Bulletin 783-A, 1926, pp. 1-39. Free on application.

Mineral industry of Alaska in 1925, by F. H. Moffit. In Bulletin 792, 1927, pp. 1-39. Free on application.

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

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

The mineral deposits of Alaska, by A. H. Brooks. In Bulletin 592, 1914, pp. 18-44. 60 cents.

The future of gold-placer mining in Alaska, by A. H. Brooks. In Bulletin 622, 1915, pp. 69-79. 30 cents.

The possible use of peat fuel in Alaska, by C. A. Davis. In Bulletin 379, 1909, pp. 63-66. 50 cents.

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

*Methods and cost of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 362 pp. (Abstract in Bulletin 259, 1905, pp. 32-46. 15 cents.)

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

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

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

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

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

Alaska's mineral supplies, by A. H. Brooks. Bulletin 666–P, 14 pp. 5 cents.

The future of Alaska mining, by A. H. Brooks. Bulletin 714–A, reprinted 1921. 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 (B); scale, 1: 1,500,000; 1915.

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.

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REPORTS

The Juneau gold belt, Alaska, by A. C. Spencer, pp. 1–137, and A reconnaissance of Admiralty Island, Alaska, 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 building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin 345, 1908, pp. 116–126. 45 cents.

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

The Yakutat Bay region, Alaska: Physiography and glacial geology, by R. S. Tarr; Areal geology, 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, Alaska, by Adolph Knopf. Bulletin 446, 1911, 58 pp. 20 cents.

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

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

The earthquakes at Yakutat Bay, Alaska, in September, 1899, by R. S. Tarr and Lawrence Martin, with a preface by G. K. Gilbert. 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.

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

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

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

The Porcupine district, by H. M. Eakin. Bulletin 699, 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, pp. 75–115. 25 cents.

Ore deposits of the Salmon River district, Portland Canal region, Alaska, 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 resources of southeastern Alaska, by A. F. Buddington. In Bulletin 773, 1925, pp. 71–139. 40 cents.

Mineral investigations in southeastern Alaska in 1924, by A. F. Buddington. In Bulletin 783, 1927, pp. 41–62. 40 cents.

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.

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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.

Hyder and vicinity; scale, 1:62,500 (No. 540C); 1927, by R. M. Wilson. 10 cents.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS

REPORTS

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

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

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

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

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

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

Headwater regions of Gulkana and Susitna Rivers, Alaska, 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, Alaska, 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.

The mineral deposits of the Yakataga region, by A. G. Maddren. In Bulletin 592, 1914, pp. 119–154. 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. 70 cents.

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.

Mining in the lower Copper River basin, by F. H. Moffit. In Bulletin 662, 1917, pp. 155–182. 75 cents.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 662, 1917, pp. 183–192. 75 cents.

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

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

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

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

*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, Alaska, by F. H. Moffit. 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.

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.

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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.

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

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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 fields; 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.

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REPORTS

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

*The Mount McKinley region, Alaska, by A. H. Brooks, with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle. Professional Paper 70, 1911, 234 pp.

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

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

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

The geology and mineral resources of Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp. 70 cents.

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.

Chromite deposits of Alaska, by J. B. Mertie, jr. In Bulletin 692–D, 1919, pp. 265–267. 15 cents.

*Mining in the Matanuska coal field and the Willow Creek district, by Theodore Chapin. In Bulletin 712, 1920, pp. 131–176.

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

Petroleum seepage near Anchorage, by A. H. Brooks. In Bulletin 739, 1922, pp. 133–147. 25 cents.

Chromite of Kenai Peninsula, Alaska, 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.

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

Aniakchak Crater, Alaska Peninsula, by W. R. Smith. Professional Paper 132–J, 1925, pp. 139–145. 10 cents.

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

Geology of the Knik-Matanuska district, by K. K. Landes. In Bulletin 792, 1927, pp. 51–72. Free on application.

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. Free on application.

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Geology of the Iniskin-Chinitna Peninsula, by F. H. Moffit. Bulletin 789.

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

Lower Matanuska Valley; scale, 1:62,500; by R. H. Sargent. In Bulletin 500, 1912, 30 cents. Not issued separately.

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

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

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Passage Canal to Turnagain Arm, Kenai Peninsula; scale, 1:62,500; by C. E. Giffin and J. W. Bagley. In Bulletin 592, 1914, 60 cents. Not issued separately.

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The Broad Pass region; scale, 1:250,000; by J. W. Bagley. In Bulletin 608, 1915, 25 cents. Not issued separately.

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.

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.

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.

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

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A reconnaissance in southwestern Alaska, by J. E. Spurr. In Twentieth Annual Report, pt. 7, 1900, pp. 31–264. $1.80.

*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, Alaska, 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 Kuskokwin region, by P. S. Smith. Bulletin 655, 1918, 162 pp. 30 cents.

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

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

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

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

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

Aniakchak Crater, Alaska Peninsula, by W. R. Smith. Professional Paper 132–J, 1925, 11 pp. 10 cents.

Geology and oil developments of the Cold Bay district, Alaska, by W. R. Smith. In Bulletin 783, 1927, pp. 63–88. In preparation. 40 cents.

Geology and mineral resources of the Chignik district, by R. S. Knappen.

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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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Iliamna region; scale, 1:250,000; by D. C. Witherspoon and C. E. Giffin. In Bulletin 485, 1912, 35 cents. Not issued separately.

Kuskokwim River and Bristol Bay region; scale, 1:625,000; by W. S. Post. In Twentieth Annual Report, pt. 7, 1900, $1.80. Not issued separately.

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

Cold Bay-Chignik region, Alaska Peninsula; scale, 1:250,000; 1924, by R. K. Lynt and R. H. Sargent (preliminary edition). Free on application.

Kamishak Bay-Katmai region, Alaska Peninsula; scale, 1:250,000; 1927, by R. H. Sargent and R. K. Lynt (preliminary edition). Free on application.

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The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin 218, 1903, 71 pp. 15 cents.

The Fortymile quadrangle, Yukon-Tanana region, Alaska, by L. M. Prindle. Bulletin 375, 1909, 52 pp. 30 cents.

Water-supply investigations in Yukon-Tanana region, Alaska, 1907–8 (Fairbanks, Circle, and Rampart districts), by C. C. Covert and C. E. Ellsworth. Water-Supply Paper 228, 1909, 108 pp. 20 cents.

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

The Bonnifield region, Alaska, by S. R. Capps. Bulletin 501, 1912, 162 pp. 20 cents.

A geologic reconnaissance of a part of the Rampart quadrangle, Alaska, by H. M. Eakin. Bulletin 535, 1913, 38 pp. 20 cents.

A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle, with a detailed description of the Fairbanks district, by L. M. Prindle and F. J. Katz, and an account of lode mining near Fairbanks, by P. S. Smith. Bulletin 525, 1913, 220 pp. 55 cents.

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

A geologic reconnaissance of the Circle quadrangle, Alaska, by L. M. Prindle. Bulletin 538, 1913, 82 pp. 20 cents.

Surface-water supply of the Yukon-Tanana region, Alaska, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 342, 1915, 343 pp. 45 cents.

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

Gold placers of the lower Kuskokwim, by A. G. Maddren. In Bulletin 622, 1915, pp. 292–360. 30 cents.

An ancient volcanic eruption in the upper Yukon Basin, by S. R. Capps. Professional Paper 95–D, 1915, pp. 59–64. 5 cents.

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

The Yukon-Koyukuk region, Alaska, 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.

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

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

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

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

*A molybdenite lode on Healy River, by Theodore Chapin. In Bulletin 692, 1919, p. 329.

*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.

Supposed oil seepage in Nenana coal field, by G. C. Martin. In Bulletin 739, 1922, pp. 137–147. 25 cents.

The occurrence of metalliferous deposits in the Yukon and Kuskokwim regions, Alaska, by J. B. Mertie, jr. Bulletin 739–D, 1922, 17 pp. 5 cents.

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