DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

BULLETIN 642

MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN

1915

BY

ALFRED H. BROOKS AND OTHERS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

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CONTENTS.

ILLUSTRATIONS.

MINERAL RESOURCES OF ALASKA, 1915.

By Alfred H. Brooks and others.

PREFACE.

By Alfred H. Brooks.

This volume is the twelfth of a series of annual bulletins [1] treating of the mining industry of Alaska and summarizing the results achieved during the year in the investigation of the mineral resources of the Territory. In preparing these reports the aim is prompt publication of the most important economic results of the year. The short time available for their preparation does not permit full office study of the field notes and specimens, and, some of the statements made here may be subject to modification when the study has been completed. Those interested in any particular district are therefore urged to procure a copy of the complete report on that district as soon as it is available.

This volume, like those previously issued, contains both preliminary statements on investigations made during the year and summaries of the condition of the mining industry, including statistics of mineral production. It is intended that this series of reports shall serve as convenient reference works on the mining industry for the years which they cover. Lack of funds prevents a visit to every mining district each year by a member of the Survey, and therefore the data used in preparing the summary on mining development are in part based on information gleaned from various reliable sources.

Again, as in previous years, the writer is under great obligations to many residents of the Territory for valuable data. Those who have thus aided him include many mine operators, engineers, prospectors, Federal officials, and officers of banks and of transportation and commercial companies. It is impossible to enumerate all who have contributed information, but special acknowledgment should be made to the Director of the Mint; the Wells-Fargo Express Co.; the Alaska

[1] U. S. Geol. Survey Bulls. 259, 284, 314, 345, 379, 442, 480, 520, 542, 592, 622, and 642.

Mexican Gold Mining Co., Alaska United Gold Mining Co., and Alaska Treadwell Gold Mining Co., of Treadwell; Arthur G. Thompson, of Katalla; George M. Esterly, of Nizina; Stephen Birch, of Kennicott; James G. Godfrey, of McCarthy; John A. Rowe, of Chitina; George R. Goshaw, of Chisana; T. E. Phillips, of Jack Wade; John L. Abrams, of Fortymile; J. J. Hillard, of Eagle; Frank A. Reynolds, of Circle; R. C. Wood, J. A. Fairburn, George Hutchison, A. Bruning, American Bank, First National Bank, Albert Johnson, R. J. Sommers, and C. W. Joynt, of Fairbanks; Jay Livengood, N. R. Hudson, Harry Patterson, C. P. Keen, W. Allmark, and J. P. Norich, of Livengood; George W. Ledger and W. B. Ballou, of Rampart; Adolph Bock and S. S. Rowell, of Hot Springs; A. J. Day, of Ruby; Alexander Cameron, of Poorman; W. A. Vinal and H. F. Fothergill, of Ophir; C. P. Wood, of Iditarod; J. C. Felix, of Hughes; O. R. Williams, of Nolan; Frank H. Waskey, of Marshall; Henry Howard, of Aniak; J. W. Felder, of Bethel; William Loiselle, of Quinhagak; R. W. J. Reed, of Nome; G. A. Adams, of Council; D. L. McDonald, of Candle; F. H. Thomas, of Shelton; Lars Gunderson, of Golovin; M. F. Moran and Lewis Lloyd, of Shungnak; and Edward Wood, of Kiana.

The arrangement and manner of treatment in this volume are the same as in those previously issued. First a paper describing the general status of the mining industry is presented, followed by those treating of special districts, arranged geographically from south to north. This bulletin contains twelve papers by nine authors. One of these papers deals with administrative matters, one is a general summary of the mining industry, and the remainder deal more specifically with the economic geology of certain districts. In the geologic papers emphasis is laid on the conclusions having immediate interest to the miner. These conclusions are discussed here briefly but will be more fully treated in reports now in preparation. The need of prompt publication requires that the illustrations in this volume be of the simplest kind.

ADMINISTRATIVE REPORT.

By Alfred H. Brooks.

INTRODUCTION.

Twelve parties were engaged during 1915 in Alaska surveys and investigations. The length of the field season varied from three to eight months, being determined both by the needs of the work and by the climatic conditions prevailing in different parts of the Territory. The parties included 10 geologists, 4 topographers, 1 engineer, and 30 packers, cooks, and other auxiliaries. In addition to these, some gage readers were employed, who gave only part of their time to the work. Six of the parties were engaged in geologic work, 2 in both geologic and topographic surveys, 2 in topographic surveys, and 2 in investigating water resources.

The area covered by geologic reconnaissance surveys, on a scale of 1:250,000 (4 miles to the inch), was 10,700 square miles; by detailed geologic surveys, on a scale of 1:62,500 (1 mile to the inch), 200 square miles. Much of the time of the geologists was devoted to the investigation of special field problems in the principal mining districts, the results of which can not be presented areally. About 10,400 square miles were covered by topographic reconnaissance surveys, on a scale of 1:250,000 (4 miles to the inch), and 12.5 square miles by detailed topographic surveys, on a scale of 1:24,000 (2.64 miles to the inch).

In cooperation with the Forest Service the investigation of water powers of southeastern Alaska was begun in May, and during the summer eight automatic gaging stations were installed and maintained until the close of the year. Records of discharge were also kept at another station.

To state the work geographically, three parties worked in southeastern Alaska, one in the Copper River basin, one on Prince William Sound, two in the Cook Inlet-Susitna region, three in the Yukon basin, one in the Yukon-Kuskokwim region, while one was engaged in general investigations which included southeastern Alaska, the Yukon basin, and Seward Peninsula.

Among the important results of the year was a reconnaissance survey of the upper Chitina basin, the completion of the detailed geologic survey of the Valdez district, the exploration of the Cosna-Nowitna region, and the tying together of the reconnaissance surveys of the Ruby, Innoko, and Iditarod districts.

The following table shows the allotments, including both field and office work, of the total appropriation of $100,000 for the fiscal year 1916 to the regions investigated. In addition to this a balance of about $11,000 from last year's appropriation was expended in equipping the parties for the season's field work. In preparing this table the general office expenses are apportioned to the several allotments, account being taken of variations in character of work. The results are expressed in round numbers. The "general investigations" include, among other things, the cost of collecting mineral statistics and of office work relating to the field investigations of previous seasons. A balance of about $6,000 will be utilized for equipping the field parties in 1916.

Approximate geographic distribution of appropriation for Alaska investigations, 1915.

Southeastern Alaska	$16,300
Copper River	10,400
Prince William Sound	5,000
Cook Inlet region	13,500
Yukon and Kuskokwim basins	40,500
General investigations	8,300
To be allotted to field work, 1916	6,000
	100,000

In the following table the approximate amount of money devoted to each class of investigations and surveys is indicated. It is not possible to give the exact figures, as the same party or even the same man may have carried on the different kinds of work, but this statement will serve to elucidate a later table, which will summarize the complete areal surveys.

Approximate allotments to different kinds of surveys and investigations, 1915.

Geologic reconnaissance surveys	$28,000
Detailed geologic surveys	3,800
Special geologic investigations	9,600
Reconnaissance topographic surveys	26,000
Detailed topographic surveys	3,000
Water-resource investigations	5,000
Collection of mineral statistics	1,300
Miscellaneous, including administration, inspection, clerical salaries, office supplies and equipment, and map compilation	17,300
To be allotted to field work, 1916	6,000
	100,000

Allotments for salaries and field expenses, 1915.

Scientific and technical salaries	$35,918
Field expenses	42,332
Clerical and other office and miscellaneous expenses	15,750
To be allotted to field work, 1916	6,000
	100,000

The following table exhibits the progress of investigations in Alaska and the annual grant of funds since systematic surveys were begun in 1898. It should be noted that a varying amount is spent each year on special investigations that yield results which can not be expressed in terms of area.

Progress of surveys in Alaska, 1898–1915.

Year.	Appropriation.	Areas covered by geologic surveys.			Areas covered by topographic surveys.[a]					Investigations of water resources (gaging stations maintained part of year).
		Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000).	Detailed (scale 1:62,500).	Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000; 200-foot contours).	Detailed (scale 1:62,500 and larger; 25, 50, or 100 foot contours).	Lines of levels.	Bench marks set.	
		Sq. m.	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Miles.*		
1898	$46,189	9,500	....	....	12,840	2,070	....	....	....	....
1899	25,000	6,000	....	....	8,690	....	....	....	....	....
1900	60,000	3,300	6,700	....	630	11,150	....	....	....	....
1901	60,000	6,200	5,800	....	10,200	5,450	....	....	....	....
1902	60,000	6,950	10,050	....	8,330	11,970	96	....	....	....
1903	60,000	5,000	8,000	96	....	15,000	....	....	....	....
1904	60,000	4,050	3,500	....	800	6,480	480	86	19	....
1905	80,000	4,000	4,100	536	....	4,880	787	202	28	....
1906	80,000	5,000	4,000	421	....	13,500	40	....	....	14
1907	80,000	2,600	1,400	442	....	6,120	501	95	16	48
1908	80,000	2,000	2,850	604	....	3,980	427	76	9	53
1909	90,000	6,100	5,500	450	6,190	5,170	444	....	....	81
1910	90,000	....	8,635	321	....	13,815	36	....	....	69
1911	100,000	8,000	10,550	496	....	14,460	246	....	....	68
1912	90,000	....	2,000	525	....	....	298	....	....	69
1913	100,000	3,500	2,950	180	3,400	2,535	287	....	....	....
1914	100,000	1,000	7,700	325	600	10,300	10	....	....	....
1915	100,000	....	10,700	200	....	10,400	12	3	2	9
	1,361,189	73,200	94,435	4,596	51,680	137,280	3,664	453	74	....
Percentage of total area of Alaska	....	12.48	16.10	0.78	8.81	23.41	0.62	....	....	....

[a] The Coast and Geodetic Survey, International Boundary Survey, and General Land Office have also made topographic surveys in Alaska. The areas covered by these surveys are of course not included in these totals.

GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

GENERAL WORK.

The writer was engaged in office work until July 9, when he started for Alaska. He held a conference with Mr. Canfield at Ketchikan, and devoted 10 days to the study of the geology and mineral resources of the Iditarod district, five days to the Hot Springs district, and sixteen days to the Fairbanks district. He returned to Washington October 14.

During the calendar year 1915 the writer devoted 46 days of his time in the office to geologic studies, 24 days to writing the progress report, 18 days to reading and revising manuscripts, 15 days to mineral statistics, 15 days to work of various committees, 9 days to field plans, and 8 days to preparation of the annual press bulletin on mining in Alaska.

To G. A. Waring was assigned the task of making a reconnaissance of the more accessible mineral springs of Alaska. He carried on field work in southeastern Alaska from June 15 to July 2, in the Yukon basin from July 10 to August 17, and in Seward Peninsula from August 28 to September 9. During this time he investigated 18 hot springs and 5 other springs and collected 27 samples of surface waters. A report of results has been submitted for publication.[1]

G. C. Martin and A. G. Maddren were engaged the entire year in office work. This respite from field work was necessary owing to the accumulation of a large amount of field data that had not been completely worked up. Mr. Martin was engaged chiefly in continuing his studies of the Mesozoic stratigraphy of Alaska, and Mr. Maddren was employed in preparing reports on the lower Kuskokwim region and on the international boundary region of northeastern Alaska.

R. H. Sargent continued the general supervision of the Alaska topographic surveys and map compilation in addition to carrying on his own field work.

E. M. Aten continued as office assistant to the geologist in charge and supervised the office work during the writer's absence in the field. He also continued to assist in collecting statistics of production of precious metals in Alaska.

SOUTHEASTERN ALASKA.

The detailed topographic survey of the region adjacent to Juneau was continued by D. C. Witherspoon. Field work was begun on May 12 and continued, so far as weather permitted, until October 7. The large scale adopted for this base map (1 : 24,000, or about 2.64 inches to the mile), the rugged character of the country, and the vegetation all combine to make the work exceedingly difficult. In spite of the adverse conditions Mr. Witherspoon completed the mapping of 12.5 square miles. He also occupied 16 triangulation stations, ran 3 miles of levels, and set two permanent bench marks.

[1] Waring, G. A., Mineral springs of Alaska, with a report on the quality of surface waters by R. B. Dole and A. G. Chambers: U. S. Geol. Survey Water-Supply Paper 418 (in preparation).

The systematic geologic survey of the Ketchikan district, begun in 1913 but interrupted in 1914, was continued in 1915 by Theodore Chapin. Field work was begun on May 16 and continued until October 23. A gasoline launch was used for transportation, and about 420 square miles was covered, besides which special investigations of mineral resources were made. Some of the results are summarized elsewhere in this volume.

Under a cooperative agreement with the Forest Service the investigation of the water powers of southeastern Alaska was begun in 1915. G. H. Canfield, who had charge of this work, established his headquarters at Ketchikan in May and continued the water measurements throughout the rest of the year. Eight automatic gaging stations and one other station were installed, in addition to which many miscellaneous measurements were made. Records of stream flow will have to be obtained through a period of years before accurate data on run-off are available.

Meanwhile the records thus far obtained are not without value and are summarized elsewhere in this volume. Many members of the Forest Service have aided in this work, but special acknowledgment should be made to William G. Weigle, supervisor at Ketchikan, and to Leonard Lundgren, district engineer at Portland, Oreg.

COPPER RIVER REGION.

Though much the larger part of the Copper River basin had been covered by reconnaissance surveys and some detailed geologic surveys had been made, there still remained a considerable area in the upper Chitina basin, which was geologically unknown. F. H. Moffit, assisted by R. M. Overbeck, was detailed to this investigation. A journey was made with pack train up the north side of the Chitina Valley to a point within 10 miles of the international boundary. Field work began on June 20 and ended September 25, and a geologic reconnaissance of about 900 square miles was completed. The topographic map made by the International Boundary Commission was used as a base and was supplemented by topographic reconnaissance surveys of an adjacent area of about 360 square miles. The economic results are summarized in this volume, and the complete report is in preparation.

PRINCE WILLIAM SOUND.

The detailed geologic survey and study of mineral resources of the Port Valdez district, begun in 1914, was completed in 1915 by B. L. Johnson. He began field work on June 5 and continued it until October 25. His report is now in preparation.

COOK INLET-SUSITNA REGION.

The construction of the Government railroad from Seward to Fairbanks has led to a demand for information about the tributary regions. Most of these had been mapped and investigated in previous years, but there were some areas east of Knik Arm and in the Talkeetna Mountains about which little was known. Two parties were detailed to explore those regions.

J. W. Bagley devoted the early part of the season to extending the topographic reconnaissance north of the previously mapped areas in the Talkeetna Mountains over an area of 835 square miles. He also surveyed an area of 150 square miles in the Knik and Turnagain Arm region. Pack-train transportation was used, and field work began on June 6 and continued until September 5. Mr. Bagley's surveys were much hampered by the smoke of forest fires in the early part of the season, and later he lost nearly three weeks because of the nondelivery of some supplies, owing to an accident that was caused by no fault of the contractor.

S. R. Capps, with a pack train and two men, studied the geology of the Knik and Turnagain Arm region, investigating the geology of an area of about 1,200 square miles. From June 14 to September 12 was devoted to fieldwork, but about a week of this time was spent in investigating the mining developments of the Willow Creek district. The results of Mr. Capps's work are presented elsewhere in this volume.

YUKON AND KUSKOKWIM BASINS.

The general features of the geology of the upper part of the Yukon basin in Alaska are fairly well known through the various reconnaissance surveys that have been made in the past. At best, however, the stratigraphic sequence and structure have been determined only on broad general lines, and present knowledge contains many gaps which are fatal to correlation. Owing to the rapid mining development a more detailed knowledge is imperative. As a preliminary measure some stratigraphic and structural studies of this region were undertaken in 1915 by Eliot Blackwelder. The work was done by a boat trip from Eagle to Circle and thence with pack train to the White Mountains, 100 miles to the southwest. The work was considerably hampered by the loss of the pack train in midsummer, but some significant stratigraphic and structural results were achieved. The return to the Yukon was made by raft down Beaver and Birch creeks, and it was thus possible to make traverses of those streams, whose courses through the flats were previously unknown. The geologic results are to be summarized in a publication now in preparation.

Before the surveys of 1915 much of the area lying between the Ruby district, on the southwest, and Tanana River, on the northeast, was practically unknown. H. M. Eakin was assigned to the work of exploring this field. He left the mouth of Cosna River, a southern tributary of the Tanana, with a pack train on June 16 and carried a geologic and topographic exploratory survey northwest to the Nowitna. Here the horses were shot, and the party continued the journey to the Yukon on a raft, arriving there on September 3. Though he had no technical assistance, Mr. Eakin made geologic exploratory surveys of an area of 2,600 square miles and topographic surveys of an area of 3,000 square miles.

A large area was also surveyed in the region including the Ruby district on the north and Iditarod on the southwest and extending southeastward to the mouth of Takotna River, a tributary to the Kuskokwim. The northern party in this field, which included C. E. Giffin, topographic engineer in charge, with G. L. Harrington as geologist, covered some 2,400 square miles by geologic and topographic reconnaissance surveys, besides revising the old surveys of some 1,600 square miles. The traveling was done by pack train and the field season extended from June 11 to September 11. R. H. Sargent, topographic engineer, had charge of the southern party, with J. B. Mertie as geologist, and worked from June 13 to September 7. This party made topographic and geologic reconnaissance surveys of 3,520 square miles and revised the previous surveys of 490 square miles. This work was accomplished between June 13 and September 7.

COLLECTION OF STATISTICS.

The collection of statistics of precious-metal production was continued by the writer, assisted by different members of the field staff but principally by Mr. Aten, as in previous years. Mine operators have shown an increasing interest in this work by furnishing statements of mineral production. There are still some who fail to make returns, thereby decreasing the accuracy of the figures on production for the different districts. Fortunately other sources of information are available, and, thanks to the public spirit shown by many residents of the Territory, it is possible to obtain data on which reliable estimates of mineral production can be based. Until all the mine operators make returns, however, it is not possible to obtain entirely accurate figures. The delinquents are chiefly placer miners, for practically all the gold and copper lode operators make annual returns on output. As has been the practice in the past, a press bulletin was issued on the first of January summarizing the estimates of mineral production and mining developments of the previous year. Though the figures on production then published vary somewhat from the final figures included in this report, yet they were near enough to the truth to serve the immediate purpose of those interested in the mining industry of Alaska. The prompt publication makes the data available when they are most needed.

PUBLICATIONS.

During 1915 the Survey published one professional paper, six bulletins, and one water-supply paper relating to Alaska. Another water-supply paper was published in February, 1916. In addition, two bulletins are in press, and ten reports, including this volume, were in progress at the end of the year. Eight topographic maps were published during the year, and three others are in press.

REPORTS ISSUED.

Professional Paper 87. Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska, by C. W. Wright; including detailed geologic and topographic maps.

Bulletin 576. Geology of the Hanagita-Bremner region, Alaska, by F. H. Moffit; including topographic and geologic reconnaissance maps.

Bulletin 587. Geology and mineral resources of Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant; including geologic and topographic reconnaissance maps.

Bulletin 605. The Ellamar district, Alaska, by S. R. Capps and B. L. Johnson; including detailed geologic and topographic maps.

Bulletin 607. The Willow Creek district, Alaska, by S. R. Capps; including detailed geologic and topographic maps.

Bulletin 608. The Broad Pass region, Alaska, by F. H. Moffit, with sections on Quaternary deposits, igneous rocks, and glaciation by J. E. Pogue; including geologic and topographic reconnaissance maps.

Bulletin 622. Mineral resources of Alaska: Report on progress of investigations in 1914.

Water-Supply Paper 342. Surface water supply of the Yukon-Tanana region, Alaska, by C. E. Ellsworth and R. W. Davenport; including topographic reconnaissance maps.

REPORTS IN PRESS.

Water-Supply Paper 372. A water-power reconnaissance in south-central Alaska, by C. E. Ellsworth and R. W. Davenport. (Published February 4, 1916.)

The Chisana-White River district, Alaska, by S. R. Capps (Bulletin 630).

The Yukon-Koyukuk region, Alaska, by H. M. Eakin (Bulletin 631).

REPORTS IN PREPARATION.

Geology of the Glacier Bay and Lituya region, Alaska, by F. E. Wright and C. W. Wright; including geologic reconnaissance map.

Geology of the region along the international boundary from Porcupine River to the Arctic Ocean, by A. G. Maddren; including detailed geologic map.

The upper Matanuska basin, by G. C. Martin.

The antimony deposits of Alaska, by Alfred H. Brooks (Bulletin 649).

The mineral springs of Alaska, by G. A. Waring (Water Supply Paper 418).

The Kotsina-Kuskulana district, by F. H. Moffit.

The Lake Clark-Central Kuskokwim region, by Philip S. Smith.

The lower Kuskokwim region, by A. G. Maddren.

The Nelchina-Susitna region, by Theodore Chapin.

TOPOGRAPHIC MAPS ISSUED.

General map of Alaska, by R. H. Sargent; scale, 1:500,000. Sale edition.

Port Valdez district, by J. W. Bagley and C. E. Giffin; scale, 1:62,500; contour interval 50 feet. Sale edition.

Index map of Alaska; including list of publications; scale, 1:5,000,000.

Kenai Peninsula, by R. H. Sargent and J. W. Bagley; scale, 1:250,000; contour interval 200 feet. (Plate II, Bulletin 587.)

Moose Pass and vicinity, by J. W. Bagley; scale, 1:62,500; contour interval 50 feet. (Plate IV, Bulletin 587.)

Willow Creek district, by C. E. Giffin; scale, 1:62,500; contour interval 100 feet. (Plate II, Bulletin 607.)

Ellamar district, by R. H. Sargent and C. E. Giffin; scale, 1:62,500; contour interval 100 feet. (Plate I, Bulletin 605.)

Broad Pass region, by J. W. Bagley; scale 1:250,000; contour interval 200 feet. (Plate I, Bulletin 608.)

TOPOGRAPHIC MAPS IN PRESS.

Lower Matanuska Valley, by R. H. Sargent; scale, 1:62,500; contour interval 50 feet. Sale edition.

Chisana-White River district, by C. E. Giffin; scale, 1:250,000; contour interval 200 feet. (Plate I, Bulletin 630.)

Yukon-Koyukuk region, by H. M. Eakin; scale, 1:500,000; contour interval 400 feet. (Plate I, Bulletin 631.)

THE ALASKAN MINING INDUSTRY IN 1915.

By Alfred H. Brooks.

GENERAL FEATURES.

The Alaskan mining industry as a whole was more prosperous in 1915 than in any previous year. This is indicated by the value of the total mineral output, which was $32,854,229, compared with $19,065,666 for 1914. The highest value for any previous year was in 1906, when Alaska produced $23,378,428 worth of minerals, but this was at a time when the bonanza placers of Fairbanks and Nome were yielding their greatest returns. Though the high value of the mineral production of 1915 was due for the most part to an enormous copper output, which was more than four times that of the previous year, yet the mining of gold, silver, and other mineral products also increased. The gold output of the placer mines was less than in the previous year, but this decrease was more than made up by the increase in gold output of the lode mines.

The enormous expansion of the copper-mining industry was directly due to the high price of copper, yet it should be noted that this expansion was possible only because of the large developments that have been under way for several years. It augurs well for the future of the industry that the Alaska copper mines are now sufficiently developed to take advantage of the market conditions of last year by producing so large a tonnage.

There were also during 1915 marked advances in the Alaskan auriferous lode mining industry. As in previous years, the gain was made principally in southeastern Alaska and especially in the Juneau district, though progress was also made in some of the other fields. The inland gold-lode camps are, however, as yet too isolated to permit extensive lode development, which must await the completion of railroads.

Most of the important placer camps are also in the inland region, and these have not yet reacted to the stimulus of railroad construction. Some of the smaller placer camps made notable gains in output, as compared with the previous year, yet these gains were more than offset by the decline in production from some of the more important Yukon districts. There are in the interior large areas of gold-bearing gravel whose values are too low to permit profitable exploitation under the present high operating costs. Until cheaper transportation and fuel lessen these costs the placer output will probably continue to decline.

The high prices of tin, antimony, tungsten, and other metals stimulated the search for and development of deposits containing these minerals. Besides the tin production, which was about the same as in previous years, during 1915 considerable antimony ore was shipped from Fairbanks and Nome—the first antimony to be produced in Alaska. In the Fairbanks district the development of a vein carrying tungsten (scheelite) was begun.

Some investigations and preparations were made for the mining of high-grade Alaska coal under the new leasing law. A little lignitic coal was mined under the permit system provided by this law, but as yet no large coal-mining enterprises have been begun. With the development of the coal fields which is now assured the metalliferous mining industry will receive a great stimulus.

In addition to the minerals mentioned above, marble, gypsum, barite, and petroleum were produced on about the same scale as in previous years. Some development work was done on deposits of molybdenite, chromic iron ore, and graphite, but so far as known these minerals were not produced on a commercial scale.

The statistics for Alaska's mineral production in 1914 and 1915 are given in the subjoined table. The output of marble, gypsum, petroleum, barite, and garnet is given as a single item because a separate listing might reveal the production of individual properties.

Mineral output of Alaska, 1914 and 1915.

	1914		1915		Increase in 1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold................fine ounces..	762,596	$15,764,259	807,966	$16,702,144	45,370	$937,885
Silver....................do....	394,805	218,327	1,071,782	543,393	676,977	325,066
Copper................pounds..	21,450,628	2,852,934	86,509,312	15,139,129	65,058,684	12,286,195
Tin........tons of metallic tin..	104	66,560	102	78,846	a 2	12,286
Antimony....tons of crude ore..	....	....	833	74,000	833	74,000
Lead................short tons..	28	1,344	437	41,118	409	39,774
Coal....................do....	....	....	1,400	3,300	1,400	3,300
Marble, gypsum, petroleum, etc.	....	162,242	....	272,299	....	110,057
		19,065,666		32,854,229		13,788,563

a Decrease.

Productive mining began in Alaska in 1880, when the Juneau gold placers were first exploited. It is estimated that since that time mineral wealth has been produced to the value of more than $300,000,000. This output, by years and substances, is summarized in the following table:

Value of total mineral production of Alaska, 1880–1915.

By years.		By years.		By substances.	
1880–1890	$4,686,714	1904	$9,569,715	Gold	$260,858,943
1891	916,920	1905	16,480,762	Silver	2,821,911
1892	1,098,400	1906	23,378,428	Copper	34,919,581
1893	1,051,610	1907	20,850,235	Tin	458,852
1894	1,312,567	1908	20,145,632	Antimony	74,000
1895	2,388,042	1909	21,146,953	Lead	108,260
1896	2,981,877	1910	16,887,244	Coal	365,833
1897	2,540,401	1911	20,691,241	Marble, gypsum, petroleum, etc.	1,346,371
1898	2,587,815	1912	22,536,849		300,953,751
1899	5,706,226	1913	19,476,356		
1900	8,241,734	1914	19,065,666		
1901	7,010,838	1915	32,854,229		
1902	8,403,153		300,953,751		
1903	8,944,134				

GOLD, SILVER, AND COPPER.

The following table gives an estimate of the total production of gold, silver, and copper since the beginning of mining in 1880. For the earlier years, especially for silver, the figures are probably far from being correct, but they are based on the best information now available.

Gold, silver, and copper produced in Alaska, 1880–1915.

Year.	Gold.		Silver.		Copper.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.	Quantity (pounds).	Value.
1880	967	$20,000			3,933	$826
1881	1,935	40,000				
1882	7,256	150,000				
1883	14,561	301,000	10,320	$11,146		
1884	9,728	201,000				
1885	14,512	300,000				
1886	21,575	446,000				
1887	32,653	675,000				
1888	41,119	850,000	2,320	2,181		
1889	43,538	900,000	8,000	7,490		
1890	36,862	762,000	7,500	6,071		
1891	43,538	900,000	8,000	7,920		
1892	52,245	1,080,000	8,000	7,000		
1893	50,213	1,038,000	8,400	6,570		
1894	62,017	1,282,000	22,261	14,257		
1895	112,642	2,328,500	67,200	44,222		
1896	138,401	2,861,000	145,300	99,087		
1897	118,011	2,439,500	116,400	70,741		
1898	121,760	2,517,000	92,400	54,575		
1899	270,997	5,602,000	140,100	84,276		
1900	395,030	8,166,000	73,300	45,494		
1901	335,369	6,932,700	47,900	28,598	250,000	40,000
1902	400,709	8,283,400	92,000	48,590	360,000	41,400
1903	420,069	8,683,600	143,600	77,843	1,200,000	156,000
1904	443,115	9,160,000	198,700	114,934	2,043,586	275,676
1905	756,101	15,630,000	132,174	80,165	4,805,236	749,617
1906	1,066,030	22,036,794	203,500	136,345	5,871,811	1,133,260
1907	936,043	19,349,743	149,784	98,857	6,308,786	1,261,757
1908	933,290	19,292,818	135,672	71,906	4,585,362	605,267
1909	987,417	20,411,716	147,950	76,934	4,124,705	536,211
1910	780,131	16,126,749	157,850	85,239	4,241,689	538,695
1911	815,276	16,853,256	460,231	243,923	27,267,878	3,408,485
1912	829,435	17,145,951	515,186	316,839	29,230,491	4,823,031
1913	755,947	15,626,813	362,563	218,988	21,659,958	3,357,293
1914	762,596	15,764,259	394,805	218,327	21,450,628	2,852,934
1915	807,966	16,702,144	1,071,782	543,393	86,509,312	15,139,129
	12,619,050	260,858,943	4,923,288	2,821,911	219,913,375	34,919,581

In the subjoined table the total gold production is distributed according to districts so far as the information at hand will permit. The error in distribution of total production previous to the year 1905, when the systematic collection of statistics on Alaska's mineral output was begun, is believed to be less than 10 per cent. Complete statistical returns from all producers are not even now available so that there is probably still some error in the distribution of the totals to the various districts. This error, however, is believed to be less than 3 per cent, and it is hoped that in the future it may be eliminated altogether.

The gold produced in the Pacific coast belt is derived chiefly from lodes in southeastern Alaska and the Prince William Sound region, but includes a small output from gold placers. Previous to 1885 the placers of the Juneau district yielded considerable gold, and since 1899 the Porcupine placer district, in southeastern Alaska, has been a small producer. The beach placers along the Pacific seaboard have been worked spasmodically since about 1888.

Up to 1909 all the gold from the Copper River and Cook Inlet region was derived from gold placers; since then there has been a considerable output from the auriferous lodes of Willow Creek and a smaller output from those of Kenai Peninsula. The gold output of Seward Peninsula is practically all derived from placers, though there has been a little lode mining. Since 1910 there has been a small lode production from the Fairbanks district, which in 1915 amounted to about 7.5 per cent of the total.

Some gold has been recovered each year since 1910 from placers in the lower Kuskokwim basin. In the table which follows, this is included in the output of the Yukon basin. It should be noted that the gold output credited to the Yukon is only that from the Alaska camps and of course does not include that of the Klondike and other Canadian districts.

Value of gold produced in Alaska, with approximate distribution, 1880–1915.

Year.	Pacific coast belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula and northwestern Alaska.	Total.
1880	$20,000				$20,000
1881	40,000				40,000
1882	150,000				150,000
1883	300,000		$1,000		301,000
1884	200,000		1,000		201,000
1885	275,000		25,000		300,000
1886	416,000		30,000		446,000
1887	645,000		30,000		675,000
1888	815,000		35,000		850,000
1889	860,000		40,000		900,000
1890	712,000		50,000		762,000
1891	800,000		100,000		900,000
1892	970,000		110,000		1,080,000
1893	838,000		200,000		1,038,000
1894	882,000		400,000		1,282,000
1895	1,569,500	$50,000	709,000		2,328,500

Value of gold produced in Alaska, with approximate distribution, 1880–1915—Contd.

Year.	Pacific coast belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula and northwestern Alaska.	Total.
1896	$1,941,000	$120,000	$800,000		$2,861,000
1897	1,799,500	175,000	450,000	$15,000	2,439,500
1898	1,892,000	150,000	400,000	75,000	2,517,000
1899	2,152,000	150,000	500,000	2,800,000	5,602,000
1900	2,606,000	160,000	650,000	4,750,000	8,166,000
1901	2,072,000	180,000	550,000	4,130,700	6,932,700
1902	2,546,600	375,000	800,000	4,561,800	8,283,400
1903	2,843,000	375,000	1,000,000	4,465,600	8,683,600
1904	3,195,400	500,000	1,300,000	4,164,600	9,160,000
1905	3,430,000	500,000	6,900,000	4,800,000	15,630,000
1906	3,454,794	332,000	10,750,000	7,500,000	22,036,794
1907	2,891,743	275,000	9,183,000	7,000,000	19,349,743
1908	3,448,318	401,500	10,323,000	5,120,000	19,292,818
1909	4,264,716	265,000	[a] 11,580,000	4,302,000	20,411,716
1910	4,182,730	351,630	[a] 8,062,389	3,530,000	16,126,749
1911	4,265,573	313,538	[a] 9,139,145	3,135,000	16,853,256
1912	4,904,753	358,401	[a] 8,857,797	3,025,000	17,145,951
1913	4,529,529	378,643	[a] 8,183,641	2,535,000	15,626,813
1914	4,538,157	597,681	[a] 7,895,421	2,735,000	15,764,259
1915	5,808,978	605,390	[a] 7,367,776	2,920,000	16,702,144
	76,259,291	6,613,783	106,423,169	71,562,700	260,858,943

[a] Includes a small proportion from the Kuskokwim basin.

The subjoined table gives an estimate, based on the best available data, of the source of the gold and silver produced in Alaska since mining began in 1880. About $65,100,000 worth of gold, or nearly one-third of the total estimated output, was produced before 1905, and there is but scant information about its source. For the period since that time fairly complete statistical returns are available, and it is probable that the figures presented in the following table are near enough to the truth to be valuable. The figures given for the silver recovered from placer gold and from siliceous ores are probably less accurate than those for the gold. Copper mining did not begin in Alaska until 1901, and the figures for gold and silver derived from this industry, as now presented, are therefore a close approximation to the actual output.

Estimate of sources of gold and silver in Alaska, 1880–1915.

	Gold.		Silver.	
	Quantity.	Value.	Quantity.	Value.
	Fine ounces.		*Fine ounces.*	
Siliceous ores	3,558,376	$73,558,164	986,188	$658,843
Copper ores	53,588	1,107,787	2,360,187	1,295,233
Placers	9,007,086	186,192,992	1,576,913	867,835
	12,619,050	260,858,943	4,923,288	2,821,911

The above table shows that about 29 per cent of the total gold production of Alaska has been obtained from the lode mines. In 1915 the lode-gold production was 38 per cent; in 1914, 32 per cent;

in 1913, 31.6 per cent; and in 1912, 29 per cent. These figures indicate a gradual transition from placer to lode mining. In the following table the production of precious metals in 1915 has been distributed as to sources:

Sources of gold, silver, and copper in Alaska, 1915.

	Total quantity.	Gold.		Silver.		Copper.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	*Fine ounces*		*Fine ounces*		*Pounds.*	
Siliceous ores	3,020,607	293,588.99	$6,069,023	91,341	$46,310	....	....
Copper ores	369,600	7,407.23	153,121	897,839	455,204	86,509,312	$15,139,129
Placers	....	506,970.00	10,480,000	82,602	41,879	....	....
	3,390,207	807,996.22	16,702,144	1,071,782	543,393	86,509,312	15,139,129

Twenty-eight gold-lode mines, including several properties that made only small outputs, were operated the whole or a part of the year 1915 in Alaska, the same number as in 1914. Work was also done on many gold prospects, some of which produced a little gold. Of the producing mines thirteen were in southeastern Alaska, five on Prince William Sound, four in Kenai Peninsula, three in the Willow Creek district, and three in the Fairbanks district. In 1914 the average value of the gold and silver contents for all the ores mined was $2.79 a ton; the average for 1915 was $2.02.

Thirteen copper mines were operated in Alaska for a whole or a part of the year 1915, compared with six in 1914. Of these, six were in the Ketchikan district, four on Prince William Sound, and three in the Kotsina-Chitina district. The average copper content of the ore was 11.7 per cent and the value of the gold and silver recovered about $1.65 to the ton. The average for 1914 was 6.98 per cent of copper and $2.04 to the ton in gold and silver.

It is estimated by Sumner Smith, the Federal mine inspector for the Territory of Alaska, that during the fiscal year ending June 30, 1915, 4,400 men were engaged in lode mining.[1] Though this figure represents the fiscal and not the calendar year, it serves to indicate approximately the number of men employed in 1915.

The value of the placer gold produced in 1915 was $10,480,000; in 1914 it was $10,730,000. Compared with the previous year there was a decrease in the placer-gold output from the Ruby, Hot Springs, Fairbanks, and Chisana districts and an increase from the Seward Peninsula, Koyukuk, Circle, and Nizina districts, as well as from some of the smaller camps. It is estimated that about 700 placer mines were operated in 1915, but many for only a part of the season; the number was 730 in 1914. About 4,575 men were engaged in

[1] Bur. Mines Fifth Ann. Rept., p. 54, 1915.

productive placer mining, most of them for only a small part of the year. In addition at least 500 men were engaged in prospecting and other nonproductive work relating to placer mining.

No new placer districts were discovered in 1915, though new ground was opened up in regions previously known to be gold bearing. The most noteworthy of these operations was the development of placers in the Tolovana district, which is now productive. Some placers were also developed on Dime Creek, in the southeastern part of Seward Peninsula and on Canyon Creek, in the lower Kuskokwim region.

In accordance with past practice a table is given here to show approximately the total bulk of gravel mined annually in Alaska and the value of the gold recovered. This table is based on certain assumptions which do not now admit of proof but which are supported by a large number of facts. Therefore, although the table is only approximately correct, it indicates the order of magnitude of the true figures.

Estimated amount of gravel sluiced in Alaska placer mines and value of gold recovered, 1908–1915.

Year.	Total quantity of gravel.	Value of gold recovered per cubic yard.	Year.	Total quantity of gravel.	Value of gold recovered per cubic yard.
	Cubic yards.			*Cubic yards.*	
1908	4,275,000	$3.74	1912	7,050,000	$1.70
1909	4,418,000	3.66	1913	6,800,000	1.57
1910	4,036,000	2.97	1914	8,500,000	1.26
1911	5,790,000	2.17	1915	8,100,000	1.29

The increase in value of gold recovered per cubic yard from $1.26 in 1914 to $1.29 in 1915, as shown in the above table, is a reflection of the fact that the dredging industry of the Seward Peninsula has declined somewhat. This increase, though very slight, is significant as being the first in the eight years shown in the table, improved methods of mining having previously gradually reduced the average recovery per cubic yard. In other words, the larger plants have made it possible to mine placers of lesser value. It is not to be supposed, however, that the minimum average recovery has yet been reached, for the value of $1.29 a cubic yard is many times the average recovery of placer mining in the States.

Thirty-five gold dredges were operated in Alaska during 1915. Of these 31 were on Seward Peninsula, 2 in the Iditarod district, 1 in the Fairbanks, and 1 in the Birch Creek district. Two of the Seward Peninsula dredges were working on placers containing both gold and tin. Two dredges engaged in tin mining exclusively are not included in the above total, nor is a gold dredge which was installed and operated on Sixmile Creek, in Kenai Peninsula, for a short time during 1915.

It is estimated that the gold dredges handled 4,600,000 cubic yards of gravel and made a gold recovery worth $2,330,000. In the preceding year 42 gold dredges handled 4,450,000 cubic yards of gravel and recovered gold to the value of $2,350,000. The average gold recovery per cubic yard was therefore about 51 cents in 1915 and 50 cents in 1914. The gold dredges of Seward Peninsula made an average recovery of 35 cents a cubic yard in 1915 and 40 cents in 1914. Most of the dredges of the Yukon districts are working on placers of relatively high gold tenor, and their average recovery in 1915 was about 80 cents a yard.

The dredges of Seward Peninsula that worked full time during 1915 were operated about 100 days in the more isolated camps, while at least one near Nome was operated for 144 days. In the Alaska Yukon the dredging season, so far as determined by the few machines operated, is from 120 to 196 days. The large dredges of the Klondike, where the climatic conditions are if anything less favorable than in the lower Yukon basin, are operated for at least 180 days, and some have even worked for 270 days.

The following table, prepared by the Yukon Gold Co., summarizes the results of the first three years' work of its dredge operated on Flat Creek, in the Iditarod district:

Results obtained by Iditarod dredge of Yukon Gold Co.[a]

Season.	Began.	Ceased.	Cubic yards handled.	Yield.		Operating cost.[b]	
				Total.	Per cubic yard.	Total.	Per cubic yard.
1912	Aug. 15	Oct. 29	172,333	$404,040	$2.34	$79,114	$0.4591
1913	May 8	Nov. 25	496,756	827,420	1.67	319,560	.6433
1914	May 4	Nov. 11	668,737	739,631	1.10½	335,825	.502
			1,337,826	1,971,091	1.47	734,499	.548

[a] High yield of Iditarod dredge: Eng. and Min. Jour., vol. 99, p. 727, Apr. 24, 1915.
[b] Includes $50,000 a year depreciation.

A later statement [1] covers the work of 1915:

> The Iditarod dredge in Alaska began operations on May 4 and closed down on November 17. During this operating season of 196 days the dredge handled 926,956 cubic yards for a gold return of $845,998, an average of 91.3 cents per cubic yard for the year. The average cost, including depreciation, was 38.7 cents per cubic yard, which was lower than in 1914 by 11.5 cents per cubic yard. The yardage handled in 1915 was 258,219 cubic yards greater than during the previous season. The dredge operated 91.64 per cent of the possible time and averaged 4,717 cubic yards per day. The daily output of the dredge was 1,216 yards more than during the 1911 season and was due to better dredging conditions and to improvement in the handling of sands.

[1] Perry, O. B., Dredging and hydraulicking in 1915 by Yukon Gold Co.: Eng. and Min. Jour., vol. 101, p. 550, Mar. 25, 1915.

The percentage of naturally thawed ground increased only 49,953 square yards, about 36 per cent having to be thawed by steam. Sand elevators were installed on the Iditarod dredge during the year to replace the pumps previously in use for this purpose.

In view of the importance to the Alaska placer-mining industry of the development of economic methods of dredging frozen ground, the following extracts are given from a paper by the general manager of the Yukon Gold Co.,[1] who has had very extensive experience in this form of mining:

While the short season and severe service have led to numerous improvements in detail and to increases in strength and size of the dredges and continue to offer problems which the dredge operator must meet, the greatest development in the Yukon as compared to the ordinary dredging operation has come in the handling of frozen ground. The heavy bedrock encountered on the creeks and the necessity of digging it to considerable depth to recover the gold were in themselves serious matters. No experienced dredge operator would have thought, in the beginning, that any dredge could handle the bedrock which the machines are digging to-day with comparative ease. When the business was further complicated by having large areas solidly frozen, the problem of dredging such areas at a profit became one of extreme difficulty. The results of attempts to dredge partly thawed areas and frozen bedrock were enough to show that the frozen condition must be completely changed before dredging could be successful. Necessity compelled the adoption of the present method of thawing, which is the development on a wholesale plan of the method which was in use in the drift mines in the Klondike before dredges were thought of. Preparing the ground for dredging by thawing with steam was an entirely new feature of dredge mining, and the success of the method has made millions of yards of gravel available for dredging which could not otherwise be worked at a profit.

The steam point as originally used was a short piece of $\frac{3}{8}$-inch pipe drawn down at one end to a point, with an orifice left for the steam to escape; the other or head end had a nipple welded to it for steam-hose connection. The point with steam turned on was gradually driven into the face of the drift, then allowed to steam until the bedrock and gravel were thawed to the height of the drift. From two to six points were used in each breast, spaced from 1 to 2 feet apart. This simple operation contained the essential features of the method whereby over 3,000,000 yards of gravel are now being thawed in a season.

In the thawing operation for dredging, the points are driven from the surface down through muck and gravel and into the bedrock from 4 to 6 feet. The points are gradually lengthened in practice, first to 24 feet, then to 30, and last season were being successively driven 40 feet to bedrock. The points are made up of triple extra heavy hydraulic pipe with drop-forged head and tool-steel tip. The small boilers first used have been replaced by larger sizes until the boiler equipment now comprises eight plants with a total boiler horsepower of over 2,000. The 150-horsepower locomotive type has been adopted as the unit, and the plants usually consist of a pair or sometimes three such boilers.

The preliminary work for the season takes the following form: (1) The dredgeable area ahead of each boat is barred for frost. From the bar-hole results the naturally thawed and frozen areas are blocked out. The bar tests are checked by drilling where thought necessary. (2) Surveyors "pick up" the thawed areas, which are mapped, and planimeter measurements are made of the frozen areas. (3) The estimated course of the boat is laid out for the year and its probable position calculated for each month of the season. (4) The total square yards of frozen ground which the dredge will dig

[1] Perry, O. B., Development of dredging in the Yukon Territory: Eng. and Min. Jour., vol. 100, pp. 1042-1044, Dec. 20, 1915.

in a season is measured from the map on which the season's work is laid out, and the necessary wood for thawing is determined and its location decided.

The "sweating" of the naturally thawed ground must also be taken into account. The duty per cord, both in thawing and in sweating, to dispose of the surface frost has been determined by experience. Knowing the square yards of frozen ground to be thawed and the area of naturally thawed ground to be "sweated" and the duty per cord of fuel, the total fuel requirement for the season is a simple computation.

The thawing operation has been described elsewhere, so that I need only give the sequence of events in a normal operation: (1) Steam-line boxes are strung out by horses, if they are available, otherwise men are used; (2) gooseneck boxes and headers coupled on; (3) bar holes for starters put down; (4) starters used to thaw holes about 8 feet deep; (5) starters pulled and long points placed in starter holes; (6) points driven down through gravel and into bedrock; (7) points allowed to steam in bedrock from 12 to 48 hours, depending on the formation; (8) points pulled, cleaned, and straightened; (9) header moved and starters put down and cycle begun again.

The improvements that have been made in steam thawing since it was adopted for large-scale dredging operations are too many to attempt to detail in a short paper. They have taken the following general lines: (1) Reduction in fuel; (2) increase in efficiency of hose and points; (3) reduction in cost of driving.

The fuel has been reduced by improving the quality, reducing the radiation losses, purifying the feed water, and improving the combustion. Experiments were made both with coal and fuel oil as a substitute for wood. The points have been greatly improved in material and manufacture, and the hose has been improved in quality and its life increased. Metal hose has been used for this work with success. The cost of driving has been reduced by improvement in the method of driving, correct spacing of points, and correct pressure and amount of steam.

The question most often asked in connection with dredging in the North is, What does it cost to thaw and dredge frozen ground? This is a difficult question to answer on account of the wide variation in conditions. All of the creek deposits contain some areas of naturally thawed ground. The percentage of frozen and thawed areas varies on the same stream, and still wider variations occur from one stream to another. This variation reflects itself in the cost per cubic yard, the cost going up or down as the percentage of frozen ground increases or diminishes.

Another variable factor is the cost of thawing or preparing the frozen ground for dredging. Thawing on Hunker Creek, for example, is a much more difficult and expensive operation than thawing on Bonanza. In 1911 the thawing for dredge No. 4 on Hunker Creek cost \$2.18 per square yard, as against \$1.085 ahead of No. 5 on Bonanza. The depth being practically the same, the cost of thawing per cubic yard was twice as great in the one case as in the other. Purely local conditions govern this cost, such as depth of ground, character of material, ease or difficulty in driving, time of steaming, cost of fuel, etc. Since the gold, practically speaking, is all confined to the bedrock, the cost per square yard of bedrock thawed becomes the controlling factor in determining what ground can be dredged at a profit and what must be left.

The appended tables show the thawing and dredging cost for the last six years of the Yukon Gold Co.'s operation. Table 4 shows the variation in working cost for the different dredges in one season. As the conditions change, the dredge holding the lowest cost for one season may show the highest cost for the next. When the costs for the eight dredges are totaled and averaged the results over several seasons are remarkably uniform.

While Table 1 shows a gradual reduction in the thawing cost, it does not reflect the improvement in efficiency, which has been marked. It is a rare occurrence now for a dredge to strike a piece of ground that is not thoroughly thawed. The improvement in this direction is shown by the gain in duty per dredge-hour, which increased from 162 cubic yards per hour in 1910 to 204 cubic yards per hour last year.

TABLE 1.—*Thawing cost, Yukon Gold Co., 1909–1914.*

Year.	Area worked.				Cost of thawing.	
	Total (square yards).	Frozen (square yards).	Naturally thawed.		Total.	Per square yard.
			Square yards.	Per cent.		
1909	298,061	212,903	85,158	28.6	$275,112	$1.5571
1910	396,837	256,033	140,804	35.5	500,689	1.7727
1911	555,393	432,693	122,700	22.1	696,034	1.6166
1912	692,522	509,574	182,948	26.4	804,854	1.455
1913	651,505	445,624	205,881	31.6	685,570	1.546
1914	586,737	402,660	184,077	31.4	602,174	1.428

TABLE 2.—*Dredging and thawing costs, Yukon Gold Co., 1909–1914.*

Year.	Cubic yards dredged.	Thawing cost per cubic yard.		Total cost per cubic yard (cents).
		Cents.	Percentage of total cost.	
1909	2,381,880	15.45	48.37	31.94
1910	3,249,788	14.14	45.57	31.09
1911	4,151,249	17.62	49.72	35.43
1912	5,157,280	15.02	49.03	30.64
1913	5,133,575	13.57	45.94	29.53
1914	4,800,781	12.18	44.09	27.62

TABLE 3.—*Detail of thawing costs, Yukon Gold Co., 1913.*

	Total expenditures.	Cost per square yard (cents).	Percentage of total cost.
Fixed salaries	$1,614.00	0.4	0.23
Labor	289,195.38	65.2	42.18
Fuel	295,928.03	66.7	43.17
Shop expense	1,722.16	.4	.25
Preliminary expense	36,021.74	8.1	5.25
Material and supplies	23,180.50	5.2	3.38
Stables	6,589.27	1.5	.96
Transportation	198.00	.1	.03
Miscellaneous	380.33	.1	.06
Depreciation	30,731.37	6.9	4.48
Power	9.45		.01
	685,570.23	154.6	100.00

Square yards thawed, 443,567; number of points driven, 63,004; cost per point driven, $10.88.

TABLE 4.—*Thawing and dredging costs of individual dredges of Yukon Gold Co.*

Dredge No.	Locality.	Percentage of area naturally thawed.	Thawing cost per cubic yard (cents).	Total cost per cubic yard (cents).
1	Bonanza Creek	22.1	12.55	31.93
2	.....do	34.6	12.28	32.55
3	.....do	14.0	18.36	33.79
4	Hunker Creek	7.2	17.95	32.11
5	Bonanza Creek	44.8	12.34	27.01
6	.....do	18.6	16.38	33.36
8	Upper Bonanza Creek	33.7	12.97	27.92
9	Eldorado Creek	58.6	7.49	21.16

Some attempts at gold dredging were made in Alaska as early as 1900. This form of mining did not, however, reach a profitable stage until 1903, when two small dredges were successfully operated in Seward Peninsula. Dredging began in the Fortymile district in 1907 and in the Iditarod, Birch Creek, and Fairbanks districts in 1912. Up to the end of 1915 gold to the value of $12,430,894 has been mined by dredges. The distribution of this output by years is shown in the following table:

Estimate of gold produced from dredge mining in Alaska, 1903–1915.

Year.	Number of dredges operated.	Value of gold output.	Year.	Number of dredges operated.	Value of gold output.
1903	2	$20,000	1911	27	$1,500,000
1904	3	25,000	1912	38	2,200,000
1905	3	40,000	1913	36	2,200,000
1906	3	120,000	1914	42	2,350,000
1907	4	250,000	1915	35	2,330,000
1908	4	170,901			
1909	14	424,993			12,430,894
1910	18	800,000			

TIN.

The Alaska mines produced 102 tons of metallic tin, valued at $78,846, in 1915, compared with 104 tons, valued at $66,560, in 1914. There was some increase in the output from the York district and a very decided falling off in the tin recovered from the gold placer mines of the Hot Springs district. No lode tin was produced in 1915, though developments of tin-bearing lodes continued. The subjoined table shows the tin production of Alaska since mining began in 1902. The figures for the earlier years are not accurate but are based on the best information available. The values given in the table are based on the average price of metallic tin for each year and do not represent the amount actually received for the crude ore by the producer. The average price of metallic tin during 1914 was 35.70 cents a pound; during 1915, 38.66 cents a pound.[1]

Tin produced in Alaska, 1902–1915.

Year.	Quantity (tons of metallic tin).	Value.	Year.	Quantity (tons of metallic tin).	Value.
1902	15	$8,000	1910	10	$8,335
1903	25	14,000	1911	61	52,798
1904	14	8,000	1912	130	96,000
1905	6	4,000	1913	69	44,103
1906	34	38,640	1914	104	66,560
1907	22	16,752	1915 (preliminary estimate)	102	78,846
1908	25	15,180			
1909	11	7,638		628	458,852

[1] Information from Frank L. Hess, of the U. S. Geological Survey.

The York Dredging Co., which is the largest producer, operated its dredge for 87 days on Buck Creek. Its season of operations was somewhat shorter than the normal season, owing to a late spring and early fall. The American Tin Dredging Co. installed a double-flume screen dredge having buckets of 2 cubic feet capacity on upper Buck Creek in 1915. This machine is operated by an 80-horsepower distillate engine and has an estimated daily capacity of 800 cubic yards. The dredge was completed in September and operated for the rest of the open season. The American Gold Dredging Co. operated two dredges on Anikovik River during 1915. One of them is of a double-flume screen type equipped with buckets holding 2 cubic feet; the other is a single-flume dredge with 1¾-foot buckets. The gravels mined by these dredges carry both placer gold and tin. Operations were begun on June 15 and continued until October 15. The four dredges mentioned employed about 50 men. It is reported that some tin-bearing gravels were sluiced on Sutter Creek, which flows into Buck Creek.

Developments were continued at several of the lode-tin properties in the York district during 1915. The noteworthy operations were the continuation of work at the mine of the Jamme syndicate, on Lost River, and on claims of the Bartell's Tin Mining Co. and the United States Tin Mining Co., on the eastern slope of Cape Mountain.

In the Hot Springs district eight operators reported the recovery of small quantities of stream tin incidental to gold placer mining. A churn drill was used extensively during 1915 to prospect for stream tin on Killarney Creek, a tributary of Baker Creek.

LEAD.

Although silver-galena deposits were among the first ores to attract attention in Alaska, practically none of them have been developed on a productive basis. Considerable lead has been produced, however, incidentally to the mining of lodes that were valuable chiefly for their gold content.

In 1915 the Alaska mines produced 437 tons of lead, valued at $41,118, compared with a production in 1914 of 28 tons, valued at $1,344.[1]

[1] Value calculated on the average price of lead during the two years, which according to C. E. Siebenthal, of the U. S. Geological Survey, was 4.7 cents a pound in 1915 and 3.9 cents in 1914.

The following table shows the lead production of Alaska, so far as can be determined from the available data:

Estimate of lead produced in Alaska, 1892–1915.

Year.	Quantity (tons).	Value.	Year.	Quantity (tons).	Value.
1892	30	$2,400	1905	30	$2,620
1893	40	3,040	1906	30	3,420
1894	35	2,310	1907	30	3,180
1895	20	1,320	1908	40	3,360
1896	30	1,800	1909	69	5,934
1897	30	2,160	1910	75	6,600
1898	30	2,240	1911	51	4,590
1899	35	3,150	1912	45	4,050
1900	40	3,440	1913	6	528
1901	40	3,440	1914	28	1,344
1902	30	2,460	1915	437	41,118
1903	30	2,520			
1904	30	2,580		1,261	109,604

ANTIMONY.[1]

There has in the past been considerable prospecting of deposits of antimony (stibnite) in Alaska, notably at the Sliscovich mine, in the Nome district, from which a few test shipments of ore were made as early as 1906. Until 1915, however, there was no commercial production in the Territory. The high price of antimony during the last two years has stimulated the development of stibnite deposits, and in 1915 shipments of stibnite ore were made from six Alaska mines. The records are incomplete as to the total ore produced, but the shipments were 833 short tons, valued at about $74,000. This ore probably averaged 58 per cent of metallic antimony. It is difficult from the information at hand to obtain any exact valuation of the stibnite ore shipped from Alaska. The evidence indicates that the producer received from $1.25 to $1.75 per unit of antimony and that the crude stibnite ore probably sold at an average price of $86 a ton at San Francisco, to which all the shipments were made. From this average has been computed the value of the total output given above.

Of the six antimony mines, four are in the Fairbanks district and two in the Nome district. The producing Fairbanks mines are the Scrafford, in the Treasure Creek basin; the Stibnite, in the Eva Creek basin; the Gilmer, in the Vault Creek basin; and the Chatham Creek mine. All the operations at these mines were on a small scale. The mining consisted chiefly of making open cuts and digging out the ore, which occurs in shoots, kidneys, and irregular masses along zones of fissuring. Most of the ore was broken and hand sorted, and no ore carrying less than 50 per cent of antimony was shipped. The ore was hauled to the railway by wagons and then sent by rail to Fairbanks

[1] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649 (in press).

and over the all-water route to San Francisco. The transportation companies offered a low freight rate to encourage the new industry. Some work was also done on other stibnite lodes in Fairbanks district.

Developments were continued on the Sliscovich mine, in the Nome district. The ore from this property carries gold, and the mine has been worked for the gold content. In 1915, however, the energies of the operators were directed toward getting out stibnite ore. Some stibnite was also mined at the Hed & Strand property, a few miles north of the Sliscovich mine. Some developments are reported on other stibnite-bearing lodes in the Nome district.

Stibnite is not an uncommon mineral in Alaska, and the recent demand for antimony has led to the prospecting of stibnite deposits in the Kantishna district, on Prince William Sound, on Kenai Peninsula, and in the Yentna district.

MINERAL FUELS.

There were no important developments in the coal or oil fields of Alaska during 1915. Under the new leasing law a number of permits were granted to mine coal in 10-acre tracts or less, and as a result some lignitic coal was mined at a number of localities to supply a local market. The largest of these operations was at the Bluff Point mine, on the north side of Kachemak Bay, an eastern indentation of Cook Inlet. This property was operated for most of the year, and its product was marketed at Seward, Anchorage, and other places near by. Smaller operations were carried on to supply coal to placer mining plants in the Yentna and Fairhaven districts and probably at other localities. It is estimated that the total production was about 1,400 tons, valued at $3,300.

The subjoined table shows the coal consumption of Alaska, including both imports and local production, since 1899. Most of the coal thus far mined is lignite. There was, however, in 1906, a small production of bituminous coal from the seaward end of the Bering River field. The table does not include 855 tons of coal mined in the Bering River field in 1912 and 1,100 tons mined in the Matanuska field in 1913 for the United States Navy. Most of the foreign coal shipped to Alaska is bituminous, only a little being anthracite. In 1915, 1,771 tons of foreign anthracite was imported into Alaska.

Coal consumed in Alaska, 1899 to 1915, in short tons.

Year.	Imported from States, chiefly from Washington.		Produced in Alaska, chiefly subbituminous and lignite.[a]	Total domestic, chiefly from Washington.[a]	Total foreign coal, chiefly bituminous from British Columbia.[b]	Total coal consumed.
	Bituminous.	Anthracite.				
1899	[c] 10,000		[c] 1,200	11,200	50,120	61,320
1900	15,048		[c] 1,200	16,248	56,623	72,871
1901	[c] 24,000		[c] 1,300	25,300	77,674	102,974
1902	[c] 40,000		2,212	42,212	68,363	110,575
1903	64,625	1	1,447	66,073	60,605	126,678
1904	36,689		1,694	38,383	76,815	115,198
1905	67,707	6	3,774	71,487	72,567	144,054
1906	68,960	533	5,541	75,034	47,590	122,624
1907	45,130	1,116	10,139	56,385	88,596	144,981
1908	23,402	491	3,107	27,000	72,831	99,831
1909	33,112		2,800	35,912	74,316	110,228
1910	32,138		1,000	33,138	73,904	107,042
1911	32,255		900	33,155	88,573	121,728
1912	27,767		355	28,122	59,804	87,926
1913	61,666		2,300	63,966	60,600	124,566
1914	37,062			37,062	21,882	58,944
1915	41,365		[c] 1,400	42,765	36,878	79,643
	660,926	2,147	40,369	703,442	1,087,741	1,791,183

[a] By calendar years. [b] By fiscal years ending June 30. [c] Estimated.

Of the coal shipped to Alaska in 1915, 4,409 tons [1] went to Nome and represents the total coal consumption of Seward Peninsula, except for a little lignite mined on Chicago Creek. The small consumption is due to the fact that most of the dredges, which are the largest consumers of fuel, use either crude oil or gasoline. About 50 tons of coal is shipped each year to St. Michael, which includes the local consumption and the blacksmith coal for the Yukon camps.

The passage of the coal-leasing act has again attracted attention to the development of the Alaska fields. As a consequence some systematic investigations were made by those who contemplated application for leases, notably in the Matanuska field, which will soon be rendered accessible by the Government railroad now under construction.

The Nenana field (see Pl. I) has also attracted some attention, for on the development of this field rests the future of the Fairbanks gold placers, where cheaper fuel is a prime necessity. As but few analyses of the Nenana coals have been published, the following, which have been furnished through the courtesy of the Director of the Bureau of Mines, are given:

[1] Data received through the courtesy of the deputy collector of customs at Nome.

Analyses of coal from Nenana field, Alaska.

[By Bureau of Mines.]

	Moisture.	Dry coal.				Heating value.					
						As received.		Dry coal.		Moisture and ash free.	
		Volatile matter.	Fixed carbon.	Ash.	Sulphur.	British thermal units.	Calories.	British thermal units.	Calories.	British thermal units.	Calories.
1	28.16	48.05	46.88	5.07	0.21	8,077	4,487	11,243	6,246	11,822	6,580
2	27.41	47.76	46.14	6.10	.22	8,287	4,604	11,416	6,342	12,157	6,754
3	25.73	49.00	46.48	4.52	.20	8,735	4,853	11,761	6,534	12,317	6,843
4	28.52	47.97	46.99	5.04	.08	8,089	4,494	11,317	6,287	11,918	6,621

1. West bank of Nenana River, 1½ miles below Lignite Creek.
2. Healy Creek, 6¼ miles from mouth.
3, 4. Igloo Creek, tributary to Healy Creek, 6 miles from mouth.

The sample from Nenana River was collected by Thomas Riggs, jr., of the Alaskan Engineering Commission, and the writer is indebted to him for the following notes on the occurrence. The sample was taken from a 5-foot bed of lignitic coal exposed on the west cut bank of the river about 1½ miles below Lignite Creek. It appears that the coal bed was much thicker but only the upper 5 feet was exposed. The bed dips about 15° NW. and has a roof of cemented gravel and a floor of sandstone. Mr. Riggs states that this particular outcrop would be covered at high water. The sample was sealed in an air-tight can two days after it was collected.

The other three samples were collected in 1913 by the late Dr. Joseph A. Holmes, and unfortunately details regarding localities and methods of sampling are not available. They serve, however, to indicate the composition of the lignitic coals of the Nenana field, the geologic conditions of which have been described by Capps.[1]

Reports on all the accessible Alaska coal fields have been published by the Geological Survey, and the Matanuska and Bering River fields have been surveyed in detail. In view of the present interest in Alaska coal the following reference list, which includes the principal Survey publications relating to this matter has been prepared. The publications marked with an asterisk (*) are out of stock at the Survey office but may be purchased from the Superintendent of Documents, Washington, D. C., at the prices stated. The other publications may be obtained free (except as indicated) on application to the Survey.

Atwood, W. W., Geology and mineral resources of parts of the Alaska Peninsula: Bull. 467, 1911. Describes the Herendeen Bay, Chignik Bay, and Unga Island fields, and is accompanied by topographic and geologic reconnaissance maps.

[1] Capps, S. R., The Bonnifield region, Alaska: U. S. Geol. Survey Bull. 501, 1912.

*Brooks, A. H., The Circle precinct: Bull. 314, 1907. Describes the coal of Washington Creek, on the upper Yukon. Price 30 cents.

——— Alaska coal and its utilization: Bull. 442–J, 1910. Describes briefly the coal fields of Alaska.

*——— The Alaskan mining industry in 1913: Bull. 592, pp. 43–74, 1914. Describes an occurrence of coal near Iditarod. Price 60 cents.

Capps, S. R., The Bonnifield region, Alaska: Bull. 501, 1912. Describes the Nenana coal field and is accompanied by geologic and topographic reconnaissance maps.

*Collier, A. J., The coal resources of the Yukon: Bull. 218, 1903. Describes the coals of the Yukon River and is accompanied by geologic reconnaissance map. Price 15 cents.

*——— Geology and coal resources of the Cape Lisburne region, Alaska: Bull. 278, 1906. Describes the Corwin and Cape Lisburne coal fields. Accompanied by geologic reconnaissance map. Price 15 cents.

*Henshaw, F. F., Mining in the Fairhaven district: Bull. 379, 1909, pp. 355–369. Describes the Chicago Creek coal mine. Price 50 cents.

Maddren, A. G., Mineral deposits of the Yakataga district: Bull. 592–E, 1914. Describes the Yakataga coal field and is accompanied by economic and reconnaissance map.

*Martin, G. C., Geology and mineral resources of the Controller Bay region, Alaska: Bull. 335, 1908. Describes the Bering River coal field and includes detailed geologic, economic, and topographic maps. Price 70 cents.

——— Map of Bering River coal field showing distribution of the various kinds of coal and location of the sections and coal samples described in Bulletin 335. For sale by Geological Survey, price 25 cents.

Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: Bull. 500, 1912. Describes the coal fields of the lower Matanuska Valley, including the Chickaloon area. Report includes detailed geologic, economic, and topographic maps.

Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys: Bull. 592–H, 1914. Describes the coal fields of the upper Matanuska Valley. Accompanied by a small-scale economic map.

Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: Bull. 587, 1915. Describes the Kachemak Bay coal field of Cook Inlet and is accompanied by geologic and topographic reconnaissance maps.

*Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull 247, 1905. Describes the occurrence of coal at Chicago Creek. Accompanied by geologic and topographic reconnaissance maps. Price 40 cents.

*Schrader, F. C., A reconnaissance in northern Alaska across the Rocky Mountains, along Koyukuk, John, Anaktuvuk, and Colville rivers, and the Arctic coast to Cape Lisburne, in 1901, with notes by W. J. Peters: Prof. Paper 20, 1904. Describes the occurrence of coal in the Colville Valley. Accompanied by geologic and topographic reconnaissance maps. Price 40 cents.

Smith, P. S., The Noatak-Kobuk region, Alaska: Bull. 536, 1913. Describes the occurrence of coal in the Kobuk Valley. Accompanied by geologic and topographic reconnaissance maps.

Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska: Bull. 449, 1911. Describes the coal deposits of Norton Bay region and is accompanied by geologic and topographic reconnaissance maps. Price 40 cents.

*Spencer, A. C., The Juneau gold belt; Wright, C. W., A reconnaissance of Admiralty Island: Bull. 287, 1906. Describes the Kootznahoo Inlet coal field on Admiralty Island. Accompanied by geologic reconnaissance map. Price 75 cents.

41354°—Bull. 642—16——3

The form of the lease and regulations governing the same have recently been made public by the Secretary of the Interior.[1] In view of the widespread interest on the part of the Alaska mining public in the development of the coal, the following data are presented, stating the conditions under which leases are granted.[2]

COAL-MINING LEASE.

Date.

THIS INDENTURE OF LEASE, entered into, in quintuplicate, this ------------------ day of ------------, A. D., 19--, by and between the United States of America, acting in this behalf by ------------------------ -------------------, Secretary of the Interior, party of the first part, hereinafter called the lessor, and ------ -- party of the second part, hereinafter called the lessee, under and pursuant to the act of Congress, approved October 20, 1914 (38 Stat., 741), entitled "An act to provide for the leasing of coal lands in the Territory of Alaska, and for other purposes," hereinafter called the "coal leasing act,"

Parties.

WITNESSETH.

Purposes.

That the lessor, in consideration of the rents and royalties to be paid and the covenants to be observed as hereinafter set forth, does hereby grant and lease to the lessee, for the period of fifty years from the date hereof, the exclusive right and privilege to mine and dispose of all the coal and associated minerals in, upon or under the following described tracts of land, situated in the Territory of Alaska, to wit: ----------------- -- containing -------- acres, more or less, together with the right to construct coke ovens, briquetting plants, by-products plants, and all such other works as may be necessary and convenient for the mining and preparation of coal and associated minerals for market, the manufacture of coke or other products of coal, and to use so much of the surface and the sand, stone, timber and water thereon as may reasonably be required in the exercise of the rights and privileges herein granted, the use of such timber to be subject to such regulations as may be prescribed by the Secretary of the Interior under the act approved May 14, 1898 (30 Stat., 414), and the acts amendatory thereof.

Description of land.

Mining and surface rights.

[1] Lane, F. K., Regulations governing coal-land leases in Territory of Alaska, Washington, Interior Dept., 1916.
[2] Idem, pp. 14-32.

ARTICLE I.

SECTION 1. The lessor expressly reserves unto itself the right to grant or use such easements in, over, through or upon the land leased, entered, located, occupied, or used as may be necessary or appropriate to the working of the same or other coal lands by or under authority of the Government and for other purposes; also the right to use, lease, or dispose of so much of the surface of the said lands as may not be actually needed, or occupied by the lessee in the conduct of mining operations. Rights reserved by lessor.

ARTICLE II.

It is expressly understood and agreed, that this lease is granted subject in all respects to the conditions, limitations, penalties and provisions contained in the "Coal Leasing Act," which act is hereby made a part hereof to the same extent as if incorporated herein. Lease subject to "Coal Leasing Act."

ARTICLE III.

It is further expressly understood and agreed that the mining rights and privileges leased as aforesaid shall extend to and include only coal and associated minerals, as hereinafter defined, and that no rights or privileges respecting any other kind or character of mineral, or mineral substance whatsoever, are granted or intended to be granted by this lease. Mining rights limited to coal and associated minerals.

ARTICLE IV.

The lessee in consideration of the lease of the rights and privileges aforesaid hereby covenants and agrees as follows:

SECTION 1. To invest in actual mining operations upon the leasing block included herein, the sum of -------- Investment.

----

dollars, of which sum not less than one-fifth shall be so expended during the first year succeeding the execution of this instrument, and a like sum each succeeding year for the period of four years; to furnish a bond, within 10 days after signature of the lease, in the sum of one-half the amount to be expended each year, conditioned upon the expenditure of such sum within said period, and submit annually, at the expiration of each year for the said period, an itemized statement, as to the amount and character of the expenditure during said year.

SEC. 2. To pay as an annual rental for each acre or part thereof covered by this lease, the sum of 25 cents per acre for the first year, payment of which amount is hereby acknowledged, the sum of 50 cents per acre per year for the second, third, fourth, and fifth years, and $1 per acre for the sixth and each succeeding year during Annual rental.

the life of this lease, all such annual payments of rental to be made on the anniversary of the date hereof, and to be credited on the first royalties to become due hereunder during the year for which said rental was paid.

Royalty.

SEC. 3. To pay a royalty of 2 cents on every ton of 2,000 pounds of coal shipped or removed from the leased lands or manufactured into coke, briquets or other products of coal, or consumed on the premises, during the first five years succeeding the execution of this lease, and 5 cents per ton for the next 20 years. Royalties shall be payable at the end of each calendar month next succeeding that of the said shipment, removal, donation, manufacture or consumption.

Lessee to keep record of all coal shipped.

SEC. 4. To accurately weigh all coal shipped or removed from the leased premises, sold, or donated to local trade, manufactured into coke, briquets, or other products of coal, or otherwise consumed or utilized, and to accurately enter the weight or weights thereof in due form in books to be kept and preserved by the lessee for such purpose, together with the car numbers, if any, of the coal shipped by rail.

Reports to be furnished monthly by lessee.

SEC. 5. To furnish in manner and form and at such time during each calendar month as the lessor shall prescribe, but in no event later than the last day thereof, the following written reports covering the month immediately preceding, certified under oath by the superintendent at the mine, or by such other agent on the property having personal knowledge of the facts as may be designated by the lessee for such purpose, to wit:

A report copied from the books required to be kept at the mine under section 4 of this article showing the facts required to be entered therein; a report of the number of mine cars of mine-run coal hoisted or trammed from each coal bed of each separate mine; a report showing the quantity, size, and character of coal shipped, used for power purposes and lease consumption; donated to employees, manufactured into coke, briquets, or other products or by-products of coal; in storage on the premises, with the quantity of coal of various sizes added thereto and taken therefrom during the month.

ARTICLE V.

Periods for readjustment of royalty.

It is mutually understood and agreed that the lessor shall have the right to readjust and fix the royalties payable hereunder at the end of 25 years from the date hereof, and at the end of 15 years thereafter, and thereafter at the end of each succeeding 10-year period during the continuance of this lease: *Provided*, That in any such readjustment the royalty fixed shall not exceed 5 per cent of the average selling price of coal of like character at the mine, per ton of 2,000 pounds in the coal field embracing the tracts covered by this lease, as shown by the books of the lessees operating in said field during a period of five years next preceding such readjustment.

ARTICLE VI.

This lease is made subject to the following provisions, which the lessee accepts and covenants faithfully to perform and observe:

Mining operations to be energetically prosecuted.

SECTION 1. The lessee shall diligently proceed to prospect for, develop, and mine the coal in or upon the leased lands; shall carry on all mining operations in a good and workmanlike manner, having due regard to the health and safety of miners and other employees; and shall leave no available coal abandoned which could be recovered by the most approved methods of mining when in the regular course of mining operations the time shall arrive for mining such coal. No mine, entry, level, or group of rooms or workings shall be permanently abandoned and rendered inaccessible, save with the approval of the authorized representative of the lessor.

Workings not to be abandoned until examination made.

Preliminary plan of mining to be submitted in advance of operations on a commercial scale.

SEC. 2. And also shall develop and mine the coal in the leased lands in accordance with a system to be shown by a preliminary plan on a scale of not more than 200 feet to the inch and a written description thereof, which plan and description shall be submitted for approval by the authorized representative of the lessor.

Where two or more beds of coal pillars in lower beds to be left until coal in upper beds extracted. Exceptions.

SEC. 3. And also where more than one bed of coal is known to exist in the leased lands, shall not draw or remove the pillars in any lower bed, before the available coal in any or all upper beds has been mined, unless it shall be decided by the authorized representative of the lessor that the workings in any or all of the upper beds will not be seriously injured by the extraction of the pillar coal in the lower workings. Where mining operations are being carried on in a bed that lies either below or above another bed in which mining has been or is being carried on and in which the pillars have not been pulled, and where the vertical distance between the two beds is less than fifteen times the thickness of the lower of the two beds, the lessee shall, as far as practicable, so arrange the pillars that those in the lower bed shall be vertically beneath those in the upper bed. Where practicable, by reason of either commercial or mining conditions, the available coal in the upper beds shall be exhausted before the coal in the lower beds is mined.

Pillars in lower beds to be arranged vertically under pillars in upper beds.

Fifty-foot barrier pillars.

SEC. 4. And also shall not, without the consent in writing of the authorized representative of the lessor first had and obtained, mine any coal, or drive any underground working, or drill any lateral bore hole within 50 feet of any of the outside boundary lines of the leased lands, nor within such greater distance of such boundary lines, as the said representative shall prescribe for the protection of the property or the safeguarding of mining operations hereunder; but in the event the coal up to the like barrier in adjoining premises shall have been worked out and exhausted, and the water therein shall have been lowered below the working level of the opera-

Lessee may be required to mine barrier pillars on adjacent lands.

tions on the same bed on the lands covered by the lease, the lessee hereunder hereby agrees, upon the written demand of said representative, to mine out and remove all the available coal in such barriers, both in the lands covered by this lease and on the adjoining premises, whenever same can be mined without hardship to the lessee and where the coal-mining rights in such adjoining premises are owned by the lessor.

Limitations of coal to be recovered in advance workings under "room-and-pillar" system.

SEC. 5. And also where the "room-and-pillar," or any other system of mining is followed which requires advance workings in the solid coal, including entries, break-throughs, and rooms, instead of a system of mining under which all the coal is mined out and extracted as the work advances, shall not, without the consent in writing of the lessor being first had and obtained, mine and remove from such advance workings more than the following maximum percentages of the coal area for the specified depths of cover, viz:

Not more than 70 per cent where the cover is 100 feet or over but less than 200 feet in depth; not more than 65 per cent where the cover is 200 feet or over but less than 300 feet in depth; not more than 60 per cent where the cover is 300 feet or over but less than 400 feet in depth; not more than 55 per cent where the cover is 400 feet or over but less than 500 feet in depth; not more than 50 per cent where the cover is 500 feet or over but less than 750 feet in depth; not more than 45 per cent where the cover is 750 feet or over but less than 1,000 feet in depth; not more than 40 per cent where the cover is 1,000 feet or over but less than 1,250 feet in depth; not more than 35 per cent where the cover is 1,250 feet or over but less than 1,500 feet in depth; not more than 30 per cent where the cover is 1,500 feet or over but less than 1,750 feet in depth; not more than 25 per cent where the cover is 1,750 feet or over but less than 2,000 feet in depth; not more than 20 per cent where the cover is 2,000 feet or over.

Definition of term "percentage of area."

The said coal areas shall mean an area parallel with the dip or raise of the coal bed. The percentages of coal areas specified shall mean the percentages of coal to be mined in the areas comprised in the advance workings as compared with the percentages of coal to be left standing in such workings, and shall not be construed to mean the percentage of the total amount of coal in any such area of any such bed, where such bed in such area is thicker than the height of any such workings, nor shall such percentages of areas be held to include the coal extracted from the pillars in any such area, panel, or district of the mine, as it is the intent of the parties hereto that save as otherwise provided in this lease, and except where the retention of pillars shall be necessary for the maintenance of main roads or passageways or for the protection of the property, all such pillars shall be mined and removed as rapidly as proper mining will permit.

Pillars to be removed as rapidly as possible.

Exceptions.

Fires in mine prohibited.

SEC. 6. And also shall not, save as hereinafter authorized, light, keep, or maintain any fire in any mine or stripping, except as approved by the authorized representative of the lessor, or underground in any mine, or in contact with the coal in place or in or along the outcrop of any coal bed. Failure to take prompt and vigorous steps for the extinguishment of any such fire shall be sufficient ground for the entry of the lessor and the cancellation of this lease.

Discovery of valuable mineral substance other than coal to be reported.

Lessee to have free use of fire clay and natural gas for lease purposes.

Record of associated minerals mined to be kept.

SEC. 7. And also shall promptly notify the authorized representative of the lessor of the discovery of any valuable mineral or mineral substance other than coal in the course of mining operations hereunder, and shall not mine or remove same unless the same is an associated mineral as hereinafter defined: *Provided*, That such quantities of fire clay, shale, or gas from the coal measures as may be required by the lessee in the conduct of operations hereunder may be removed and used without such written permission and without payment of royalty therefor. The lessee shall keep careful and accurate record in manner and form as may be prescribed by the lessor of all such associated minerals mined, used, or carried away, and shall pay such rates of royalty thereon as may be fixed by the said lessor, except as above provided.

Mine map required to be kept at the mine office.

SEC. 8. And also shall keep at the mine office clear, accurate, and detailed maps on a scale of 100 feet to the inch, in the form of a horizontal projection on tracing cloth, of the workings in each coal bed in each separate mine on the leased lands, a separate map to be made for each such bed, and for the surface immediately over the underground workings, and to be so arranged with reference to a public land corner that the maps can be readily superimposed.

Things required to be shown on detailed map of workings.

Each map of the workings in any coal bed shall show the location of all openings connecting such bed with the workings in any other bed, or with any adjacent mine, or with the surface; the location of all entries, gangways, rooms, or breasts, and any other narrow or wide workings, including the outlines of abandoned workings, and record of whether accessible or inaccessible; also barrier pillars, refuge chambers, stoppings, ventilating doors, overcasts, undercasts, regulators, and direction of air currents at the time of making map; location of stationary haulage and hoisting engines; permanent electrical generators, dynamos, and transformers; indications of trolley roads throughout their extent; also fire walls, sumps, and large bodies of standing water; position of main pumps and fire pipe lines; there shall also be marked on such maps the elevations above or below sea level or approved datum at points not over 200 feet apart horizontally, or over 100 feet apart vertically, in all main slopes, entries, levels, or headings, together with the thickness of coal beds at such intervals, and the elevations at the tops and bottoms of all shafts, slopes, and inclines.

Requirements for map of surface over working.

The map of the surface immediately over the mine workings shall show all prominent topographic features and culture, section and township lines, the elevations above sea level or an approved datum, and contours at vertical intervals of 25 feet of such topographic features. Such map, together with the maps of the underground workings, shall be brought up to date not less than once in every six months.

Things required to be shown on general property map to be kept at mine office.

The lessee shall also make and keep at the mine office, at such time after the commencement of mining operations as the authorized representative of the lessor may direct, a clear and accurate general map of the entire leased lands, on a scale of 400 feet to the inch. Such map shall show all prominent topographical features and culture; the location of the surface areas immediately over the mine workings shown on the detailed surface map hereinbefore required; township, section, and property lines; the location of high-water marks; the outline of coal outcrops where known; the outlines of the chief mine workings, indicating the workings in each separate coal bed by distinguishing marks and the elevations above sea level or an approved datum, and contours at vertical intervals of 25 feet of the chief topographic features. Such map shall be brought up to date not less than once in every six months.

Prints of maps to be furnished lessor.

Blue prints or reproductions in duplicate of the maps required as aforesaid shall be furnished the authorized representative of the lessor when made, and supplemental prints or reproductions in duplicate furnished on or before January 1 of each succeeding year, showing the extensions, additions, and changes since the last map or supplement was submitted. All mine progress maps kept by the lessee shall at all times be subject to examination by said representative.

Abandoned areas to be surveyed and mapped.

The lessee whenever any mine, or any workings therein are to be abandoned or indefinitely closed, and before same shall be abandoned or closed, or allowed to become inaccessible, shall make a survey thereof so as to accurately show the entire worked-out area or areas, and shall extend the results of such survey on the map or maps of the underground workings hereinbefore required, and promptly forward blue prints or reproductions thereof in duplicate to the said representative.

Maps may be made at lessee's expense in case of failure to furnish.

If the lessee shall fail to make or furnish any map or extension or revision as herein required within 90 days after demand therefor shall have been made by the authorized representative of the lessor, such representative may employ a competent engineer to make a survey of the mine, and plat the same as above provided, the expense thereof to be paid by the lessee, and in the event that the lessee shall fail to make such payment within 60 days after demand therefor by the authorized representative of the lessor, such failure shall constitute a cause of forfeiture of this lease.

SEC. 9. And also shall, where more than ten men are employed underground on any one shift in any separate mine, provide an escapeway or second exit to the surface, which shall be separated at the surface from the first exit by not less than 50 feet of strata in case of drift, slope, or tunnel workings, or in case of vertical shafts, or of inclined shafts having a pitch of more than 45°, by not less than 200 feet of strata. An escapeway or outlet through an adjoining mine shall be regarded as a satisfactory compliance with this requirement if kept at all time in proper condition for use. If such adjoining mine shall be abandoned at any time, or shall cease to operate indefinitely, the lessee hereunder shall be solely responsible for the cost and expense of maintaining such outlet, and in the event such outlet shall be abandoned or permitted to become unsafe for use, the number of men employed on any one shift shall be reduced below ten until such time as a second exit or escapeway shall be provided.

Second exit to surface to be provided, where more than 10 men employed on a shift.

Outlet through adjacent mine sufficient compliance.

SEC. 10. And also shall not employ more than five men underground on any one shift in any new working of any mine unless such new working shall be so connected with adjacent workings as to provide two distinct and separate means of escape from such new working: *Provided*, That with the approval of the authorized representative of the lessor, not exceeding ten men may be so employed in advance of the making of such second opening, but in no case shall any rooms, drifts, or slopes be opened or worked until such second opening is constructed.

Not more than five men to be employed in new workings unless second opening provided.

Exceptions.

SEC. 11. And also shall not construct or maintain any structure of inflammable material within 75 feet of any mine opening; nor within said distance permit any structure of noninflammable material to be connected to any other structure by means of any structure or erection of inflammable material, or to be connected to any structure beyond said distance which shall be constructed of inflammable material, except as follows, that is to say:

No building of inflammable material to be constructed within 75 feet of any mine.

(*a*) An open timber framework or headframe of timber may be constructed over a shaft, slope, or incline.

Exceptions.

(*b*) The posts, studs, and rafters of any such structure may be of wood if the covering or lining is made of noninflammable material, but under no circumstances shall wood flooring be used, except in tipple and trestle structures.

SEC. 12. And also, except in a prospect opening, shall separate the main intake and return airways and all workings parallel to such airways by not less than 50 feet of strata except for break-throughs or crosscuts for ventilation or haulage, and shall provide for such greater distance between such airways or between any such airway and parallel workings as may be required in the judgment of the authorized representative of the

Main intake and return airways to be separated by not less than 50 feet of natural strata.

Pillars to be left standing until prior to final abandonment of mine.

lessor. The lessee agrees that the pillars thus provided for shall be left standing until in the proper course of mining operations the time shall arrive for their removal immediately prior to the final abandonment of the workings in that particular coal bed.

Ventilating fan to be provided where more than 10 men employed on shift.

SEC. 13. And also shall whenever more than ten men are employed underground on any one shift provide a fan or other mechanical means for circulating such amount of ventilating current as may be required by any law of the United States or of the Territory of Alaska now or hereafter enacted, or by the rules and regulations prescribed by the lessor, such fan or other mechanical means and the connection between same and the point of the entrance of the air current into the mine to be made of noncombustible material; and the lessee shall not set same in line with the axis of any mine opening, but shall place same at a distance of not less than 15 feet from the projection of the nearest side of such opening, and shall provide explosion doors of the full area of the air shaft or airway, in direct line with any and all such mine openings in order to protect said fan or other mechanical means of air circulation in case of a mine explosion: *Provided,* That during such time as the mine is being opened up and less than ten men are employed under ground on any one shift, and with the written approval of the authorized representative of the lessor, a furnace may be used for ventilation in a nongaseous mine if the fire box thereof is inclosed by brick, rock, or concrete walls, and a passageway around such inclosure at least two feet in width provided: *And provided further,* That if a wooden stack is used in connection with such furnace the lessee shall not permit such stack to be in contact with any coal bed or with any inflammable shale.

Fan not to be placed in direct line with any mine entrance.

With written approval of lessor's representative furnace may be used for ventilation under specified conditions.

Slack and refuse to be disposed of so as not to become a public or private nuisance.

SEC. 14. And also shall make such provisions for the disposal of the waste, slack, and refuse of the mine that the same shall not be a nuisance, inconvenience, or obstruction to any right of way, stream, or other means of transportation or travel, or to any private or public lands, or embarrass the operation of any other mine on the leased lands, or on adjoining lands, or in any manner occasion private or public damage, nuisance, or inconvenience. All waste containing practically no coal shall be deposited separate and apart from waste containing coal and in accordance with the directions of the authorized representative of the lessor.

Abandoned workings to be covered or fenced.

SEC. 15. And also shall upon abandonment substantially fence, fill in, cover, or close all surface openings or workings where persons or animals are likely to be injured by falling therein, or endangered by accumulations of gas, except as the lessor shall otherwise direct; and shall maintain all such fencing or covering in a secure condition during the term hereof.

SEC. 16. And also expressly agrees that all mining and related operations shall be subject to the inspection of authorized representatives of the lessor, and that such representatives, with all proper and necessary assistants, may at all reasonable times enter into and upon the leased lands and survey and examine same and all surface and underground improvements, works, machinery, equipment, and operations, and further expressly agrees to furnish said representatives and assistants all necessary assistance, conveniences, and facilities in making any such survey and examination.

Operations subject to inspection of lessor's representatives.

Lessee to furnish all necessary assistance.

SEC. 17. And also shall permit any authorized representative of the lessor to examine all books and records pertaining to operations under this lease, and to make copies of and extracts from any or all of same, if desired. The information so derived to be held confidential.

Lessee to permit examination of books for purpose of checking royalty returns.

SEC. 18. And also shall permit the lessor, its lessees, or transferees to make and use upon or under the leased lands any workings necessary for freeing any other mine from water, causing as little damage or interference as possible to or with the mine or mining operations of the lessee hereunder. Any such use by a lessee or transferee shall be conditioned upon the payment to the lessee hereunder of the amount of actual damages sustained thereby and adequate compensation for such use.

Lands leased and easements therein may be used for purposes of rendering operations on adjoining lands more safe; such use to be compensated for.

SEC. 19. And also shall accurately weigh or measure in the car and truly account for the coal mined and loaded by each miner, where the miners are paid either by the weight of their output or upon the basis of the measurement of the coal in the car; keep a correct record of all coal so weighed or measured; post or display such record daily for the inspection of the miners and other interested persons; and require the weighman or person appointed to measure the coal in the car where the miners are paid upon the basis thereof, before entering upon his duties, to make and subscribe to an oath before some person duly authorized to administer oaths that he will accurately weigh or measure and keep true record of the coal so weighed or measured and credit same to the miner entitled thereto, such affidavit to be kept conspicuously posted at the place of weighing, if any, but nothing contained herein shall be construed to prevent the lessee, in case rock and bone is loaded by the miner, from estimating or separately weighing, and deducting the amount thereof from the weights of coal accredited to such miner. The lessee hereby agrees that if a majority of the miners employed on the leased lands so desire they shall be permitted to employ at their own expense one of their fellow employees to see that the coal is properly weighed or measured and that a correct account of same is kept, and agrees to afford such person every facility to certify the weights and measurements while the weighing or measuring is being done: *Pro-*

Lessee to keep true and accurate weights or measurements of coal mined and loaded by miners.

Weighman to take oath for faithful discharge of duties

Miners to be permitted to employ check-weighman.

Checkweighman to take oath for faithful discharge of his duties.

vided, That the lessee shall not be required to so do unless such person, before entering upon his duties, shall make and subscribe to an oath before some person authorized to administer oaths that he will faithfully discharge the duties of his position, such oath to be kept conspicuously posted at the place of weighing, if any.

Wages to be paid in lawful money.

SEC. 20. And also shall pay all miners and other employees, both above and below ground, at least twice each month in lawful money of the United States, and shall permit such miners and other employees full and complete freedom of purchase, but with a view to increasing safety this provision shall not apply to the purchase of explosives, detonators or fuses, and shall not require or permit miners or other employees, except in case of emergency, to work underground for more than eight consecutive hours in any one calendar day, not including time for lunch or meals, or the time required to reach the usual working place.

Freedom of purchase to be allowed.

Eight-hour work day required.

Premises to be surrendered in proper condition for continuance of mining operations.

SEC. 21. And also shall, at the expiration or earlier termination of this lease, deliver up to the lessor the lands covered by this lease, together with all fixtures, improvements, and appurtenances, save as hereinafter provided, in such a secure and proper state that mining operations may be continued immediately to the full extent and capacity of such mine.

ARTICLE VII.

It is further mutually understood and agreed as follows:

Suspension of operations for more than three months without consent to be cause of forfeiture.

SECTION 1. That the suspension of mining operations by the lessee for a longer period than three months without the consent in writing of the lessor or its authorized representatives shall be cause of forfeiture of this lease. If the lessee shall be unable to continue the operation of the mine for any cause, not due to the fault or negligence of the lessee, he shall be entitled to the suspension of operations for such a length of time, and upon payment of such minimum royalties, and such other conditions as may be specified in the order of suspension, but the issuance of any such order shall not excuse the payment of any rents or royalties due under this lease, or prevent forfeiture for failure to pay same, and the acceptance of any such rent or royalty shall not waive any other right of the lessor hereunder.

Upon application consent for suspension for a specified period may be obtained.

Lease not to be assigned without consent of lessor.

SEC. 2. That the lessee shall not assign this lease or any interest therein, nor sublet any portion of the leased premises, or any of the rights and privileges herein granted, without the written consent of the lessor being first had and obtained.

Breach of lease covenants may be waived in writing.

SEC. 3. That the lessor or its authorized representative may by notice in writing waive any breach of the covenants and conditions contained herein, except such as are required by the aforesaid "coal leasing act," but any such waiver shall extend only to the particular breach so waived, and shall not limit the rights of the lessor with respect to any future breach. No waiver not in writing shall be in any way binding upon the lessor.

Lease may be terminated at any time upon payment of rents, etc.

SEC. 4. That the lessee may terminate this lease at any time upon giving four months' notice in writing to the lessor or its authorized representative, and upon payment of all rents, royalties, and other debts due and payable to the lessor, and upon payment of all wages or moneys due and payable to the workmen employed by the lessee, but in no case shall such termination be effective until the lessee shall have made provision for the preservation of any mine on the leased lands in accordance with the provisions of this lease: *Provided*, That in such case the right of valuation and purchase, accorded the lessor in the section next following (5), shall be exercised within said period of four months.

Termination not to be effective until property examined.

Lessor to have privilege of valuing and purchasing equipment, etc., on termination of lease.

SEC. 5. That at the expiration or earlier termination of this lease all tools, machinery, and equipment, including tracks, rails, and pipe placed by the lessee in the mine or on the property, shall before removal from normal position, if requested by the lessor or its authorized representatives, be valued by three disinterested and competent persons to be chosen in the manner hereinafter provided for the appointment of arbitrators, the valuation of these three or of a majority of them to be conclusive of the value of any or all of the said property; and the lessor or its agent, licensee, or lessee shall have the right to purchase within four months thereafter any or all such tools, machinery, equipment, or materials at the said valuation, deducting therefrom all rents, royalties, or other payments at that time due and payable by the lessee. If such valuation shall not be requested or the purchase shall not be made within said time the lessee shall have the privilege of removing same from the premises within one year from the expiration or termination of this lease, provided all debts and moneys specified in section 4 of this article shall have been paid. The lessee shall not, and hereby covenants not to, remove any mine supports, timbers, or props in place. All buildings and improvements erected upon the leased lands shall become a part of the property, and machinery and equipment shall not be removed therefrom in such a way as to cause any permanent injury to such buildings or improvements.

Lessee may remove same within year.

Forfeiture of lease.

SEC. 6. That if the lessee shall make default in the performance or observance of any of the terms, covenants, and stipulations of this lease, and such default shall continue for 60 days after service of written notice thereof by the lessor or its authorized representatives, then all the rights and privileges of the lessee cease and determine, and the lessor may, by appropriate proceedings, have this lease forfeited and canceled in a court of competent jurisdiction.

A waiver of any particular cause of forfeiture shall not prevent the cancellation and forfeiture of this lease for any other cause of forfeiture or for the same cause occurring at any other time.

Questions which may be submitted to arbitration.

SEC. 7. That in case any dispute shall arise between the lessor and lessee as to any question of fact, or as to the reasonableness of any requirement made by the lessor under the provisions of this lease, in the matter of operation, methods, means, expenditures, use of easements, compensation for joint occupancy by another lessee of a portion of the leased premises, or such other questions as are not determined by express statutory provision, such questions or disputes shall be settled by arbitration in the manner provided for by this section, and the lessor and lessee hereby covenant and agree each with the other to promptly comply with and carry out the decision or award of each and every board of arbitration appointed under this section.

Manner of appointing arbitrators.

Questions in dispute to be determined by arbitration hereunder shall be referred to a board of arbitration consisting of three competent persons, one of which persons shall be selected by the lessor or its authorized representative, and one by the lessee, and the third by the two thus selected: *Provided*, That the lessor and lessee may agree upon one sole arbitrator or upon the third arbitrator. The party desiring such arbitration shall give written notice of the same to the other party, stating therein definitely the point or points in dispute, and name the person selected by such party hereto within 20 days after receiving such notice to name an arbitrator; and in the event it does not do so, the party serving such notice may select the second arbitrator and the two thus named shall select the third arbitrator. The arbitrators thus chosen shall give to each of the parties hereto written notice of the time and place of hearing, which hearing shall not be more than 30 days thereafter, and at the time and place appointed shall proceed with the hearing unless for some good cause, of which the arbitrators or a majority of them shall be the judge, it shall be postponed until some later day or date within a reasonable time. Both parties hereto shall have full opportunity to be heard on any question thus submitted, and the written determination of the board of arbitration thus constituted or of any two members thereof or, in case of the failure of any two members to agree, then the determination of the third arbitrator shall be final and conclusive upon the parties in reference to the questions thus submitted. All such determinations shall be in writing, and a copy thereof shall be delivered to each of such parties.

Decision of third arbitrator to be final.

New board to be chosen in event of failure of arbitrators first selected to choose a third.

It is further agreed that in the event of the failure of the lessor and lessee, or of the two arbitrators selected as aforesaid by the parties hereto, within 20 days from notice to them of their selection, to agree upon the third arbitrator, then the Secretary of the Interior shall appoint such arbitrator.

The said third arbitrator shall receive not to exceed $15 per day as full compensation for his services and for all expenses connected therewith, exclusive of transportation charges; but such compensation shall not be in excess of $150 for any arbitration. The losing party to such arbitration shall be liable for the payment of such compensation and transportation expenses of such third arbitrator.

SEC. 8. That any notice in writing as to any matter mentioned in this lease, addressed to the lessee and left upon the premises with the superintendent, manager, clerk, or other person in charge of the mine or of the office, or, in the absence of any such person, posted on the door of the office, shall have the same force and effect as if served upon the lessee, and 15 days shall be considered a reasonable notice, unless a longer notice be herein provided for or be so provided in such notice.

ARTICLE VIII.

It is further expressly agreed and declared that the terms and phrases hereinafter mentioned shall have the meanings hereinafter assigned unless the context shall otherwise require, that is to say:

(*a*) The phrase "available coal" as used in this lease shall mean merchantable coal from any coal bed which, when reached in the prosecution of the lessee's operations hereunder, can be mined at a reasonable profit by the use of machinery and methods which at that time are modern and efficient.

(*b*) The term "mine" as used herein shall mean and include all underground workings now or hereafter opened or worked for the purpose of mining and removing coal and associated minerals, together with all buildings, machinery, and equipment, above and below ground, used in connection with such mining operations.

(*c*) The term "pit" or "open pit" shall mean and include stripping operations or any open-air workings.

(*d*) The term "coal" as used herein shall mean and include anthracite, semianthracite, semibituminous, bituminous, subbituminous, lignite, and graphitic coal, lignite, natural coke, and such bony coal as is suitable for use as a fuel.

(*e*) The term "associated minerals" as used herein shall mean and include fire clay, shale, sandstone, and the bedded materials of the coal measures, exclusive of gold-bearing or other metalliferous deposits.

(*f*) The term "lessee" as used herein shall mean and include the heirs, executors, administrators, successors, or assigns of the lessee hereinbefore specified.

ARTICLE IX.

It is further mutually covenanted and agreed that each obligation hereunder shall extend to and be binding upon, and every benefit hereof shall insure to, the heirs, executors, administrators, successors, or assigns of the respective parties hereto.

ARTICLE X.

It is also further agreed that no member of or delegate to Congress or resident commissioner, after his election or appointment, or either before or after he has qualified, and during his continuance in office, and that no officer, agent, or employee of the Department of the Interior, shall be admitted to any share or part in this lease, or derive any benefit that may arise therefrom, and the provisions of section 3741 of the Revised Statutes of the United States and sections 114, 115, 116 of the Codification of the Penal Laws of the United States approved March 4, 1909 (35 Stat., 1109) relating to contracts enter into and form a part of this lease so far as the same may be applicable.

In witness whereof—

THE UNITED STATES OF AMERICA,
By ---------------------------------[L. S.]
Secretary of the Interior.

Witnesses:

------------------ ---------------------------------[L. S.]
------------------ ---------------------------------
------------------ ---------------------------------

APPLICATION FOR COAL-MINING LEASE.

The undersigned, --, a resident of--, a --,
(Native born or naturalized; if the latter, furnish certificate.)
citizen of the United States, over 21 years of age, hereby applies, under the provisions of the act of October 20, 1914 (38 Stat., 741), for a mining lease of the certain leasing blocks, or tracts, of coal lands, to wit: Block ----, embracing the following specified legal subdivisions --

----
aggregating ---- acres. If I secure said lease, I propose to invest not less than ------------ dollars in active, productive mining operations conducted upon said lease; the active development will begin not later than ----------------------. My experience in coal-mining operations is as follows: ------------------------------

----
I neither own nor hold any interest, either as a stockholder or other-

wise, in any lease under this act, or in any application for such a lease, save and except the application now made; and I hereby refer to --

----

as to my financial standing.

If I am awarded a lease, I will supply a satisfactory bond as required in section 9 of the regulations.

My post-office address is ----------------------------------

(Signed) ----------------------------

Subscribed and sworn to before me, a ------------------------, ------------------, on this -------------------------- day of ------------------------------

[SEAL.] ------------------------------

COAL-MINING PERMIT.

REGULATIONS GOVERNING THE ISSUANCE OF PERMITS FOR THE FREE USE OF COAL IN THE UNRESERVED PUBLIC LANDS IN ALASKA.

Section 10 of the act of October 20, 1914 (Public 216), provides:

That in order to provide for the supply of strictly local and domestic needs for fuel the Secretary of the Interior may, under such rules and regulations as he may prescribe in advance, issue to any applicant qualified under section three of this act a limited license or permit granting the right to prospect for, mine, and dispose of coal belonging to the United States on specified tracts not to exceed ten acres to any one person or association of persons in any one coal field for a period not exceeding ten years, on such conditions not inconsistent with this act as in his opinion will safeguard the public interest without payment of royalty for the coal mined or for the land occupied: *Provided,* That the acquisition of holding of a lease under the preceding sections of this act shall be no bar to the acquisition, holding, or operating under the limited license in this section permitted. And the holding of such license shall be no bar to the acquisition or holding of such a lease or interest therein.

Owing to there being no settlements or local industries in or adjacent to the Bering or Matanuska coal fields, and the contemplated leasing offer of coal lands in said fields, these regulations and the permits provided for shall not at present apply to coal deposits in those fields.

Qualifications.—Under the terms of the act, expressed in section 3 thereof, only citizens of the United States above the age of 21 years, associations of such citizens, corporations, and municipalities organized under the laws of the United States or of any State or Territory thereof, provided the majority of the stock of such corporations shall at all times be owned and held by citizens of the United States, are eligible to receive a permit to prospect for and mine coal from the unreserved public lands in Alaska.

Who may mine coal for sale.—All permittees may mine coal for sale except railroads and common carriers, who by the terms of section 3 of the act are restricted to the acquirement of only such an amount of coal as may be required and used for their own consumption.

Duration of permits.—Permits will be granted for two years, beginning at date of filing, if filed in person or by attorney, or date of mailing, if sent by registered letter, subject to the approval of the Commissioner of the General Land Office, and upon application and satisfactory showing as to the necessity therefor, may be extended by the commissioner for a longer period, subject to such conditions necessary for the protection of the public interest as may be imposed prior to or at the time of the extension. Misrepresentation, carelessness, waste, injury to property, the charge of unreasonable prices for coal, or material violation of such rules and regulations governing operation as shall have been prescribed in advance of the issuance of a permit, will be deemed sufficient cause for revocation.

Limitation of area.—The act limits the area to be covered in any one permit to 10 acres. It is not to be inferred from this, however, that the permits granted thereunder shall necessarily cover that area. The ground covered by a permit must be square in form and should be limited to an area reasonably sufficient to supply the quantity of coal needed.

Scope of permit.—Permits issued under section 10 of the act of October 20, 1914, grant only a license to prospect for, mine, and remove coal free of charge from the unreserved public coal lands in Alaska, and do not authorize the mining of any other form of mineral deposit, nor the cutting or removal of timber.

How to proceed to obtain a permit.—The application should be duly executed on Form 4—020, and the same should either be transmitted by registered mail to, or filed in person with, the register and receiver of the United States land office of the district in which the land is situated. Prior to the execution of the application the applicant must have gone upon the land, plainly marked the boundaries thereof by substantial monuments, and posted a notice setting forth his intention of mining coal therefrom. The application must contain the statement that these requirements have been complied with and the description of the land as given in the application must correspond with the description as marked on the ground. The permit, if granted, should be recorded with the local mining district recorder, if the land is situated within an organized mining district.

When coal may be mined before issuance of a permit.—In view of the fact that by reason of long distances and limited means of transportation many applicants may be unable to appear in person at the United States land office to file their applications, it has been deemed advisable to allow such applicants the privilege of mining coal as soon as their applications have been duly executed and sent by registered mail to the proper United States land office. Should an application be rejected, upon receipt of notice thereof all privileges under this paragraph terminate and the applicant must cease mining the coal.

Action by register.—The register will keep a proper record of all applications received and all actions taken thereon in a book provided for that purpose. If there appear no reason why the application should not be allowed, the register will issue a permit on the form provided for that purpose. Should any objection appear either as to the qualifications of the applicant or applicants, or in the substance or sufficiency of the application, the register may reject the application or suspend it for correction or supplemental showing under the usual rules of procedure, subject to appeal to the Commissioner of the General Land Office. Upon the issuance of a permit the register will promptly forward to the Commissioner of the General Land Office, by special letter, the original application and a copy of the permit, and transmit copies thereof to the Chief of the Alaskan Field Division, and to the local representatives of the United States Bureau of Mines, for their information.

NOTE.—These regulations are intended merely as a temporary arrangement to meet immediate necessities, as authorized by section 10 of the act of October 20, 1914, and are not to be construed as applying to the leasing of public coal lands in Alaska provided in other sections of the act.

APPLICATION FOR COAL-MINING PERMIT.

---------------------------------, 191

The Commissioner of the General Land Office,
Washington, D. C.

SIR: The undersigned, ---------------------------------
(Name of applicant.)

----

of ---------------------------------, hereby appl for a permit to
(Post-office address.)
prospect for, mine, and remove coal from the following-described land:

(Describe the land by legal subdivision if surveyed, and by metes and bounds with reference to some per-

----
manent natural landmark if unsurveyed.)
containing approximately ------------ acres, situated within the ----------- land district, -------- miles -------- of -----------
(Direction.)
Alaska, and in support of this application make the following representation as to qualifications to receive a permit: -----------------
(Citizenship of applicant or appli-

----
cants must here be shown. If the applicant is a municipality or corporation, it must be shown under what

----
laws it is organized; and if the latter, it must also be shown whether a majority of its stock is owned and

----
held by citizens of the United States.)

The applicant further represent that ----------------- ha not,
(He, they, or it.)
within two years last past, applied for or received a permit to mine coal under the provisions of section 10 of the act of October 20, 1914, in the coal field in which the land described in this application is situated, ---
(State exceptions here, if any.)

----
and that the coal herein applied for is to be mined for the purpose of supplying the following demands, for which approximately -------- tons are required annually: ---------------------------------
(Here itemize the various uses to which the coal is to be applied,

----
stating the number of tons necessary for each use.)

It is further represented that the boundaries of the tract described in this application have been plainly marked by substantial monuments, and that a proper notice describing the land and showing the intention of the applicant to apply for a free permit to mine coal therefrom has been posted in a conspicuous place upon the land.

On consideration that a permit be granted, the applicant hereby agree :

1. To exercise reasonable diligence, precaution, and skill in the operation of the mine, with a view to the prevention of injury to workmen, waste of coal, damage to Government property, and to comply substantially with the instructions and the rules and regulations printed on the back of this application.

2. To charge only such prices for coal sold to others as represent a fair return for the labor expended and reasonable earning value to which the investment in the enterprise is entitled, without including any charge for the coal itself.

3. Not to mine or dispose of, either directly or indirectly, any coal from the area covered by said permit for export or any purpose other than "strictly local and domestic needs for fuel."

4. To leave the premises in good condition upon the termination of the permit, with all mine props and timbers in the mine intact, and with the underground workings free from refuse and in condition for continued mining operations.

Signature of applicant ------------------------------

The foregoing application was signed by--------------------------
----
of ------------------------, the applicant therein, in the presence of the undersigned, who, at ---------- (His or their). request and in ---------- (His or their.) presence and in the presence of each other, have subscribed our names as witnesses to the execution thereof.

Dated this -------- day of ------------, 19 , at -------------- Territory of Alaska.

Name ------------------- Residence ------------------
Name ------------------- Residence ------------------

There were no important developments in the Alaska oil fields during 1915. The company that has been producing oil and making gasoline at Katalla went into the hands of a receiver and was reorganized. Operations were not interrupted, however, and the production of crude petroleum and gasoline was continued as in previous years. According to current reports an oil seepage was discovered in northern Alaska near Wainwright Inlet, about 100 miles southwest of Point Barrow. (See Pl. I.) If this report is confirmed, it is probably a western extension of the oil field southwest of Smith Bay.[1]

As the Alaska petroleum is a refining oil similar to that of Pennsylvania and has a high percentage of volatile compounds, the present market conditions would seem to justify the systematic prospecting of the more accessible fields of the Territory. No doubt if the fields are opened by a leasing law such as is now under consideration this work will be undertaken. Meanwhile large quantities of petroleum and petroleum products are annually shipped to Alaska, as shown in the following table:

[1] Brooks, A. H., The mining industry [Alaska] in 1908: U. S. Geol. Survey Bull. 379, pp. 61-62, 1909.

Petroleum products shipped to Alaska from other parts of the United States, 1905–1915.

Year.	Oil used for fuel, including crude oil, gas oil, residuum, etc.	Gasoline, including all lighter products of distillation.	Illuminating oil.	Lubricating oil.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*
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	2,685,943	513,075	271,981
	147,258,988	15,681,791	6,432,669	1,421,668

STRUCTURAL MATERIAL AND MISCELLANEOUS MINERAL PRODUCTS.

Two marble quarries, one in Ketchikan and one in the Wrangell district, and one gypsum mine, in the Sitka district, were operated in southeastern Alaska during 1915. Some shipments of barite were made from a deposit on the west coast of Prince of Wales Island, and the garnet mine near Wrangell was operated during the year. Some graphite deposits in Seward Peninsula were prospected, but no shipments were made from them.

REVIEW BY DISTRICTS.

The subjoined review is intended to summarize briefly the principal developments in all the districts. The information at hand about mining in some of the districts is very scant, and some are treated at greater length in other sections of this volume. The space here devoted to any district is therefore not necessarily an indication of its relative importance. The arrangement is geographic from south to north.

SOUTHEASTERN ALASKA.

Thirteen gold-lode mines, including several which made only a small output, six copper mines, three placer mines, two marble quarries, and one gypsum mine were operated in southeastern Alaska in 1915. Besides these operations some shipments of garnet and barite were made. The value of the mineral production from these mines is as follows: Gold, $5,435,586; copper (1,728,182 pounds), $302,431; silver, marble, lead, gypsum, etc., $352,554; total, $6,090,571. Details in regard to the mining developments are presented elsewhere in this report.

YAKATAGA DISTRICT.

About 20 men were engaged in mining the beach placers at Yakataga during 1915. It is reported that they had an unusually successful season. The White River hydraulic mine, also in the Yakataga district, was operated during the mining season.

COPPER RIVER REGION.

Mining in the Copper River region includes the development of the copper mines in the Kotsina-Chitina copper belt and placer mining in the Nizina, Kotsina, and Chistochina districts. In 1915 three copper mines were operated throughout the year and during the summer about 18 placer mines were worked.

At the Bonanza-Kennicott copper mine some 5,540 feet of underground development work was done during the year, and the ore has been opened up to a depth of about 600 feet. At the Jumbo-Kennicott 4,240 feet of underground work was done. The 400-foot level has been opened, and the sinking of the shaft to the 500-foot level is under way.

Work was continued on the Mother Lode copper mine throughout the year. The total underground developments now include some 5,040 feet of mine workings, of which 2,480 feet was opened in 1915.

Although the three mines above mentioned were the only ones commercially productive, the high price of copper has stimulated development throughout the field. Work is reported to have been continued on the claims of the Alaska Copper Corporation, on Nugget Creek; the Hubbard & Elliott Co., on Elliott Creek; and the Lakina Copper Co., on Lakina River. Developments were also made on the Berg property, in the Kuskulana Valley, and on the Copper Mountain property, near Kennicott. Undoubtedly work was done on many other copper claims about which no information is available at this time.

It is reported that a molybdenite-bearing quartz vein was discovered in 1915 on Canyon Creek, a northerly tributary of Chitina River above the Nizina, about 50 miles from McCarthy.

Five hydraulic plants were operated in the Nizina district during the open season. There were some shipments of placer copper from the district. There were also some smaller placer operations in the Nizina and Bremner districts. About 10 placer mines were operated in the Chistochina district during the summer. As in previous years, the largest operations were on Slate Creek and Miller Gulch. Gold to the value of about $200,000 was taken from the placer districts of the Copper River region in 1915, and about 150 men were employed.

PRINCE WILLIAM SOUND.

Four copper mines and five gold-lode mines were operated on Prince William Sound in 1915. The value of the total mineral production from this region, including gold, copper, and silver, was $1,340,996 in 1915, compared with $1,198,742 in 1914. Details in regard to mining developments on Prince William Sound are presented elsewhere in this volume.

KENAI PENINSULA.

Preparations for placer mining on a larger scale than in previous years were continued on Kenai Peninsula during 1915. For the most part these developments did not reach a productive stage, though there was an increase in placer mining compared with previous years. Prospecting of dredging ground continued, but the dredge on Kenai River was idle in 1915, and the one on Six-mile Creek was operated for only a short time.

The prospecting of auriferous lodes continued, but there were no notable developments of this form of mining. Some work was also done on stibnite deposits, though, so far as known, no shipments of antimony ore were made. It is reported that an antimony lode was discovered on Bear Creek during the year, and there is also an occurrence of stibnite on Kenai Lake which has long been known.[1]

Unfortunately, some of the mine operators in Kenai Peninsula fail to make returns of production and developments, hence no exact figures on the gold output are available. The information at hand indicates that gold to the value of about $88,123 was produced in 1915, of which $70,000 is to be credited to the placer mines. It is believed that about 25 placer mines were commercially productive, and some gold was also won incidentally to the prospecting of other properties. About a dozen hydraulic plants, large and small, were operated during the mining season, which in Kenai Peninsula is about 150 days in length. The largest plants are on Crow,[2] Bear, Resurrection, and Canyon creeks, but placer mining was also done on Sixmile, Miller, Quartz, Cooper, Winner, Gulch, and Lynx creeks. A dredge was built on Sixmile Creek and operated for a short time. A steam shovel was installed on Resurrection Creek toward the end of the mining season.

Some production was made from four auriferous lodes, besides smaller outputs from other properties incidentally to development work.

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[1] Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, p. 179, 1915.

[2] The output of the hydraulic mine on Crow Creek is included with that of the Kenai Peninsula placers, though it is located north of Turnagain Arm.

At the Bluebell mine work has been continued on two adits, which have reached a total length of 350 feet. A small mill on this property was operated for a part of the time. Work was continued at the Kenai-Alaska on the 200-foot level, and a total of 385 feet of underground work was done during the year. The 5-stamp mill was operated from August to November. About 75 feet of drifting was done at the Lucky Strike mine. The plant, including a 1-stamp mill, was operated from May to October. In the Moose Pass region developments were continued on the Gilpatrick claims. Considerable development work was also done on the Skeen-Stevenson property, in the same region, and some rich ore was found, which was treated in an arrastre. Besides the work noted above assessment and development work was done on many other lode claims.

Some coal was produced at the Bluff Point mine, on Cook Inlet, during 1915. Coal beds located near Point Woronzof and near McNeil Creek, both on the west side of Kenai Peninsula, were also prospected.

SUSITNA-MATANUSKA REGION.

The productive mineral resources of the Susitna-Matanuska region include those in the Willow Creek gold-lode district and the Yentna and Valdez Creek placer districts. A little placer mining has also been done on Willow Creek and on tributaries of the upper Chickaloon. Three gold lode mines and 25 placer mines were operated in this region during 1915 and produced gold to the value of $317,267. The three lode mines are in the Willow Creek district, where there is also one placer mine, which is described elsewhere in this volume. About twenty placer mines were operated in the Yentna district and five in the Valdez Creek district, employing about 90 men in all. The largest operations were those of the Valdez Creek Placer Mining Co., which operated a large hydraulic plant.

SOUTHWESTERN ALASKA.

No direct information as to the mining developments in the Iliamna region, Kodiak Island, or the Alaska Peninsula is available. It is known, however, that beach mining continued on Kodiak and Popof islands on about the same scale as in previous years. There were probably some lode developments in the Iliamna region and on Kodiak Island. The sulphur deposits of Makushin volcano, on Unalaska Island, have been prospected to some extent.

YUKON BASIN.

GENERAL FEATURES.

The value of the placer-gold output of the Alaska Yukon districts in 1915 is estimated to have been $7,050,000, compared with $7,570,000 in 1914. About 460 placer mines were operated in 1915, giving employment to about 2,900 men. Only three lode mines were productive in the Yukon basin in 1915, and these were all in the Fairbanks district, but several other lode properties produced some gold incidentally to development. The following table gives the estimated gold output of the principal Yukon placer camps in 1915:

Estimated value of gold produced from placers in the Yukon basin, 1915.

District.	Value.	District.	Value.
Fairbanks	$2,450,000	Koyukuk	$290,000
Iditarod	2,050,000	Circle	230,000
Ruby	700,000	All others	720,000
Hot Springs	610,000		
			7,050,000

The Yukon placer mines also produced $31,118 worth of silver. The above figures do not include the output of the lode mines, which in 1915 produced gold to the value of $217,776 and silver to the value of $910. There was also a small output of tin from the Hot Springs district (see p. 27), and considerable antimony ore was shipped from Fairbanks district (see p. 29). The total value of the entire mineral production from the Alaska Yukon in 1915 was $7,423,352.

FAIRBANKS DISTRICT.

The first placer mining in the Fairbanks district consisted of some small operations in 1903. Owing to the exhaustion of the bonanza deposits the placer-gold output has been on the decline since 1908. In these 13 years of mining gold to the value of about $65,490,000 has been won from the placers. The production of gold and silver from the placers is shown in the following table. Silver occurs as an impurity in the placer gold, and the figures given for silver are based on an estimate of its percentage.

Placer gold and silver produced in the Fairbanks district, 1903–1915.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1903	1,935.00	$40,000	348	$188
1904	29,025.00	600,000	5,225	2,821
1905	290,250.00	6,000,000	52,245	28,212
1906	435,375.00	9,000,000	78,367	42,318
1907	387,000.00	8,000,000	69,660	37,616
1908	445,050.00	9,200,000	79,909	43,151
1909	466,818.75	9,650,000	84,027	45,375
1910	295,087.50	6,100,000	53,116	28,683
1911	217,687.50	4,500,000	52,245	27,690
1912	200,756.25	4,150,000	48,182	29,632
1913	159,637.50	3,300,000	20,274	12,245
1914	120,937.50	2,500,000	29,024	16,050
1915	118,518.75	2,450,000	28,444	14,421
	3,168,078.75	65,490,000	601,066	328,402

The data relating to the source of gold by creeks are not very accurate. An attempt has been made in the following table, however, to distribute the total placer-gold production of the Fairbanks district by the creeks on which the mines are located.

Approximate distribution of gold produced in Fairbanks district, 1903–1915.

Cleary Creek and tributaries	$22,270,000
Goldstream Creek and tributaries	13,050,000
Ester Creek and tributaries	10,680,000
Dome Creek and tributaries	7,570,000
Fairbanks Creek and tributaries	6,970,000
Vault Creek and tributaries	2,510,000
Little Eldorado Creek	1,870,000
All other creeks	570,000
	65,490,000

The above tables show only the placer output of the district immediately tributary to Fairbanks. They do not include the output of Bonnifield, Tenderfoot, Salchaket, and other smaller camps which are supplied from Fairbanks and whose gold is sent to Fairbanks. Several other districts, such as Hot Springs and Ruby, send a part of their gold output to Fairbanks. All these districts have contributed from $500,000 to $1,000,000 of gold to the total which annually passes through Fairbanks.

Lode mining began at Fairbanks in 1910, and since that time gold to the value of $1,068,845 has been produced by this industry. Therefore, the total gold production of Fairbanks district, including both lode and placer production, is about $66,500,000. The lode output is shown in the following table, which is based on more accurate data than those used for the placer production:

Lode gold and silver produced in the Fairbanks district, 1910–1915.

Year.	Total quantity of crude ore (tons).	Gold.		Silver.	
		Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1910	148	841.19	$17,339	106	$57
1911	875	3,103.02	64,145	582	308
1912	4,708	9,416.54	194,657	1,578	971
1913	12,237	16,904.98	349,457	4,124	2,491
1914	6,526	10,904.75	225,421	2,209	1,222
1915	5,845	10,534.91	217,776	1,796	910
	30,339	51,705.39	1,068,845	10,395	5,959

It is estimated that about 115 placer mines were operated in the district during 1915, employing about 1,050 men. Of the total value of the placer gold produced about $500,000 was taken out during the winter. The mines of Cleary Creek basin and adjacent parts of the Chatanika Flats are still the largest producers, but those of Goldstream Creek and its tributaries, including Pedro and Gilmore creeks, made nearly as large a gold output in 1915.

The placers on lower Cleary, Vault, Dome, and Eldorado creeks occur as deep channels, so that here the mining is done by underground methods. On Goldstream, Pedro, Gilmore, and Fairbanks creeks the operations are carried on chiefly by open-cut methods, and the steam scraper is largely used. On Ester Creek both open-cut and deep mining is practiced. The dredge on Fairbanks Creek was operated throughout the season. The success of this enterprise should encourage the investigation of the many other large deposits of auriferous gravels in the district which are of too low grade to mine by the methods now in use. No doubt larger mining ventures will be undertaken as soon as the Government railroad now being constructed to Fairbanks cheapens the cost of fuel and other operating expenses. Meanwhile there is little hope that the placer mining industry will expand. During the last two years many of the operators have been developing the narrower pay streaks on smaller creeks that were formerly believed not to be available for economic exploitation. Last summer such mining was done on Wolf, Chatham, Happy, Eva, Wildcat, Big Eldorado, Steamboat, Flume, Twin, and other small creeks, and a considerable quantity of gold was produced. Another significant feature of the year's operations was the reworking of a claim in the middle part of Cleary Creek by open-cut methods. Though this claim was said to have been worked out years ago, the new operations yielded good returns. There is no doubt that a large amount of gold left in many of the mines that have been worked in the past, especially where it is not too deep for mining by open cuts, will in the future be taken out. The presence of large bodies of gravel carrying less gold than can be recovered under existing conditions is too well known to need mention again.[1]

The conditions that have led to a decline in placer mining have also halted the exploitation of lodes. There is no hope of the development of a lode-mining industry until operating costs are reduced. In spite of the adverse conditions, some lode miners have persisted, and it is entirely due to the enterprise of a few individuals that the Fairbanks district may still be classed as a lode camp.

The salient feature of the lode development in 1915 was the shipment of some 685 tons of antimony ore mined on four properties. This development of stibnite ore was possible only because of the high value of antimony and the low freight rates offered by the transportation companies to San Francisco, to which all the ore was shipped. The stibnite deposits of Fairbanks have been described in detail elsewhere[2] and need not be considered here. (See also p. 29.)

[1] Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska, 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: U. S. Geol. Survey Bull. 525, 1913.
Brooks, A. H., The future of gold placer mining in Alaska: U. S. Geol. Survey Bull. 622, pp. 69-79, 1915.

[2] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649 (in press).

During 1915 three auriferous lode mines were operated on a regular productive basis in the Fairbanks district. These are the Rhoads & Hall, on Cleary Creek, and the Gilmore & Stevenson and Crites & Feldman, on Fairbanks Creek. There was also considerable development on other properties, incidentally to which some gold ores were produced from at least half a dozen. The ores were treated at small customs mills.

The Rhoads & Hall mine and mill were operated to September 10 and then were closed until cheaper operating costs insure greater returns. Most of the mining done in 1915 was on the first level, and about 200 feet of underground work was completed. Some of the tailings were treated in a small tube mill of local manufacture. The Crites & Feldman mine and mill were operated throughout the year. The mine is developed by two adits, the upper of which is 700 feet and the lower 400 feet long, and is equipped with a 5-stamp mill, an air compressor, and a sawmill. Most of the ore milled in 1915 came from the lower level. Nars, Anderson & Gibbs have continued work on their claims at the head of Moose Creek, a tributary of Fairbanks Creek. The developments consist of a 100-foot shaft and a 100-foot adit. Gilmore & Stevenson installed a 5-stamp mill on upper Fairbank Creek, which was operated from September 1 to the end of the year. This mill was supplied with ore from the Ohio group of claims, as well as from other properties in the vicinity. At the North Star claims near by a 30-foot incline was sunk, 60 feet of drifting on the vein was done, and some ore was milled.

Developments were continued on the Mizpah and adjacent claims, also in the upper valley of Fairbanks Creek. Some ore was produced and treated at a small customs mill near by. A 100-foot shaft has been sunk on the Rob & Roy claims, at the head of Too Much Gold Creek, a tributary of Fairbanks Creek. In addition 170 feet of drifting was done on the 70 and 100 foot levels and some ore was produced and milled.

At the American Eagle claim, at the head of Fairbanks Creek, a shaft 107 feet deep has been sunk, and an adit planned to cut the vein underground has been driven about 400 feet. Some work is also reported by the Territorial mine inspector [1] on the McCarty property, at the head of Fairbanks Creek; at the Homestake mine, at the head of Wolf Creek; at the Colorado claims, on Bedrock Creek; and at the Soo and Wild Rose claims, on Dome Creek.

An adit about 30 feet long was driven on the Independence claim, on Twin Creek. Here the bedrock is coarse porphyritic granite,

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[1] Maloney, William, Report of the Territorial mine inspector to the governor of Alaska for the year 1915, pp. 14-15, Juneau, 1916.

and the lode consists of a zone of fracture striking about east and standing vertical, which has been permeated and mineralized by vein quartz. The quartz veins appear to be lenses or wedge-shaped masses cut off by joint planes that are nearly at right angles to lode. These joint planes are themselves mineralized, and some of the joints are filled with vein quartz. The rock breaks out in rhombohedral forms, including both quartz and mineralized granite. At the face of the adit in September, 1915, 3 to 4 feet of quartz and more or less mineralized granite were exposed, bounded on the north by a well-defined wall but having no sharp line of demarcation on the south side. Within this 3 or 4 feet there is probably a total of 12 to 15 inches of quartz exposed, occurring in several stringers. Martin Harrais, the owner, reports that the quartz stringers assay as high as $38 a ton and the mineralized zone from $4 to $22 a ton. About three-quarters of the gold is said to be in the concentrates. The vein has been traced about 1,500 feet east of Twin Creek, to the granite and schist contact. It has also been found in the schist, but this part of it is reported to carry no gold. The vein quartz is glassy to white in color and includes some well-developed crystals. Besides the gold the vein carries pyrite, arsenopyrite, and galena.

Though there are a number of promising quartz veins in the Ester Creek basin, only a few claims were under development during 1915. The principal developments in this part of the field were on claims owned by Tyndall, Finn & McGlauglin, and most of the work was done on the Bondholder group and on Mohawk claim. The Mohawk claim is developed by two shafts, one of which was examined and is about 50 feet deep. In this shaft a well-defined lode 2 feet or more in width is exposed. On the Bondholder claim work was continued on the lower adit, which is now nearly 600 feet long. It cuts some narrow mineralized shear zones, but the main lode has not yet been reached. Work was also continued on the claims controlled by McGlone & Smith, which adjoin those of Tyndall & Finn, but details in regard to this work are lacking.

In September, 1915, Albert Johnson discovered a lode carrying scheelite (tungstate of calcium) on the divide between the heads of Gilmore and Smallwood creeks, about 15 miles northeast of Fairbanks. This deposit has not been examined by any member of the Survey, but Mr. Johnson has kindly furnished a very complete description of it, on which the following notes are based.

The country rock in the vicinity of the discovery is schist, but the tungsten lode is in a bed of crystalline limestone 25 to 50 feet wide. It occurs close to a greenstone band, which is described as a dike intruded along the contact of the schist and limestone. The lode itself, which appears to be a pegmatite intrusive, occurs within the crystalline limestone. It strikes about east and dips 40° N. and has been traced on the surface by pits for a distance of some 200 feet. So far as determined, the lode ranges from a few inches to 4 feet in width. It has been opened to a depth of 40 feet by an incline, along which it is reported to be about 4 feet wide for the full depth. A specimen of the ore furnished by Mr. Johnson showed it to be made up of quartz, augite, scheelite, apatite, titanite, and a little biotite and hornblende, the last three chloritized. This rock appears to be a pegmatite in which the scheelite is a primary mineral. The scheelite is said to occur in part in small rich lenses or shoots, but most of the ore is of concentrating grade. Mr. Johnson reports that one analysis of concentrates yielded 72.82 per cent of tungsten trioxide. Though this is the only tungsten lode yet discovered in the district, the occurrence of scheelite in some of the Fairbanks placers has been reported. Scheelite is not, however, as common a mineral in this district as it is in some of the placers of Iditarod and Nome.

CHISANA DISTRICT.

About 17 mines were operated in the Chisana district during the summer of 1915 and 2 in the previous winter. These employed about 110 men in the summer and 8 in the winter. The total gold output of the camp was $160,000, of which about $150,000 came from the placers of Bonanza Creek. Sluicing began on June 25 and continued until about the middle of September. There was, however, some interruption owing to the lack of water because of a dry season. Besides the operations on Bonanza Creek mining was done on Little Eldorado, Skookum, Gold Run, Big Eldorado, and Coarse Money creeks. A high-line ditch was surveyed and partly built on Bonanza Creek.

FORTYMILE AND EAGLE DISTRICTS.

It is estimated that during 1915 about 30 placer mines were operated in the Fortymile and Eagle districts, employing about 110 men. In addition to this work many men were engaged in prospecting, and as usual a number were employed in working on the bars of Fortymile River and produced some gold. Exact information in regard to the value of the gold output is lacking, but it is probably about $90,000.

In the Fortymile district the principal producing creeks are Wade, Chicken, and Lost Chicken. There was also some mining on Ingle, Camp, Squaw, and Flat creeks and Franklin Gulch. Good prospects are said to have been found on Liberty Creek but are undeveloped. Plans are said to have been made to develop some placers on Dome Creek, a tributary of O'Brien Creek. Some deep holes were sunk on the benches of Wade Creek with a view of finding a buried channel. A steam scraper was operated on Squaw Creek. Besides the usual number of "snipers" there were some larger mining plants along Fortymile River. These include some extensive ground-sluicing outfits near Atwater Bar, a steam scraper below Steel Creek, and a small hydraulic plant near by.

In the Eagle district three mines were worked on American Creek, and mining was continued on about the same scale in the Seventymile region as in the previous year. A new discovery of placer gold is said to have been made on Fox Creek, in the Seventymile basin.

CIRCLE PRECINCT.

The Circle precinct includes the Birch Creek district and the placers of Woodchopper and Beaver creeks. It is estimated that gold to the value of $230,000 was produced here from 50 mines employing some 200 men. The principal event of the year was the installation of a new dredge on Mammoth Creek, which began operations about June 1 and continued to the end of the season. This dredge is equipped with buckets of $3\frac{1}{2}$ cubic feet, has a daily capacity of 2,000 cubic yards, and is capable of digging ground 15 feet deep. Wood is used as fuel. Hydraulic plants were operated on Switch, Mastodon, Deadwood, and Eagle creeks; deep gravel mining was done on Woodchopper, Coal, and Deadwood creeks; and open-cut operations on Woodchopper, Coal, and adjacent creeks were unusually successful. The largest output came from Mammoth Creek, and the largest number of operations were on Deadwood Creek.

TOLOVANA DISTRICT.

Workable gold placer ground was discovered on Livengood Creek, in the Tolovana district, July 24, 1914. As a result, there was a considerable influx of prospectors and miners into the new district during 1915. A deep channel was opened on Livengood Creek and traced for several miles, and this has been the source of most of the gold produced. There has been, however, some open-cut mining on tributaries of Livengood Creek and also on Olive Creek, which flows directly into Tolovana River. Good prospects have also been found in the adjacent Hess Creek basin, but here there was no productive mining.

It is probable that about 40 or 50 claims were more or less sytematically prospected in this district during 1915. Of these about 10 can be classed as productive mines, which produced gold to the value of about $80,000. Livengood (see Pl. I, in portrait), the distributing point of the district, has a post office, a wireless station, and a United States commissioner's office. It can be reached by a horse trail and winter road about 55 miles long from Olnes, a railway station near Fairbanks. Another route available in summer is by launch up Tolovana River to the Log Jam and thence overland. The Log Jam is about 15 miles from Livengood. A more detailed account of the Tolovana district will be found elsewhere in this bulletin.

HOT SPRINGS DISTRICT.

About 30 placer mines, employing some 275 men, were operated in the Hot Springs district during the year. These yielded gold to the value of about $610,000, and incidentally some stream tin was won from the placers. The tin developments are described on pages 27–28. The most important development was the opening and mining of some placers on the lower part of Woodchopper Creek. Large plants were also operated on Oakley Creek, on the Lieber & File claims, Midnight Sun group, and on American Creek. A large hydraulic plant was operated on Eureka Creek, in the northern part of the district. There were smaller operations on Miller, Cache, Boulder, Sullivan, Patterson, Dalton, and Gold Run creeks. Much of the mining in this district is that of deep channels, in which operations are carried on both in summer and winter.

RAMPART DISTRICT.

Mining continued in the Rampart district on about the same scale as in recent years. In the district proper about 15 mines were operated on Hunter, Little Minook, Hoosier, Slate, Big Minook, Quail, and Ruby creeks. Gold to the value of about $35,000 was recovered from these operations, which were all on a small scale. A little winter mining was done on several creeks. Summer operations were hampered by lack of water. Considerable prospecting was done in the Dall and Hodzana river basins, and some encouraging results were reported, though there was no productive mining.

KOYUKUK DISTRICT.

About 35 mines, employing probably 150 men, were operated during 1915 in the Koyukuk district, including the Indian River region. The gold produced in these operations is estimated to have a value of $290,000. Of this amount about $225,000 was taken from the deep mines during the winter. The deep mines of Hammond River made the largest production, but winter mining was also done on Nolan, Linda, and Gold creeks. Some of the Hammond Creek deep placer ground is wet and owing to lack of pumps of sufficient size could not be mined. In 1915 some 4-inch steam pumps were brought in, and their successful operation makes it probable that deep mining will increase in the district.

The largest summer production was obtained from the placers of Jay Creek, which were discovered in 1915. Jay Creek flows into Rye Creek, which is a tributary of Wild River. The pay streak is said to be about 30 feet wide and 4 feet thick, and gold has been found on five claims. Placer prospects have also been found on Rye Creek. Nolan Creek made the second largest summer output, but productive mining was also done on Gold, Linda, Smith, Myrtle, and Crevice creeks. A little gold was won from the gravels of the South Fork and its tributaries. About $15,000 worth of gold was taken from the placers of Indian River and vicinity. This came chiefly from Indian River and its tributaries, but there was also a little mining on Black and Utopia creeks.

RUBY DISTRICT.

Sixty-one placer mines were worked in the Ruby district during 1915, and the value of the gold produced is estimated at $700,000. The most extensive mining was done on Long and Poorman creeks and their tributaries. The principal event of the year consisted in the preparations to install a dredge on Greenstone Creek, which will be in operation in 1916. Details in regard to the operations in this district are contained elsewhere in this volume.

INNOKO DISTRICT.

In spite of the dry weather during the summer, which resulted in some shortage of water, mining was active in the Innoko district. There was during the year a notable advance in the installation of larger mining plants than had been previously used, which augurs well for future gold production. It is estimated that 38 mines were operated in the Innoko district, including the Cripple Mountain region, during 1915, employing about 140 men and producing gold to the value of $190,000. This mining was done on Yankee, Little, Spruce, Ophir, and Ganes creeks, named in the order of the size of their gold output. Two steam scrapers were used on Yankee Creek, and a steam hoisting plant with self dumper on Spruce Creek. Late in the summer a small scraping plant was installed on Ganes Creek and operated for a short time. There was also some extensive prospecting with churn drill on Ganes Creek. Preparations were made for installing a hydraulic plant on Little Creek. There was considerable ditch building on Ophir and Spruce creeks. Some deep placer ground was found on Dodge Creek, and preparation was made for winter mining. Mining continued in a small way in the Cripple Creek Mountain region.

Twelve plants, employing about 40 men, were operated during the winter on Little, Ophir, and Ganes creeks and produced gold to the value of about $40,000.

IDITAROD DISTRICT.

Twenty-four mines were operated in the Iditarod district in 1915, employing about 400 men and producing gold to the value of $2,050,000. The largest operations were those of the two dredges on Flat and Otter creeks. There were also some extensive operations by open-cut methods on Otter Creek near Discovery, and large plants were operated near the heads of Flat, Chicken, and Happy creeks. The largest quantity of gold was obtained from Otter and Flat creeks.

A drag-line excavator, the first used in Alaska, was installed at a mine on Willow Creek during the summer and successfully operated. At this mine the frozen muck, about 10 feet deep, had during the previous year been ground-sluiced from an area about 1,500 by 100 feet, forming a cut to the gravels, which are 3 to 4 feet deep. It is this gravel which, having thawed out, is to be handled by the excavator and dumped into elevated sluice boxes. The machine has a 60-foot boom and a 1½ cubic foot bucket and is equipped with a 60-horsepower boiler. It is expected that the average daily capacity will exceed 1,000 cubic yards. This new method of mining, which promises to be a success, may have an important use in mining some of the Alaska placers.

No lode mining has been done in the Iditarod district, though some antimony-bearing quartz veins have been prospected.[1] Some of these deposits carry cinnabar, which with scheelite is abundant in some of the concentrates from placer mining. These antimony-cinnabar lodes, which also carry gold, are worthy of further prospecting. It is suggested that, on account of the present high price of tungsten, the placer miners might well consider the recovery of the scheelite from the concentrates. The placer-mining operations at the head of Flat Creek, on the Upgrade claims, have revealed some quartz stringers carrying considerable gold that cut the monzonite bedrock. Some of this material was dug out last year and shipped and represents the first production of lode gold from the Iditarod district. The distribution of placers at the heads of Flat, Happy, and Chicken creeks clearly indicates that there are zones of mineralization in the monzonite stock in which these creeks have their heads. It is possible that the gold may be sufficiently concentrated in some of these zones to justify lode development. In any event, there can be no question that there has been much auriferous mineralization in parts of this monzonite. The geology of the Iditarod district is discussed elsewhere in this bulletin.

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[1] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649 (in press).

SMALLER YUKON DISTRICTS.

In the Chandalar district there were no developments of importance in 1915. In the summer eight or ten men worked on about five claims and made a gold output of $4,000 to $5,000. The mining, as in previous years, was done on St. Marys, Squaw, and Big creeks. Some winter deep mining at the mouth of St. Marys Creek was planned. No lode mining was done, but some promising discoveries of auriferous quartz are reported.

About 10 mines, employing about 30 men, were operated in the Tenderfoot and Salchaket region. In this region mining is reported on Tenderfoot, Caribou, and No Grub creeks. There was also a little mining on Kenyon Creek, in the Healy River district. Some small placer-mining operations were continued in the basin of Chena River, which was the scene of considerable prospecting during the year. The above-mentioned operations yielded gold to the value of about $95,000.

Mining continued in the Bonnifield and Kantishna districts on about the same scale as in previous years, with a total gold production of about $40,000. Most of the mining is pick and shovel work, but some automatic dams and small hydraulic plants are in use. Some investigations were made during the year with the view of installing larger plants in the Kantishna district. The gold and antimony bearing lodes of this district[1] are also receiving some attention, though none are yet productive. In all, some 1,200 feet of underground work has been done on these lodes.

The Wade Hampton precinct lies in the lower Yukon basin, centering on the settlement of Marshall (see Pl. I), but the exact location of its boundaries is not known at this writing. Gold was discovered on Wilson Creek, which enters the Yukon at Marshall, in 1913. In the following year some claims were opened on this stream and on its tributary Disappointment Creek, and about $15,000 worth of gold was recovered. Meanwhile gold prospects had been discovered on several other creeks in the district. It is reported that in 1915 some seven claims were opened and that the gold produced had a value of about $25,000. In 1915 one placer claim on Wilson Creek, one on Disappointment Creek, and four on Willow Creek were worked by opencut methods, and one bench claim on Willow Creek was worked by drifting.[2] Considerable prospecting was done during the summer with churn drills on Elephant Creek. A small quartz vein, said to carry considerable gold and silver, was found on Willow Creek, and a test shipment of ore was made. A vein carrying gold, galena, and

[1] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649 (in press).

[2] Maloney, William, Report of the Territorial mine inspector to the governor of Alaska for the year 1915, p. 18, Juneau, 1916.

molybdenite is also said to have been found on the divide between Disappointment and Willow creeks.

KUSKOKWIM REGION.

Placer gold has been mined at several localities in the Kuskokwim region along an ill-defined belt stretching northeastward from the vicinity of Goodnews Bay for some 300 miles to Takotna River. (See Pl. I.) The northern part of this belt includes the Takotna district and the placers of the Georgetown region, described elsewhere in this volume. In the southern part are the Tuluksak-Aniak and Goodnews Bay districts.[1] In this zone also are some quicksilver deposits[2] on which some small developments were probably continued during 1915, though no reports about them have been received at this writing.

In the Tuluksak-Aniak district five claims were worked by 16 men on Bear, Spruce, Bonanza, and Marvel creeks. One small plant was operated on New York Creek, tributary to the Kuskokwim from the north, above the settlement of Aniak. The most important developments of the year in the lower Kuskokwim region were on Canyon Creek, which forms a part of the Kwikluk drainage basin. Here five mines were operated during the year, and some fairly rich placers were developed. There was also a little mining on Rainy and Kapon creeks in the same district. Good prospects are reported to have been found on Fork and Windy creeks, also in the Kwikluk River basin. The benches on Fork Creek are said to carry gold. Mining continued in the Goodnews Bay district on a small scale, as in previous years. The gravels of the lower Kuskokwim region are not frozen, and it appears that some of them are worthy of investigation for development by dredges.

It is estimated that in all about 25 mines were operated in the Kuskokwim region in 1915, employing about 80 men, and that they produced gold to the value of about $100,000. In addition to the men employed in productive mining, a larger number were engaged in prospecting and development work.

SEWARD PENINSULA.

The estimated value of the gold output from Seward Peninsula in 1915 is $2,900,000; that of the 1914 output was $2,700,000. Tin, antimony, and coal were produced on Seward Peninsula in 1915 to the value of about $84,000. Absolutely reliable statistics of gold production of the peninsula are far from being complete, but the following table, based on the best data available, gives an estimate of the yearly output since mining began in 1897.

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[1] Maddren, A. G., Gold placers of the lower Kuskokwim, with a note on copper in the Russian Mountains: U. S. Geol. Survey Bull. 622, pp. 292–360, 1915.

[2] Smith, P. S., and Maddren, A. G., Quicksilver deposits of the Kuskokwim region: U. S. Geol. Survey Bull. 622, pp. 272–291, 1915.

Gold and silver produced in Seward Peninsula, 1897–1915.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1897	725.63	$15,000	87	$52
1898	3,628.12	75,000	435	256
1899	135,450.00	2,800,000	16,254	9,752
1900	229,781.25	4,750,000	27,574	17,097
1901	199,822.61	4,130,700	24,579	14,747
1902	220,677.07	4,561,800	26,481	14,035
1903	215,994.38	4,465,000	24,171	13,052
1904	201,462.52	4,164,600	24,175	14,021
1905	232,200.00	4,800,000	27,864	16,997
1906	352,812.50	7,500,000	43,537	29,605
1907	338,625.00	7,000,000	25,497	16,828
1908	247,680.00	5,120,000	20,577	10,905
1909	206,077.50	4,260,000	20,871	10,853
1910	169,312.50	3,500,000	20,317	10,971
1911	149,962.50	3,100,000	17,996	9,718
1912	145,125.00	3,000,000	17,415	10,710
1913	120,937.50	2,500,000	12,094	7,305
1914	130,612.50	2,700,000	15,673	8,667
1915	140,287.50	2,900,000	17,510	8,878
	3,451,174.08	71,342,100	383,107	224,449

Most of this gold was taken from placers, although from 1903 to 1907 the Big Hurrah lode mine produced some gold, and small outputs have been obtained from several lodes at different times.

A small amount of silver-lead ore was shipped from the Omalik mine, in the Fish River basin, as early as 1881, and several other shipments of ore have been made from this property, but these are not included in the table. The silver output above noted has largely been recovered from the placer gold. The only other mineral resources of the peninsula that have been developed are some coal deposits in the Fairhaven district that have been mined in a small way since 1902; the York tin deposits, first developed in 1900; and the antimony deposits, first exploited on a commercial scale in 1915.

The most important advances made on the peninsula during the year were the revival of deep mining and the development of antimony lodes. Gold dredging continued on a large scale but was not as productive as in the preceding year. Thirty-one gold dredges were operated and handled about 3,000,000 cubic yards of gravel, yielding gold to the value of $1,050,000. In 1914, 39 dredges dug about 3,400,000 cubic yards of gravel and recovered $1,280,000 worth of gold. The total gold recovered by dredges since this method of mining was first introduced in 1903 has an estimated value of $8,850,000. Of the 31 dredges operated in 1915 two were engaged in mining placers in the York district that carry gold as well as tin. In addition to the gold dredges, two tin dredges were operated in the York district in 1915, making 33 dredges in all on Seward Peninsula. Three gold dredges and one tin dredge were built during the year.

The cause of the decrease in production of dredge gold is not clear, as there are known to be large areas of auriferous gravels [1] on the peninsula which appear to be suitable for profitable exploitation by dredges. One reason, however, is that most of the successful dredges appear to have worked on placers of rather high grade, and their success has been due to this fact rather than to economical mining by large operations. Little attempt has been made to work the permanently frozen placers, as has been so successfully done in the Alaska and Canadian Yukon. In the Yukon region wood costs from $9 to $14 a cord, which is less expensive per heat unit than the retail price of coal at Nome, about $20 a ton. The cost of fuel oil per heat unit is said to be still less. To this price must be added the expense of hauling the fuel to the dredge. It would seem that there is in Seward Peninsula a field for strong companies that could introduce economies in the operation of dredging and thawing.

Some placers were developed during 1915 in the southeastern part of the peninsula. It has long been known that placer gold occurs in this region,[2] but until recently mining has been only intermittent. The following notes on the new developments are based largely on information furnished by Mr. Lars Gunderson, who resides in the district.

The developed placers were on Dime Creek, which joins Koyuk River about 40 miles from Norton Bay by the windings of the stream. The bedrock of the district is schist with some crystalline limestone. Gold placers are said to have been found on nine contiguous claims on Dime Creek, which would mark a pay streak about 2 miles in length. Placer gold has also been mined at different times in the adjacent region.

Though little productive mining has yet been done on Dime Creek, nearly $3,000 is said to have been taken out of three claims. Some of the gold is said to be worth over $19 an ounce. A settlement has been established on Dime Creek, and provisions and mining supplies, including boilers, have been brought in. The systematic opening of the placer ground is therefore assured.

Including the gold dredges, it is estimated that 120 placer mines were operated on the peninsula in 1915, employing about 1,200 men. These do not include the placer tin mines, of which there were three, employing 40 men. The distribution of the gold production by districts is shown in the following statement, which, however, owing to the failure of some of the operators to make returns, is only an approximation.

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[1] Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts: U. S. Geol. Survey Bull. 328, pp. 111-135, 1908.

Brooks, A. H., The future of gold placer mining in Alaska: U. S. Geol. Survey Bull. 622, pp. 69-79, 1915.

[2] Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska: U. S. Geol. Survey Bull. 449, 1911.

Approximate distribution of gold produced in Seward Peninsula, 1915.

Nome district	$1,500,000
Council district	685,000
Fairhaven district	250,000
Solomon district	250,000
Kougarok district	140,000
Port Clarence and smaller districts	75,000
	2,900,000

More deep placer mining was done at Nome during 1915 than there has been for many years. About 36 deep placer mines, employing about 250 men, were operated in the Nome district during the winter of 1914–15, and the value of their gold output and that of the mines operated in summer was about $300,000. Though there was a shortage of water in the peninsula during August, in general the season was favorable to placer-mining operations.

The Sliscovitch mine was opened late in the summer, and some antimony ore was shipped from it. Some antimony ore was also shipped from the Hed & Strand mine, about 3 miles north of the Sliscovitch. Antimony-bearing lodes were prospected at other localities in the peninsula, notably on Anvil Creek. A summary of the antimony resources of the peninsula is in press.[1] The developments in tin mining are noted elsewhere in this volume. (See pp. 27–28.)

Some gold was probably recovered incidentally to the mining of antimony deposits, but there appears to have been no other lode production, though prospecting of auriferous quartz veins continued. A gold-bearing vein was found on Boulder Creek, in the Nome district, and is said to have been traced for a considerable distance. Plans are under way for prospecting this deposit.

KOBUK REGION.

Placer mining in a small way continued in the Kobuk region during 1915. Four claims were worked on Klery Creek, in the Squirrel River district, and four claims on Dall, Shungnak, and Lynx creeks, in the Shungnak district. An 8½-ounce nugget was found on Klery Creek. In the Shungnak district two dams with automatic gates were installed. The entire gold output of the Kobuk region is estimated to have a value of $20,000.

[1] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649.

MINING DEVELOPMENTS IN SOUTHEASTERN ALASKA.

By Theodore Chapin.

INTRODUCTION.

A considerable advance in both copper and gold lode mining was made in southeastern Alaska in 1915. The development consisted in the opening up of large bodies of gold-bearing ore, in the installation of mining machinery and power-developing plants for its expolitation, and in the resumption of operations in a number of copper mines. This revival of activity was felt throughout the region extending from Ketchikan to Berners Bay.

Juneau, which has long ranked as an important gold producer owing in large part to the production of the Treadwell group of mines on Douglas Island, now bids fair to surpass all previous records in the production of ore. The extensive deposits of low-grade ore that for years have been known to exist on the mainland are now being actively exploited. The opening of the Alaska-Gastineau mill and the breaking of ground for the new mill of the Alaska-Juneau Gold Mining Co., part of an extensive plan of development which will place this company among the principal producers of the region, are notable developments of the year. Other events are the prospecting operations of the Alaska Gold Belt Co. in the Sheep Creek Basin, the formation of the Alaska-Taku Co. with holdings on Taku Inlet and Gastineau Channel, and consolidations and plans for active developments in the Eagle River and Berners Bay district. These activities are the natural response to the successful mining of low-grade ores on a large scale.

The gold produced in southeastern Alaska is won largely from lode mines. The only known productive placer mining in 1915 was in the Porcupine district, where several companies operated with good success. Placer development work, however, was done at Sumdum and on Chichagof Island.

In the Ketchikan district the interest centers largely in copper mining, which was done on a larger scale than in any other year since 1907, the record year of copper production in southeastern Alaska. Several gold mines in this district were productive also.

Interest in the development of marble continues, especially in the southern part of the region. Other nonmetalliferous deposits that have been worked for some time are gypsum and garnets, and in 1915 a small quantity of barite was produced.

The location of the mines and prospects of southeastern Alaska is shown on Plates II and III.

The value of the total mineral output of southeastern Alaska for 1915 was $6,090,571, distributed as follows: Gold, $5,435,586; copper, $302,431; silver, marble, lead, and gypsum, $352,554.

GOLD MINES AND PROSPECTS.

PRODUCTION.

Gold produced in southeastern Alaska, 1914 and 1915.

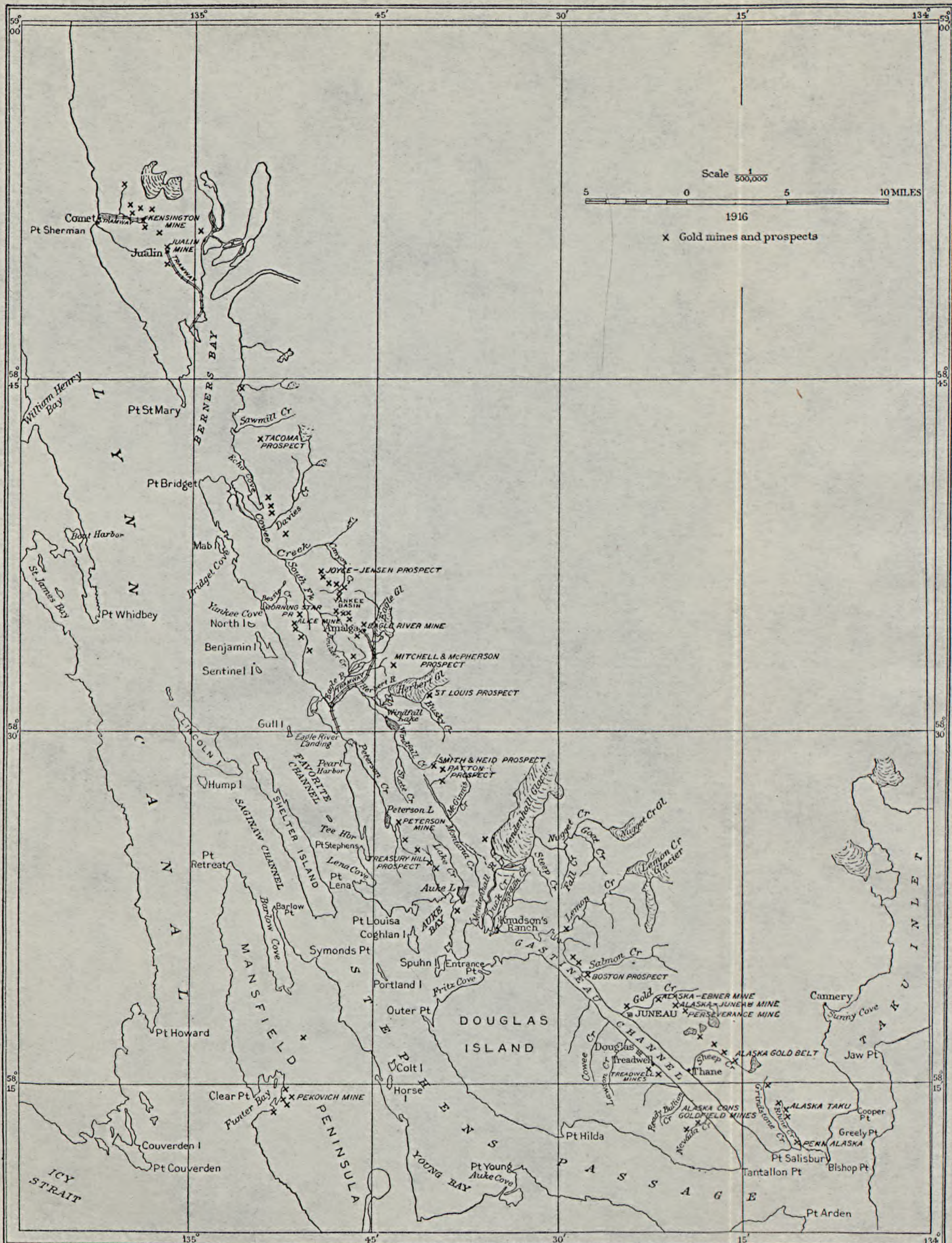
Year.	Ore mined.	Gold.		Silver.		Average per ton.			
						Gold.		Silver.	
		Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
	Tons.	*Fine ounces.*		*Fine ounces.*		*Fine ounce.*		*Fine ounce.*	
1914	1,712,530	201,104.11	$4,157,191	23,767	$13,143	0.117	$2.43	0.014	$0.008
1915	2,989,730	258,963.72	5,353,255	87,953	44,592	.087	1.79	.029	.015

JUNEAU MINING DISTRICT.

DOUGLAS ISLAND.

The Treadwell group of mining companies, comprising the Alaska-Treadwell, Alaska-Mexican, and Alaska-United, operating on Douglas Island, continued their large-scale operations throughout the year. Over 25,000 feet of underground development work was accomplished, of which about equal amounts were in vein matter and in waste. These operations extended over 22 levels but were confined principally to the lower levels. Over 4,300 feet of work was done on the 2,100-foot level in the Treadwell, Mexican, and Seven Hundred Foot mines; extensive development was also continued on the 1,570-foot, 1,750-foot, and 2,200-foot levels. The central shaft was extended to the 2,400-foot level, and development work was started. During January 30 stamps were added to the mill of the Seven Hundred Foot mine, and in October a like addition was made to the Ready Bullion mill, bringing the aggregate number up to 960.

All four mills of the Treadwell group were in nearly continuous operation throughout the year, except in parts of June and July, when an accident to the hoist caused a curtailment of operations at the Treadwell and Mexican mills. A total of 1,650,058 tons of ore was crushed, and 35,502.2 tons of concentrates was saved.



MAP OF THE NORTHERN PORTION OF THE JUNEAU GOLD BELT, ALASKA.

The Alaska Consolidated Goldfield Co. is a new company formed on the reorganization of the Alaska Treasure Gold Mining Co., whose holdings are on Nevada Creek, 4 miles southeast of Treadwell. Development work was resumed in October, 1915, a crew of men being put to work on surface improvements, with the intention of resuming the underground work soon with a larger force. The present developments consist of a mile of underground openings. The first work will be to extend the lower adit and raise to connect with the upper workings.

MAINLAND.

The most notable achievement of the year was the completion of the new Alaska-Gastineau mill at Thane, near the mouth of Sheep Creek. The mill was designed to treat 6,000 tons daily, but tests show that it is capable of handling 8,000 to 10,000 tons. It is a concentrating plant that produces four grades of concentrate for shipment to the smelters. A re-treatment plant is in course of construction. Ore is hauled from the Perseverance mine over an electric railway for more than 3 miles, part of which is through the Sheep Creek adit.

The first unit of the mill was completed in February, and during the year the output gradually increased to nearly the full capacity. During the year an estimated total of about 1,200,000 tons of ore was treated. The average value per ton was somewhat lower than was originally estimated, by reason of a large horse of slate on the fifth level, where high-grade ore was believed to occur. Power for the mill and mine is furnished by the company's hydroelectric plants on Salmon Creek. Another plant, known as the Annex power project, under construction in 1915, will furnish additional power. It is designed to run a 1-300-foot tunnel to tap Annex Lake 100 feet below its surface, thus avoiding the necessity of a dam and outlet. From the mouth of the tunnel a pipe line will carry the water 8,000 feet to the generating plant. The company employs 1,300 men.

The Alaska-Juneau Gold Mining Co. has recently appropriated $2,500,000 to carry out an extensive plan of mine development and improvements, which include the construction of a large mill and power plant, already under way. The plans call for a ball-type mill to be built in four sections, each of which will have a daily capacity of 2,000 tons. It is expected that the first unit will be in operation by January 1, 1917, and that the mill will be completed three months later. The 50-stamp mill built two years ago will eventually be equipped with ball mills. A power plant and oil tanks, equipped with two 5,000-kilowatt turbo generators, will be built near the present site of the Alaska-Juneau offices. This plan of development obviously involves also extensive underground work to furnish a sufficient supply of ore.

No productive mining was in progress at the Alaska-Ebner mine, and owing to litigation the workings were not open to inspection, but underground development work is being continued.

Development of the holdings of the Alaska Gold Belt Co. is being actively pushed. An adit is being driven in the upper part of Sheep Creek basin to cut the ore body, and if feasible a sea-level working adit will be run later. During the year 2,500 feet of the upper adit was driven and work was continued on power installation and the mill site on Gastineau Channel.

The Alaska-Taku group of claims has recently been located and is now being developed. It comprises 43 lode claims and eight mill sites on Grindstone and Rhein creeks and the divide between these creeks and Sheep Creek. The lode claims adjoin those of the Alaska Gold Belt Co. and extend along the strike of the formations for 4 miles, nearly to the patented claims of the Penn-Alaska Mining Co. on Taku Inlet. Five mill sites cover the camp and power sites at the mouths of Rhein and Grindstone creeks, and two mill sites on Gastineau Channel afford sites for a crosscut adit near sea level. The ore deposits were not examined but are said to be stringer lodes similar in character to the Perseverance lode. The locations cover the main greenstone and slate contact and a considerable part of the overlying black slate.

Mining operations were continued on the Pekovich claims, on Funter Bay, Admiralty Island. The Alaska Gold Mining Co., recently formed to exploit this property, will install new machinery and increase the present output.

The mining property on Windham Bay, including mill sites and water rights, was recently sold to the Alaska Bond & Development Co., which will start work in the spring.

A company was recently formed to take over and develop a group of claims on William Henry Bay. It is announced that work will commence soon.

The development of the Eagle River mine, which has been in progress for a number of years since the old workings were closed, was actively continued in 1915, and a considerable production was also made. Recent work has been directed toward driving an adit at an elevation of 400 feet above the mill and 600 feet below the old mine workings. This was designed to prospect the ground and to serve as a working adit. In places it drifts along the lode and in others cuts across. In addition to stopes 2,600 feet of underground workings have been driven. The adit cuts a wide mineralized zone containing ore bodies of more or less irregular shape. Several ore bodies have been opened and two stopes removed. The ore consists of quartz with galena, pyrite, arsenopyrite, and pyrrhotite. From the portal the ore is trammed to the head of a 1,200-foot surface tram that leads to the mill. The mill began operations in June.

Assessment work has been kept up on several claims on Montana Basin and Yankee Cove. The old AB claims have been relocated as the Morningstar group and are being developed in a moderate way.

The Peterson mine, on Pearl Harbor, has been developed more or less throughout the year. A 40-foot adit was recently driven on a vein 7 feet in width, composed of irregular masses of banded quartz. This ore contains considerable free gold, one panful of dirt taken from the lode exposed at the face of the adit yielding a long string of colors. Work has also been done on the Cannonball claim. An adit has been driven for 80 feet along a stringer lode of quartz penetrating slate. This lode carries pyrite and arsenopyrite and contains specks of free gold. It strikes east and dips south at a steep angle. Other large veins of quartz occur on the property, but development has not yet been extensive enough to determine their extent or value. The lodes are easily mined and contain considerable free gold that is readily won in a homemade mill. The surface indications are promising enough to justify a thorough investigation of the property.

On Berners Bay the principal developments were in the Jualin mine. During the winter of 1914–15 sampling and examination were carried on preparatory to active operations in the spring. The present openings consist of an adit level nearly a mile in length and workings on the 60-foot, 160-foot, and 310-foot levels, aggregating 13,000 feet. Recent development work consists of a number of raises from the 160-foot level and the extension of all the levels. On the 310-foot level the back and intermediate veins have been reached. A new lode called the "unknown vein" has been opened on the 160-foot level, and two raises have been started to explore it. This lode is northeast of the other ore bodies and has not yet been found on the other levels. The stamp mill started early in summer. The failure of adequate water power during winter and dry seasons has necessitated the enlargement of the present hydroelectric plant and also the erection of an emergency power plant, which in October, 1915, was nearing completion. It is 1½ miles below the mine and comprises four oil engines of 150 horsepower each. Fuel for these engines will be piped part way and hauled by wagons the remainder. At this mine 75 men are employed.

The Kensington, Bear, and Comet properties have been consolidated by the Hayden-Stone interests and are being actively developed. The Kensington adit has been driven 5,000 feet on through the Johnson lode, which has been explored by 1,600 feet of drifts and crosscuts. It is similar to the Eureka and Kensington lodes but occurs in the greenstone. The adit crosses the granite and greenstone contact 3,200 feet from the portal. A new surface tram has replaced the old switchback between the mine and the coast. Work at present is confined mainly to the Kensington, but the Bear and Comet are included in the general scheme of development. The erection of a 500-ton unit of a flotation mill was planned for the spring of 1916.

The Tacoma group of claims is on one of the tributaries of Sawmill Creek 7,000 feet from Sawmill Cove, at an elevation of about 1,000 feet. The developments consist of several short openings on two or more lodes. The country rock is black slate of the Berners formation, which strikes N. 60° W. and dips steeply northeast. A 70-foot adit has been opened to explore a quartz fissure vein striking east and dipping 75° N. The footwall side of the lode is a large vein of quartz strongly mineralized with pyrite. Its thickness was not determinable, as the adit does not expose the footwall and the vein on the surface is covered with slide material. A 2-foot vein of quartz occurs on the hanging wall of the lode and is separated from the footwall vein by a horse of slate. Overlying the hanging wall is a mineralized zone of slate with many stringers of quartz, forming a stringer lode several feet thick, mineralized with disseminated pyrite. Southwest of this lode on the footwall side, but some distance from it, is a similar stringer lode. An opening has also been made on an 8-foot quartz vein. Slate, country rock, and vein all strike N. 45° W., and a short adit shows the vein to be horizontal at the surface. The vein material is rusty brecciated quartz containing much pyrite.

Considerable prospecting and some development work were done in the vicinity of Auk Bay.

SITKA AND WRANGELL MINING DISTRICTS.

The only productive mining in the Sitka district in 1915 was done at the Chichagof mine, on Klag Bay, on the west coast of Chichagof Island, 50 miles south of Sitka. The mining and milling facilities here have recently been increased by additional stamps, a tube mill, and a new compressor plant. The mine and milling plant were operated continuously throughout the year, and mining has reached the 700-foot level. Shaft sinking was continued on the Fleming gold-copper property, 14 miles from the Chichagof mine.

In the Wrangell district development work was continued by the Olympic Mining Co. on the Helen S. group, on Woewodski Island; on the Berg claims, on Blake Channel, and on the Maid of Mexico mine. The Groundhog properties were sold in the fall, and the new owners began development work, which, it was said, would be carried forward in the spring on a large scale. (See fig. 1.)

KETCHIKAN MINING DISTRICT.

In the Ketchikan district four gold mines were in operation during 1915, and three other properties not classed as mines made a small production. The greater part of the gold produced in this district, however, was derived from the copper ores, all of which carry gold and silver in varying amounts.

PRINCE OF WALES ISLAND.

The old Puyallup mine, on Prince of Wales Island, is now called the Ready Bullion. It is about 1½ miles northwest of Hollis Cove,

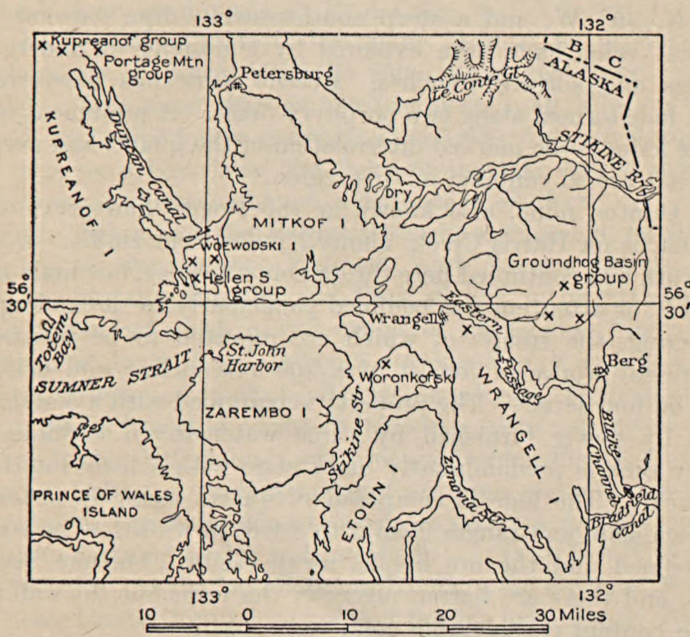


FIGURE 1.—Map showing location of prospects in the vicinity of Wrangell.

with which it is connected by a tramway. The mine is on a narrow vein of quartz inclosed in altered tuffs, slate, and quartzite. The vein is bordered by seams of gouge along two well-defined walls, from which it breaks away easily. The vein where examined ranges in width from 3 to 18 inches, and it is said to be 3 feet wide in places. Its average is about 6 or 7 inches. The hanging wall is stoped out for working space, and the vein matter is broken down and let fall on canvas, care being necessary in extracting the rich ore shoots. The present developments consist of an adit 1,160 feet long, driven along the vein, a 212-foot adit 200 feet above, and a 312-foot adit 70 feet below the long adit. From the portal of the main adit for a distance of 1,000 feet the ore has been stoped above the adit for a vertical height of 150 to nearly 200 feet, the stopes in places reaching the surface; at 840 feet from the portal a raise extends to the surface.

The mine is equipped with cabins, a blacksmith shop, and a 5-stamp Risdon mill. A Pelton wheel runs the mill, compressor, and electric-light plant. The gold, most of which is caught in the amalgam, is retorted and blocked at the mill; the concentrates are shipped.

Development work was continued during the year at the Crackerjack-Hollis group of claims, adjoining the Ready Bullion on the southwest. The country rock is black slate, having a general strike of about N. 30° W. and a steep southwesterly dip. Several large, persistent veins have been explored by a number of underground workings and surface trenches. Recent work has uncovered an 18-foot lode formed along two porphyry dikes. A prominent feature of these lodes is the marked interrelation of the quartz and porphyry dikes that are so common in this region.

The Dunton mine, also known as the Rogers and previously as the Julia, is on Harris Creek, about 2 miles from Hollis. Development work was continued here throughout the year, but little milling was done, as attention was confined particularly to the underground prospecting, the results of which are reported to be satisfactory. The present workings consist of a 300-foot incline and drifts and stopes on four levels. The property is equipped with a 5-stamp mill driven by power furnished by three water-driven turbines. The country rock is predominantly black slate with a little interbedded graywacke. The lode is composed of quartz stringers penetrating the black slate and ranges from 2 to 8 feet in width. The walls are well defined and the ore breaks away easily. The ore occurs in shoots, and there are barren places in the vein, but the wall rock is said to contain considerable gold.

The Treasure group of claims, on Granite Mountain, was relocated in 1912 as the Last Chance 1, 2, and 3. These claims are on Granite Mountain and may be reached by trail from either Karta Bay or Hollis. At an altitude of 2,400 feet an adit has been driven for about 50 feet in a mass of brecciated granite. Masses of quartz occur here, but the vein in place has not been located. Above the adit the vein has been traced for several hundred feet by surface pits and short adits. In some places it pinches to a mere gouge seam, and in others it swells to 3 feet; the average width is about 18 inches. Outcrops of what appears to be the same vein have been traced for 2 miles. The vein strikes N. 45° W. and dips northeast at varying angles. The vein matter is rusty cavernous quartz with considerable free gold. In places pyrite is abundant, and a little chalcopyrite also occurs. The country rock is granite. It is planned to treat the ore temporarily in an arrastre, which in September, 1915, was in course of construction. Other veins carrying galena, chalcopyrite, and pyrite and containing both silver and gold have been opened, and considerable ore has been extracted from them, but at present they are not being worked.

An arrastre has also been built on the Snowdrift claim, about 2 miles west of the Crackerjack, at an altitude of 1,650 feet. On this claim a 2-foot stringer vein is being prospected by a short adit driven along the vein. The vein strikes N. 60° E. and dips steeply southeast. The arrastre was constructed to test the ore on this and the Cascade claim, but no gold has yet been produced.

The Valparaiso mine is on Paul Lake, in the vicinity of Dolomi. For the last three years it has made little or no production, but development of power and the mine plant has been carried on actively. The main shaft is 330 feet deep, and drifts on the first, second, and third levels aggregate over 1,600 feet. A drainage adit was recently driven from the shore of the lake to the intersection of the vein on the second level, a distance of 400 feet.

In the vicinity of the Valparaiso mine assessment work is being kept up on the Jumbo, Wellfleet, and Amazon claims. Recent locations are the Standby and Cook claims. The Standby claim, about 1,000 feet north of the cabins of the Golden Fleece mine at the head of James Lake, is being developed on a 3½-foot lode composed of stringers of quartz in silicified limestone. Pyrite is abundant, and in places free gold occurs in lenticular quartz stringers.

The Chicago Kid claim is south of the Golden Fleece, on the shore of James Lake. A shallow opening has been made on a 5-foot vein composed of brecciated limestone cemented with veinlets and masses of quartz carrying pyrite and tetrahedrite. It strikes N. 60° E. and dips 70° SE. At the foot of James Lake are the Fortune, Moonshine, and other claims, located on another breccia lode or vein that strikes N. 60° W. and dips northeast. The country rock is banded blue limestone and schist, and the lode is composed of blocks of limestone and schist with a network of quartz veins carrying disseminated chalcopyrite and pyrite. The developments consist of a number of openings from 50 to 100 feet in length, extending across the lode. The New Era claim, on the southwest shore of James Lake, is on a 30-foot quartz vein carrying disseminated pyrite. An adit extends across the vein, which strikes N. 30° W. and stands about vertical.

Assessment work was continued on Cholmondeley Sound at a number of places, but no gold was produced. Four claims, the Portland, Seattle 1, Seattle 2, and Minnetonka, lie along a mineralized zone extending from Mineral Lake to Dora Lake. The main workings are on the Seattle 1, where a crosscut adit has been driven 200 feet to the vein, which was followed by a 70-foot drift and a 25-foot raise. Open cuts and surface trenches expose the vein at a number of places. It strikes generally about north and dips east. The country rock is limestone and schist, and the lode is a fissure vein of banded quartz with considerable galena, sphalerite, chalcopyrite, and pyrite carrying gold and silver. The lode varies in width from place to place. The narrowest part noted is in an open cut on the Portland claim, where it crosses the limestone country rock. Here the vein contains considerable calcite. At some places it widens to 9 feet.

Work was also done on the Hope and Moonshine groups, on the South Arm of Cholmondeley Sound, and on several properties on Kitkun Bay.

MAINLAND AND REVILLAGIGEDO ISLAND.

The Sea Level mine, at the head of Thorne Arm, has not been worked for a number of years, although attempts have been made to reopen it. Last year an option was taken on the property, the tram rebuilt, and the mine partly pumped out, when work was discontinued. The adjoining group of claims, the Majestic, Googoo, and Golden Rule, have been relocated as the Googoo 1, 2, and 3, and some development work has been done on them. The vein, which strikes N. 60° E., has been explored for 2,000 feet by a 35-foot shaft and crosscut and several surface cuts. It is composed of white glassy quartz with large crystals and bunches of pyrite, which in places penetrate the wall rock. Rich pockets of fine gold occur in places. One such pocket recently mined in an open cut was profitably extracted with a long tom.

The Gold Standard mine, on Helm Bay, was worked on a lease, and the lessees made several shipments of ore. Adjoining the Gold Standard property is the South Lakeview claim, on an eastward-trending vein dipping north. The vein is 18 to 24 inches wide and is composed of rusty banded quartz with chalcopyrite and a little pyrite. Gold occurs free and in the chalcopyrite and is mostly confined to a pay streak about 3 inches wide. The vein is bordered on both sides by gouge, and cuts greenstone schist striking N. 40° W. and dipping steeply northeast.

Several low-grade ore bodies are being exploited in this vicinity. On the Bay View and West Bay View claims a number of open cuts have disclosed a mineralized zone, which in places is 150 feet across. Its general strike is north, but at the north end of its exposures it swings toward the northwest. It is composed of greenstone schist and more siliceous schist filled with bodies of quartz ranging from mere stringers to some 18 inches thick. The greenstone and schist bordering the quartz contain considerable pyrite, although the quartz itself does not appear to be strongly metalized. Other large low-grade bodies are being opened near by.

Gold lodes associated with deposits of copper and silver occurring in the Salmon River region are described under the head of "Copper mines and prospects" (pp. 96–98).

GRAVINA ISLAND.

The Goldstream mine, on Gravina Island, was unwatered late in the fall of 1915 with the intention of resuming operations, but no productive mining was in progress on Gravina Island. Lodes containing both gold and copper occurring on this island are described below, under "Copper mines and prospects."

COPPER MINES AND PROSPECTS.

GENERAL CONDITIONS.

Kasaan Peninsula and the region adjoining Kasaan Bay were again the center of copper mining in southeastern Alaska in 1915. The Granby Consolidated Mining, Smelting & Power Co. (Ltd.) took over the Mamie and It mines and for a portion of the year produced over 260 tons of ore a day. The Rush & Brown mine was operated throughout the year about as usual. Development work was continued at the Mount Andrew mine, and ore was produced. The Jumbo mine on Hetta Inlet was operated on about the usual scale, and shipments of ore were made also from the Goodro and Cymru properties. The general distribution of copper-bearing lodes is shown on Plate III (in pocket).

PRODUCTION.

Copper, gold, and silver produced from copper mines of southeastern Alaska, 1915.

Ore mined	tons	50, 406
Copper:		
Quantity	pounds	1, 728, 182
Value		[1] $302, 431
Gold:		
Quantity	fine ounces	1, 321. 90
Value		$27, 326
Silver:		
Quantity	fine ounces	10, 938
Value		[1] $5, 545

The copper production was an enormous increase over that of the preceding year, in natural response to the intensified demand and high price. Only two copper mines were operating in 1914, and therefore the production for that year is not published, as it might reveal the output of the individual mines.

[1] Computations based on average price of copper ($0.175) and silver ($0.507) for 1915.

KETCHIKAN MINING DISTRICT.

PRINCE OF WALES ISLAND.

KASAAN BAY AND VICINITY.

The Granby Co. is operating the Mamie and It mines, on Kasaan Peninsula. At the Mamie work preparatory to actual mining was started in December, 1913, and continued for several months. The summer of 1914 was spent in development work, rebuilding the aerial tram, and putting the mine plant into condition for production. On account of the low price of copper the mine was shut down from September, 1914, to the following April, when operations were resumed; the output then averaged 200 tons of ore a day. The aerial tram, which originally extended to the smelter only, now extends to the dock in Hadley Harbor, where the ore is loaded direct into barges and transferred to the company's smelting plant at Anyox, British Columbia.

A new hoist was put in at the shaft, and ore from the main adit level and two lower levels has been mined. The main ore bodies at the Mamie mine are associated with deposits of magnetite, garnet, epidote, and other contact minerals formed along the border of a large mass of dioritic rock intrusive into limestone and altered sediments. Stoping of ore was confined chiefly to large low-grade lenses of copper-bearing magnetite which had been exposed by the old Brown-Alaska Co. but which at that time was of too low grade to extract at a profit. This magnetite has served the purpose of a flux at the Anyox smelter. At the time of visit (September, 1915) about 1,000 feet of development work had been done and 30,000 tons of ore shipped since the Granby Co. took over the property. On the 125-foot level ore has been encountered in a porphyry dike, and a drift on it for 150 feet showed an average width of 8 feet and a copper content of 4 per cent. This ore has served the purpose of raising to commercial grade the low-grade magnetite which it invades.

A contour map with 10-foot contour interval has been constructed on a scale of 50 feet to the inch, and the surface geology has been mapped in considerable detail. A survey has also been made and stakes placed at intervals of 25 feet, preliminary to a magnetic survey of the area adjoining the proved ore bodies in the contact zone. Diamond drilling will be done in the spring. Fifty men are employed at the mine.

The Granby Co. also operates the It mine and adjoining properties. The old workings consisted of a vertical shaft sunk 150 feet to the ore body, a number of vertical workings, and a 1,500-foot adit reaching a vertical depth of 280 feet below the bottom of the shaft, or 530 feet below the surface. The first work of the Granby Co. was to drive an inclined raise from this adit to the bottom of the old shaft.

Considerable ore left around the borders of the old stopes was extracted by starting at the bottoms of the stopes and filling them as they came up on walls of ore. Ore was also discovered in the shaft between the 100-foot and 150-foot levels. In the meantime active prospecting has been carried on along the contacts of quartz diorite dikes and limestone. Work was carried on simultaneously at the Dean claim of the It group, which was purchased outright by the Granby Co. Besides copper, the ore carries notable amounts of gold.

An 8-horsepower gasoline motor is used to haul the ore from the mine to the beach, a distance of three-quarters of a mile, over a surface tramway. Despite the grade on the tram it is considered a success, as high as 150 tons to the shift being hauled to the beach. Ore is shipped to the smelter at Anyox, British Columbia. About 40 men are employed at the mine.

The Goodro mine is near the head of Karta Bay, about half a mile north of the "Salt Chuck." It is entered by an adit 200 feet long, which cuts the ore body 150 feet from the portal. At this point a winze has been sunk for 100 feet, from the bottom of which drifts have been opened along the ore body in both directions. A shaft from the surface opens into a chamber from which a winze also extends down to the adit. From this stope ore was extracted in 1915. The ore trends northeast. It is composed essentially of bornite, with lesser amounts of other copper sulphides, and the country rock is gabbro. Ore from the mine is trammed by hand 300 feet to the ore bins, where the shipping ore is sorted out and trammed to the wharf, to be loaded on barges.

The Leibrant claims are a quarter of a mile west of the Goodro mine. An adit, which at the time of visit was inaccessible, is said to be 100 feet in length, with an 18-foot shaft. It is driven along a vertical fault striking N. 36° E. At the mouth of the adit the country rock is gabbro mineralized with chlorite and epidote. Specimens of similar rock taken from the dump contain considerable quartz with particles of disseminated bornite and chalcopyrite. Other surface openings are close by.

The Mount Andrew mine made several shipments of ore, although the activities of the operators were directed more to the development of the mine than to the production of ore. Prospecting has continued on the Jim, Rico, and Peacock claims, which have been connected with the main workings by an aerial tram. The present developments consist of about 4,000 feet of underground workings and a number of large glory holes and other surface openings. The ore bodies are composed of magnetite-chalcopyrite rock. Besides the ore rich enough in copper to be mined for that metal, there are large bodies of low-grade material that would become valuable for their iron content if facilities were available for magnetic separation.

The Poorman group of claims is on the southwest shore of Kasaan Peninsula, 2 miles northwest of Kasaan, with which it is connected by a trail near the beach. A surface tram 2,500 feet in length connects the workings with the cabins at tidewater. The tram is now in poor repair, but a good trail leads to the workings. The ore bodies, which consist of magnetite with a small copper content, are of interest as possible iron ores. The claims have been prospected by several short adits and open trenches driven in a northeasterly direction. Near the blacksmith shop at the end of the tram is an adit 80 feet long in which a body of magnetite is cut 40 feet from the portal and continues to the face. A few feet to the south a 90-foot adit crosscuts what is apparently the same body of magnetite. At the face a shaft extends 30 feet to the surface and 60 feet below the level of the adit. Another adit 50 feet long is all in magnetite. South of these workings two open trenches, 150 and 60 feet in length, are both entirely in magnetite ore. South of the trenches is a large outcrop of magnetite, and northeast of the shaft for a distance of 500 feet are numerous outcrops and surface pits, indicating a considerable width to the magnetite ore zone. North of the Poorman property are the Kansas and Blackbird claims of the Coleman group.

The Rush & Brown mine has proved the most persistent copper producer in southeastern Alaska. It is on two lodes, known as the magnetite and sulphide ore bodies, which have been worked to the 250-foot level. The magnetite ore body is a contact deposit occurring along the border of intrusive diorite and altered sediments. It has been developed by a glory hole 100 feet deep and by workings on the underground levels. Surface exposures of ore northeast and east of the developed lode indicate either a greater length and width of the ore body than was at first expected or large ore bodies near by that have not yet been explored by the mine workings. These surface exposures are revealed by shallow pits opened through the overburden. Magnetite-chalcopyrite ore occurs in a small pit north of the east end of the glory hole, and similar ore is found in the excavations of the ore bins about 25 feet to the west. (See fig. 2.) Magnetite ore occurs also in a recently opened pit 75 feet east of the glory hole, about in line with the other pits. The size of the body is not evident, as ore occurs across the entire width of the pit, about 11 feet. It is mainly magnetite-chalcopyrite ore, with a little native copper and seams of copper carbonate.

The relation of these outcrops of copper-bearing rock to one another or to the known ore bodies is not evident, but their position indicates either an extension of the old ore bodies or new lodes of considerable size. In either case the probability of an increased area of productive ground is strong. The glory hole and surface pits show ore more or less continuous for nearly 200 feet, and the presence of bodies of

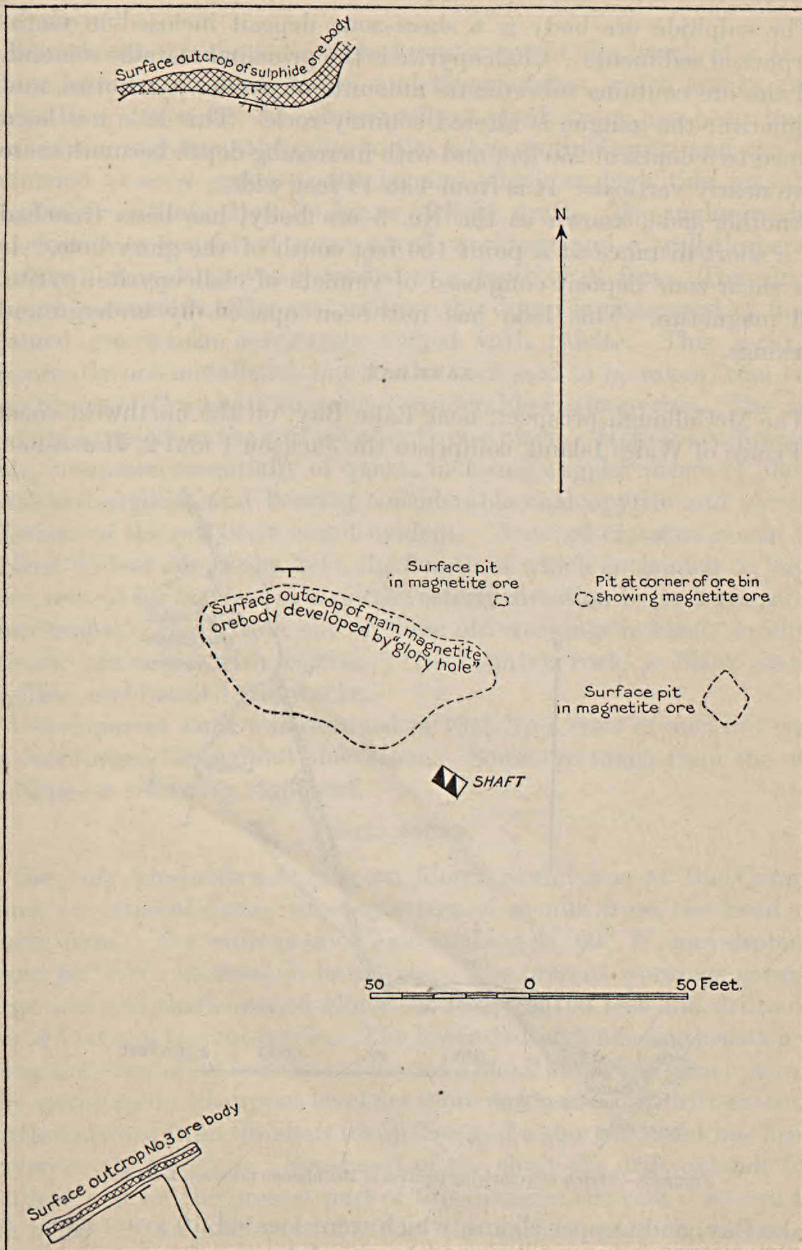


FIGURE 2.—Sketch of surface outcrops of ore bodies, Rush & Brown mine. (From Surveys by U. Rush.)

magnetite southeast of the known lodes has been shown by magnetic surveys.

The sulphide ore body is a shear-zone deposit inclosed in metamorphosed sediments. Chalcopyrite is the principal metallic mineral, and the ore contains subordinate amounts of pyrite, pyrrhotite, and magnetite; the gangue is altered country rock. This lode has been opened to a depth of 250 feet and with increasing depth becomes more more nearly vertical. It is from 4 to 14 feet wide.

Another lode, known as the No. 3 ore body, has been trenched for a short distance at a point 150 feet south of the glory hole. It is a shear-zone deposit composed of veinlets of chalcopyrite, pyrite, and magnetite. This lode has not been opened by underground workings.

LAKE BAY.

The McCullough prospect, near Lake Bay, on the northwest coast of Prince of Wales Island, comprises the Jackson 1 and 2, Horseshoe,

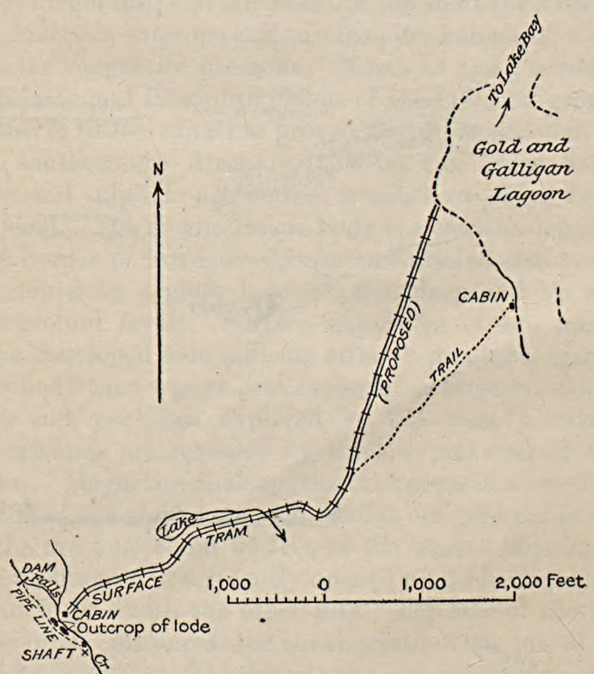


FIGURE 3.—Sketch map showing location of McCullough prospect, Lake Bay.

Lake Bay, and Copper claims, which were located 10 years ago. At that time some prospecting was done and 4 tons of ore was shipped for treatment, the results of which were satisfactory enough to encourage further development. A substantial building houses the hoist, sawmill, and blacksmith shop. The power house is equipped with an 8-foot Pelton wheel, which develops electric power for the hoist and sawmill.

The claims are about 6,000 feet southwest of the beach of a salt-water lagoon connecting Sweet and Barnes lakes, which empty into Lake Bay. (See fig. 3.) An excellent plank tram has been built part of the way from the mine to the cabin on the lagoon and can be extended at easy grade to the lagoon, which at high tide may be reached from Lake Bay by boats of light draft. The underground developments consist of some caved workings and a well-timbered shaft, which in 1915 was extended to a depth of 61 feet. This shaft was not accessible. The material on the dump is composed of fine-grained graywacke, intricately veined with calcite. This rock is apparently not metallized, but similar rock said to be taken from the lower part of this shaft contains considerable chalcopyrite. The ore body is exposed on the surface at only one place. Here it is a breccia lode, composed essentially of quartz inclosing angular pieces of black slate and argillite and bearing considerable chalcopyrite and pyrite. The size of the ore body is not evident. A caved crosscut is said to extend 35 feet across the lode, the length of which is claimed to have been proved for 300 feet in a northwesterly direction by test pits, now inaccessible. Rock from one of these old workings is black argillite breccia cemented with calcite. The country rock is black slate, argillite, and banded graywacke.

Development work was resumed in 1915 by a crew of men but was not continued throughout the season. Some ore taken from the old workings is ready for shipment.

MOIRA SOUND.

The only productive mining on Moira Sound was at the Cymru mine, on Mineral Lake, three-quarters of a mile from the head of North Arm. The mine is on a lode striking N. 60° W. and dipping about 60° SW., inclosed in limestone. The present workings consist of an inclined shaft opened along the lode for 100 feet and drifts on the 30-foot and 90-foot levels. The lower drift extends southeastward along the vein for 96 feet, and at its end a small stope has been opened. The workings on the upper level are more extensive. A drift extends northwestward from the shaft for 30 feet, and a short crosscut has been driven to cut the vein. Southeast of the shaft the drift extends for 400 feet, and for the greater part of this distance the vein is stoped to the surface. An adit extends from the surface near the shore of Mineral Lake to this level, which it reaches about 60 feet from the shaft. The ore is hoisted through the shaft and trammed to the ore bunkers on tidewater, a distance of about three-quarters of a mile. After lying idle for some time this mine was worked on a lease during the summer of 1915, and some shipments of ore were made. The mine is equipped with good mine buildings and a substantial wharf and bunkers on tidewater, which are connected with the mine by a tramway.

No mining was done in 1915 at the Niblack mine, but investigations relative to the development of water power were made. Assessment work was continued on the Wakefield group and other claims near by. Workings on the Westcott claim have exposed a body of low-grade ore 120 feet across, inclosed in quartz-sericite schist. The lode is essentially pyrite, with a little chalcopyrite inclosed in a siliceous gangue.

On McLean Arm, 20 miles south of Moira Sound, development work has been in progress for a number of years.

HETTA INLET AND CORDOVA BAY.

The Jumbo mine, which is on Copper Mountain, near the head of Hetta Inlet, was the only productive mine in this vicinity in 1915. The mine is connected by an aerial tram with the company's wharf and ore bunkers at tidewater. The ore bodies are contact deposits containing chalcopyrite-pyrrhotite ore of irregular size and shape, with a footwall of diorite and hanging wall of crystalline limestone, silicified schist, or banded quartzite.[1]

Operations proceeded about as usual in 1915. Shipments of ore were started early in the summer and were maintained throughout the remainder of the year. The present developments consist of 10,000 feet of underground workings. Recent work has proved the large ore bodies to be more extensive than was at first expected.

A prospect near the head of Keete Inlet has been developed recently on a copper-bearing lode striking N. 20° W. and dipping 60° NE. The lode is being opened by an incline, which below the 10-foot level was covered with water and inaccessible at the time of visit. The ore is a shear-zone deposit containing disseminated particles and lenses of chalcopyrite and pyrite in siliceous beds occurring in greenstone schist. On the dump were samples of quartz veins carrying bornite and chalcopyrite, but similar rock was not seen in place. The property is a short distance from tidewater and is equipped with a blacksmith shop and cabins built on a small cove.

The Marion and Ella claims are on the northwest shore of Nutkwa Lagoon, three-quarters of a mile from the head. Nutkwa Lagoon is a body of water 3½ miles long separated from the head of Nutkwa Inlet by a "skookum chuck," which is navigable only at slack tide and then only with a boat of shallow draft. The claim is being developed on a vein trending N. 25° W. and dipping from 85° SW. to nearly

[1] Wright, C. W., Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska: U. S. Geol. Survey Prof. Paper 87, p. 60, 1915.

vertical. It has been followed for 400 feet by an adit, from which a winze has been sunk for 50 feet at a point about 200 feet from the mouth. The ore body is a quartz vein about 6 feet in width, carrying chalcopyrite and a little galena. At the mouth of the adit a schist horse fills about half of the vein, but a short distance from the portal the vein material fills the fissure. An aerial tram leads from the workings to the beach of the lake, a distance of about 200 yards. On the beach are cabins and a blacksmith shop.

The Goodhope claim is half a mile by trail from the head of Hunters Bay, on the west coast of Prince of Wales Island. The ore is magnetite and chalcopyrite, occurring in irregular bunches in greenstone near the contact of granitic rocks. The development work consists of an adit driven for 40 feet northwestward, cutting a lens of ore. A trail connects the workings and blacksmith shop with the beach, half a mile away.

Work on the property of the Alaska Consolidated Mining & Smelting Co. at Coppermount has been suspended temporarily, but application is being made for patent on five claims, and plans for future mine development are being worked out by the engineer in charge.

WEST COAST.

The Big Harbor mine is on the west coast of Prince of Wales Island, on Trocadero Bay, locally known as Big Harbor, though this name is used more specifically for the inner part of the bay. The claims were staked in 1907 by M. Zimmerman and later acquired by the Northland Development Co., the present owners. The company was organized in March, 1908, under the management of A. B. Hill, C. D. Calhoun, and P. A. Tucker. Since that time considerable development work has been done. The mine has not been a steady producer, but small shipments were made in 1912 and 1913. Work was again started in 1915, but no shipments were made. The property consists of 11 claims located along the ore body half a mile from the beach and two mill-site claims at tidewater. The underground developments consist of workings on 3 claims, aggregating 650 feet of adits, crosscuts, and shaft. Cabins have been erected on the beach and at the workings. An aerial tram connects the wharf site with the main workings at a distance of 2,400 feet. The beach claims occupy a sheltered harbor offering no difficulties to wharf construction or the approach of seagoing vessels.

The ore bodies form the hanging wall of a mineralized zone of greenstone several hundred feet wide, within which are shear zones carrying lenses of chalcopyrite ore and stringer lodes. The mineralization was accompanied by intense silification of the country rock, which has affected in greater or less degree the entire zone. This zone strikes N. 60° E. and dips 60° NW., about parallel to the individual lodes contained within it. The country rock termed greenstone is composed of altered igneous rocks, which beyond the footwall of the lode pass downward into deformed arenaceous and calcareous sediments. On the hanging-wall side the wall rock is greenstone schist, composed essentially of albite with a little sericite, chlorite, calcite, and magnetite. It is evidently an altered lava flow.

On the Northland No. 1 claim an adit has been driven 120 feet to the hanging wall of the lode, drifts extended to the northeast and southwest, and a number of crosscuts driven. An inclined shaft 52 feet long connects this drift with the surface. (See fig. 4.) The relations revealed by these workings and surface outcrops will be briefly set forth. Separated from a well-defined hanging wall by about 4 feet of quartz-sericite rock is a copper-bearing lode composed of schistose greenstone in which occurs lenses of chalcopyrite in a greenstone gangue accompanied by blebs of quartz and a little calcite. One such ore shoot from 2 to 6 feet wide has been stoped out for 40 feet. Another one 4½ feet wide was cut in the adit, and its possible extension was opened in a crosscut at the end of the northeast drift. Southeast of the greenstone is a stringer lode of quartz and silicified greenstone 120 feet in width, and beyond this for a distance of 700 feet across the strike occur a series of stringer lodes which, with the intervening silicified greenstone, form the mineralized zone. These stringer lodes contain disseminated pyrite and chalcopyrite with some gold. The hanging wall is marked by the zone of copper ore. The footwall is not so well defined and is marked only by a decrease in the number of quartz stringers and degree of silicification.

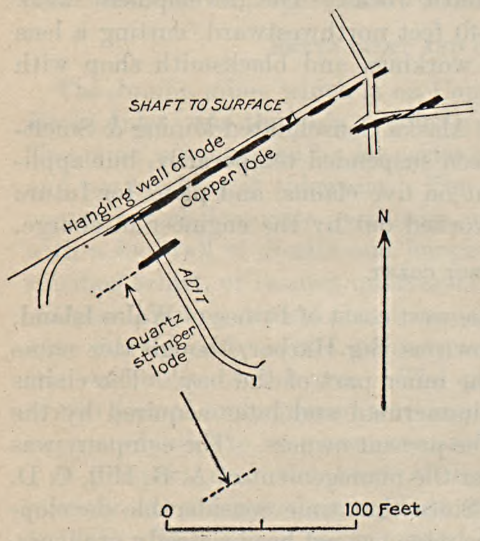


FIGURE 4.—Plan of workings on Northland No. 1 claim, Big Harbor mine.

Other developments consist of workings on Northland Nos. 2 and 3 claims. A shaft on the end line between the two claims has been driven for 117 feet and crosscuts extended at 30 and 80 feet below the adit, which cuts the shaft 17 feet from the surface. This adit for its entire distance is in rock similar to the disseminated sulphide ore exposed in the adit of the main workings. The lower part of the shaft was not accessible at the time of visit. Chalcopyrite ore on the dump was said to have come from the shaft.

The mine at present is being exploited solely for the copper content of the ore. It is suggested, however, that the stringer lodes should be thoroughly prospected for gold-bearing portions.

The Nancy claim is about 2 miles up the creek that enters the head of Trocadero Bay. The country rock is greenstone with interbedded argillite and conglomerates. Shallow surface workings along the stream show a shear zone about 25 feet wide composed of silicified greenstone impregnated with pyrite and chalcopyrite. Within this shear zone are more definite ore lodes separated by horses and barren places. Near the center of the shear zone is a vein of pyrite about 18 inches thick bordered on both sides by seams of gouge and inclosed in greenstone with disseminated pyrite and chalcopyrite. Within the shear zone are other masses of silicified greenstone in which lie stringers of quartz carrying pyrite and chalcopyrite. One such lode, apparently in place, is a foot in thickness. Other brecciated masses are too much faulted and crushed to show their relations. About 100 yards up the creek this lode is again exposed for a distance of 150 feet. At this place it is a quartzose lode with much pyrite and chalcopyrite, averaging about 6 feet in thickness. The lode strikes N. 70° E. and dips 45° NW.

DALL ISLAND.

Considerable prospecting has been done in a mineralized zone said to extend from Sea Otter Harbor, on the west coast of Dall Island, to the head of Coco Harbor, on the east coast. On the ridge south of Sea Otter Harbor two adjacent groups of claims in limestone are being developed. Prospecting has also been done on Coco Harbor.

GRAVINA ISLAND.

Prospecting and development work has been continued by Sanford & Lhote on a group of claims on a mineralized zone extending from Dall Bay to Seal Cove, on the south end of Gravina Island. The Sanford claim, a short distance from Dall Bay, is being developed by a shaft opened on a shear zone in green chlorite schist. On the Algonquin 2 claim a shear zone in schistose greenstone is being prospected by several open cuts. The lode is essentially quartz carrying chalcopyrite. It is about 50 feet wide where exposed and strikes N. 30° E. Another vein that crosses the main lode at a sharp angle occupies a fracture zone and is composed of banded quartz and specular iron. The north end of this group of claims lies in an area of granitic rocks, light-colored intrusives composed essentially of quartz and feldspar and in places porphyritic. Here the lode averages about 50 feet in width. It has been traced for 1,500 feet by open cuts. The gaugue is quartz with stringers of specularite and carries chalcopyrite and a little bornite. Smaller parallel veins 8 to 10 feet in width border the main lode in places.

Adjoining the patented claims of the Victory Copper Mining Co. on Seal Cove are the Tiernan and Lhote groups of claims, comprising the Anthony, Lizzie L., and Deer Lodge 1, 2, and 3. These claims have been held for a number of years without active development but are now being prospected by surface trenching with a view of developing several large bodies of low-grade ore recently uncovered. Four or five almost parallel and nearly vertical main lodes strike about N. 20° W. Where exposed by surface trenches they range in thickness from 30 to 75 feet and have an aggregate thickness of over 200 feet. The quartz lodes are inclosed in greenstone and carry disseminated pyrite, chalcopyrite, and specular hematite. Besides the copper content the ore is said to carry gold.

Assessment work was also continued on a group of claims on the west coast of Gravina Island, on the cove directly across the island from the head of Dall Bay.

MAINLAND.

SALMON RIVER DISTRICT

General features.

No extensive copper mining is done on the mainland of the Ketchikan district, and little prospecting has been carried on except in the Salmon River basin, where a number of claims have been located and a small production has been made by the selective mining of high-grade deposits.

The term Salmon River district is here used for the Alaskan part of the Salmon River basin. It joins the Salmon River mining district of British Columbia. Salmon River is a large stream entering Portland Canal 2 miles from its head on the American side. The main part of the stream lies within Alaskan territory but is joined near the international line by tributaries from British Columbia. (See fig. 5.)

The ore deposits of the Salmon River district and the adjoining Bear River district on the Canadian side were discovered in 1898, during the rush to Dawson. The position of the international boundary was for a time in doubt and many of the locations then made in what was supposed to be Alaska proved later to be in British Columbia. With the opening of the property of the Portland Canal Mining Co. in the Bear River district in 1907, Portland City was laid out on the tide flat at the mouth of Salmon River, during a short-lived boom which retarded the development of the region.

The best-developed mineralized area of the Salmon River basin lies in British Columbia, but this area is accessible through Alaskan territory, and the recent construction by the Dominion Government of a trail to the upper part of the district has stimulated interest and made more accessible the entire region, including the Alaskan district, where a number of promising claims have been located.

The principal source of Salmon River is Salmon Glacier, a large ice stream crossed by the international boundary near its foot. Its principal tributaries are Texas Creek, issuing from Texas Glacier on the Alaskan side, and Cascade Creek, which lies almost entirely in British Columbia and flows into Salmon River near the boundary. Fish Creek, another tributary, enters Salmon River 5 miles above its mouth. Salmon River occupies a flat-bottomed glaciated valley between high mountains that rise to altitudes of 5,000 feet and show precipitous cliffs and rugged topography.

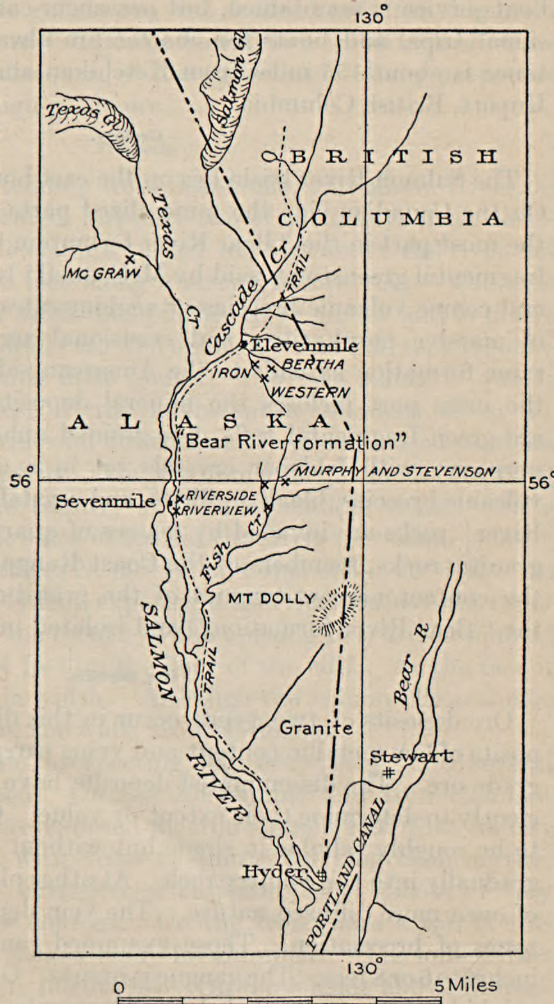


FIGURE 5.—Sketch map showing location of claims on Salmon River and geologic relations.

Up to altitudes of 3,000 feet the hills are timbered with hemlock and spruce of good grade, in quantity adequate for all mining and building needs. Hemlock is the more abundant. The possibilities for developing water power, though not examined in detail, are regarded as sufficient for the needs of the district.

An option on the Big Missouri group of claims and other properties on the Canadian side has been taken recently by the Alaska-Gastineau Mining Co. The erection of the contemplated reduction plant for the development of these large deposits and the provision of railroad facilities between tidewater and the international line would further stimulate prospecting on the American side. The name of Portland City has recently been changed to Hyder, and a post office has been ordered established. The Salmon River district may be reached by boat to Hyder and thence by trail. At present no regular boat service is maintained, but passenger-carrying boats make occasional trips, and boats for charter are always available. The distance is about 155 miles from Ketchikan and 135 miles from Prince Rupert, British Columbia.

Geology.

The Salmon River basin lies on the east border of the Coast Range. On the Canadian side the mineralized parts of the district occur for the most part in the "Bear River formation," a series of massive and fragmental greenstones said by McConnell [1] to include "fine, medium, and coarse volcanic breccias or agglomerates, tuffs, bands, and areas of massive porphyrites, and occasional argillaceous bands." This same formation extends to the American side of the district and for the most part incloses the mineral deposits. Prominent members are green fragmental tuffs, fine-grained aphanitic flows, and diorite porphyry with feldspar crystals set in a dense dark groundmass, volcanic breccias, black argillites, and crystalline schists. The "Bear River" rocks are invaded by masses of quartz diorite and associated granitic rocks, members of the Coast Range intrusive series. Along the contact narrow tongues of the granitic rocks have penetrated the "Bear River formation," and isolated masses occur within it.

Ore deposits.

Ore deposits of two types occur in this district—disseminated deposits of low metallic content and veins carrying shoots of very high-grade ore. The disseminated deposits have not been exploited sufficiently to determine their extent or value. One such deposit appears to be roughly tabular in shape but without definite outline, merging gradually into the country rock. At other places the mineralization is of even more diffused nature. The vein deposits occupy fissures and zones of brecciation. Those examined range in width from a few inches to 6 or 8 feet. The gangue is quartz. Galena, the most abundant sulphide, is accompanied by chalcopyrite, tetrahedrite, sphalerite, pyrite, and pyrrhotite. The occurrence of rich seams of sulphide ore penetrating the quartz gangue, a common feature of the vein deposits, is evidence of more than one period of mineralization. An older system of quartz veins containing chalcopyrite and pyrite is believed to be connected genetically with the Coast Range intrusive rocks. The

[1] McConnell, R. G., The Salmon River district: Canada Geol. Survey, Dept. Mines, Mem. 32, pp. 63, 64, 1913.

sulphide enrichment is regarded as belonging to a later period of mineralization in which some of the quartz veins were reopened and enriched by sulphides of lead, antimony, and copper, in part gold and silver bearing.

The production of this district has so far been slight. At one prospect a ton of high-grade galena ore was sacked ready for shipment. At another property a small shipment is reported. The lack of transportation facilities has discouraged the exploitation of any properties except those carrying high-grade ore.

Prospects.

A group of claims extending from Sevenmile, on Salmon River, to Fish Creek, has been located, but only two of them have been developed. On the Riverside claim a tunnel 100 feet above the river flat has been driven for 140 feet along a strong fissure vein. The vein averages about 4 feet in width but pinches to 18 inches and in places widens to 6 feet. Both walls are well defined. The wall rock is somewhat altered but contains little gouge. The vein filling is quartz with abundant sulphides. Pyrite is the most abundant along the hanging wall and occurs in solid bunches and in disseminated particles associated with chalcopyrite. On the footwall galena is the most plentiful sulphide. The country rock is crystalline schist. On a parallel lode of much the same character the Riverview claim is being developed. The vein strikes N. 60° W. and dips about 60° NE. An adit has been driven for 17 feet, exposing a vein that varies from 1 foot to 4 feet in width. At the mouth of the opening it is 2 feet wide on the roof and widens to 4 feet on the floor of the adit. At the face it is from 12 to 18 inches in width. Although the vein swells and narrows from place to place, the walls are well defined.

At Elevenmile a little prospecting has been done, and several claims have been located. On the Elevenmile and Iron claims a number of open pits have exposed an iron-stained lode that follows a brecciated zone filled with veins of quartz carrying chalcopyrite, sphalerite, and galena. Stringers of sulphides form shoots of very rich ore with high silver content. On the Iron claim a ton of this high-grade ore has been sacked ready for shipment. The lode strikes northeast and dips steeply northwest. On the hillside above Elevenmile, at an altitude of 1,500 feet, the Bertha and Western claims are being developed on a northeastward-trending lode. One surface cut shows the lode to be at least 15 feet in width. It consists of silicified schistose green tuff of the "Bear River formation," with disseminated pyrite, chalcopyrite, galena, and sphalerite. A number of claims have been staked on a zone of disseminated deposits exposed along Salmon River at Eightmile and Ninemile but only a little work has been done.

Some promising fissure lodes have been located by Murphy & Stevenson on Fish Creek and its tributary Skookum Creek, where more than the necessary amount of assessment work has been done. Near the mouth of Skookum Creek an adit was driven for 25 feet along a fissure that had been traced by surface trenches for 2,000 feet. The vein is 4½ feet wide, strikes N. 40° E., and dips about 55° SE. The quartz gangue carries galena, chalcopyrite, tetrahedrite, sphalerite, and pyrite in veinlets and irregular patches. It is being exploited mainly for its gold and silver content.

Near the head of Skookum Creek, at an altitude of 1,600 feet, a fissure vein has been opened by an adit 320 feet in length and several crosscuts and inclines. The gangue is quartz. Metallic sulphides present are tetrahedrite, chalcopyrite, galena, sphalerite, and pyrite in blebs and veinlets penetrating the quartz, and the richest ore occurs in veinlets of tetrahedrite and galena. The country rock is porphyry and schistose tuff of the "Bear River formation." The lode strikes N. 55° W. and dips 45° SW. At the portal it is about 18 inches wide. At 70 feet from the portal only a part of the vein is exposed, as the ore has been removed to a wall within the vein. At this place the vein is 3 feet wide plus an unknown width in the wall of the adit. At various places portions of the vein said to be very rich have been stoped out. At 300 feet from the adit mouth the lode is abruptly cut by a vertical fault trending nearly perpendicular to the lode and short drifts along the fault plane in both directions had not shown the position of the faulted lode. Samples of ore said to come from a near-by prospect, which was not visited, contain particles of free gold in a siliceous gangue.

Several claims have been staked on Texas Creek. The ore bodies are reported to be quartz veins carrying seams of tetrahedrite penetrating granite and pegmatite. Little work has been done in this locality.

MISCELLANEOUS OPERATIONS.

No metals other than those won from the mines operated for their gold and copper content were produced in southeastern Alaska in 1915, but promise of future output is given by a number of prospects, including some on lodes carrying silver, lead, zinc, antimony, and molybdenum. A notable amount of lead produced at the Perseverance and Alaska-Juneau mines is obtained from the galena concentrates. Silver-lead deposits occur at the head of Cholmondeley Sound, on Eastern Passage, on Coronation Islands, and on Whiting River. The Groundhog Basin property lies between the Coast Range and Eastern Passage, in a mineralized belt of slate and schist penetrated by dikes of acidic porphyry and aplitic rock and mineralized by galena, zinc blende. pyrite and chalcopyrite carrying gold and silver in varying amounts.[1] This property changed hands in 1915 and work was started toward its development.

A small output has been made from the silver-lead deposits of the Moonshine and Hope groups, near the head of South Arm of Cholmondeley Sound. No productive mining was in progress in 1915, but some development work was continued. The only workings accessible when examined were surface cuts. The ore bodies exposed consisted of irregular masses of galena, epidote, and garnet, all replacement deposits in limestone and evidently connected with fissure veins. A small production has been also obtained from galena deposits occurring on Coronation Island, on the west coast of Prince of Wales Island, but these workings were idle in 1915.

Claims are reported to have been located recently on the south side of Whiting River 10 miles from its mouth, on silver-bearing galena ore occurring in a quartz vein 6 to 8 feet in width. Samples of the ore said to be taken from this lode are composed esssentially of galena carrying a notable amount of silver.

On Salmon River near the head of Portland Canal a number of claims exploited as copper properties contain rich silver-bearing lodes. On the Elevenmile and Iron claims, at Elevenmile, is an iron-stained lode following a brecciated zone filled with veins of quartz carrying chalcopyrite, zinc blende, and galena. Where the galena predominates this sulphide forms stringers of very rich silver ore. On the Iron claim a ton of this high-grade ore was sacked ready for shipment. Another copper lode in this vicinity is the fissure vein at the head of Skookum Creek, described with the copper deposits. The metallic sulphides present are tetrahedrite, chalcopyrite, galena, zinc blende, and pyrite in blebs and veinlets penetrating the quartz gangue. Among these are silver-bearing veinlets composed essentially of tetrahedrite and galena, rich enough to be mined and the ore sorted for shipment.

The lodes of this region carry more or less zinc blende. Where this mineral occurs in small amounts it is considered a detriment, as it introduces metallurgic difficulties in its treatment. There are now being exploited, however, in the Salmon River district of British Columbia large lodes containing sulphides of zinc, lead, and copper carrying gold and silver, in which zinc is the principal valuable metallic constituent. A large body of ore carrying 14 per cent of zinc and lesser amounts of gold and copper was recently reported to have been discovered on Tracy Arm.

The discovery of molybdenite-bearing lodes in the vicinity of Skagway was recently announced.[2] Blocks of granitic rock contain-

[1] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, 1908.

[2] Alaska and Northwest Min. Jour., vol. 7, p. 98, 1915.

ing molybdenite found in the vicinity of Mile 6 on the White Pass Railway led to the discovery of the lodes in place. The vein, known as the Combination lode, is said to crop out 3,000 feet north of Denver station. It is composed of white quartz and is inclosed in "granite gneiss traversed by diorite dikes." A mile and a half north of this lode is the Combination No. 12 lode, a 50-foot ledge of quartz-feldspar pegmatite impregnated with molybdenite.

The region north of the east fork of Skagway River extending from Mile 6 eastward for 8 miles is said to contain molybdenite-bearing float. Molybdenite lodes are known in British Columbia at Lake Bennett, where several veins have been opened.

NONMETALLIC PRODUCTS.

MARBLE.

The marble quarry of the Vermont Marble Co., at Tokeen, was operated as usual. This company has recently opened a quarry on claims bonded from Woodbridge & Lowery. The new camp, known as Skyrus, is on the west shore of Red Bay, on the north end of Prince of Wales Island.

Interest in the development of marble properties continues, especially in the Ketchikan district. The Alaska Marble Co. did considerable development work on its claims at Calder, also some prospecting on Dry Pass, with satisfactory results.

Marble prospecting has been continued at other places on Dall Island, Long Island, and Revillagigedo Island, and some commercial marble of very good grade has been located. These marble deposits will be described in more detail in a forthcoming bulletin.[1]

Assessment work is being continued by Lhote, Ickis, and others on marble deposits near the head of Waterfall Bay, on the west coast of Dall Island. The property comprises 20 claims, including the Eurus, Marble Heart, St. Augustine, and Marble Bay groups. The claims are on the steep hillside only a short distance from the head of the bay.

The geology of the region is simple. South of the bay the rock is limestone. The dominant color is blue to black, but the marmarized portions are lighter. Schistose greenstone overlies the limestone with apparent conformity; it contains conglomerate beds and occupies the north shore of the bay. The contact extends about N. 75° E. from the cabin at the head of the bay. Both limestone and greenstone beds stand nearly vertical but dip northwest at high angles except where they are overturned. The best marble noted occupies a belt of varying width along the greenstone contact. At one

[1] Burchard, E. F., Marble resources of southeastern Alaska: U. S. Geol. Survey Bull. — (in preparation).

locality the outcrop has a measurable width of 400 feet, besides a considerable thickness of semicrystalline limestone. The marble has been exposed by surface stripping for several hundred feet from the head of the bay. At an altitude of 220 feet the following section is exposed:

Section of marble on Waterfall Bay 300 feet from cabin.

	Feet.
Greenstone.	
Bluish-gray marble (occasional outcrops only)	300 (?)
Blue and white mottled marble	4
Dike	½
Thin-bedded white marble, with black specks and white mica	4
Pink-mottled white marble	13
Blue and white mottled marble, base concealed.	

The finest commercial marble in this section is the 13-foot bed of pink-mottled white marble. The upper and lower parts of the bed are even-textured, medium to fine grained white marble, mottled with a very delicate pink tint and veined with irregular threadlike veinlets of yellow. In the central part of the bed the pink color is more pronounced and the rock contains much white mica, a combination that produces a handsome rock.

A short distance beyond this point, at an altitude of 400 feet, the following section is exposed:

Section of marble on Waterfall Bay 600 feet from cabin.

	Feet.
Schistose greenstone.	
Bluish-gray marble, in part mottled and veined with black	300
Fine-grained white marble with brown veinlets carrying mica and pyrite	26
White marble with green patches and brown veinlets	7
White marble with brown and green veinlets carrying mica and pyrite, fine-grained, with few large crystals of calcite	9
White and pink marble with green areas	11
Fine-grained white marble with pyrite in tiny veinlets and disseminated in particles	16
Quartz schist containing pyrite	1
White marble with pyrite and much chlorite in tiny stringers and veinlets	10
Dike	2
Concealed	15
Blue limestone with beds of white marble and schistose beds, grading downward into fossiliferous limestone.	

The beds of white and pink marble with mottled green areas are very handsome and are susceptible of a high polish except where the green minerals predominate. The greater part of the bed is white and pink marble, composed of nearly pure calcite of very fine grain, the individual minerals averaging about 0.05 millimeter in diameter. The base and top of the bed are variegated with green areas which, combined with the pink-mottled white rock, give a very striking effect. Under the microscope the green areas are seen to be sericite, quartz, and chlorite; the white and pink rock is essentially calcite. The thick mass of bluish-gray marble at the top of the measured sections contains beds of ornamental marble of commercial value. These beds are black and white, mottled in very intricate pattern, and bluish white with black veinlets. This rock takes a smooth polish.

Marble crops out at several places along the south shore of the bay between the cabin and the greenstone contact. Near the cabin an opening has been made on a bed of fine-grained, even-textured white marble carrying flakes of white mica. Another commercial marble on this bay is a fine-grained black variety that takes a good polish. The polished surface shows a black field with white-mottled areas and irregular veinlets of white calcite that give it a pleasing appearance.

Marble deposits occur at a number of places on the east coast of Dall Island. Near the head of View Cove a stream that enters from the southwest flows in a gorge following joint planes in the marble. This stream was traversed from the beach for half a mile, and for that distance the beds strike about northwest, directly across the course of the stream, and stand nearly vertical. Most of the marble seen is pearl to gray in color, mottled and veined with white. At one locality occurs a 4-foot band of yellow marble with a green stripe, and bordering it is white marble, mottled with yellow. The yellow marble takes a good polish and has a warm, soft tone. Associated with these beds is a little bluish-black marble. A polished specimen shows a black field variegated with dark-gray areas and tiny veinlets of white calcite.

Marble was also noted on the northwest side of Coco Harbor, half a mile from the head. Where it crops out along the beach it is evidently faulted against gray limestone. Back from the beach the outcrops are too few to determine its relations accurately. The marble is white to gray. Much of it is very fine grained and pure white, and some parts are coarsely crystalline, with large flashing crystals of calcite. Pyrite is not abundant but was noted in places as veinlets and disseminated particles.

Marble claims are held at a number of other localities on Dall Island, but they were not visited in 1915.

Deposits of marble have recently been located near the northwest end of Long Island, 3 to 4 miles north of Howkan, on two small bays known locally as Waters and Gotsongni bays. At this locality the brush is very thick along the shore and outcrops are few, making prospecting difficult, but the physical conditions favor the exploitation of the deposits. The shore of the island rises abruptly from the beach, the timber is plentiful and of an exceptionally good grade, and the deposits occur on sheltered harbors which afford easy access to boats.

On Waters Bay three claims, the Lily, Long Island, and White Cloud, have been located, and assessment work has been done on them. Most of the marble exposed has a bluish-white field with white-mottled areas and blue-black stripes. Under the microscope the rock is seen to be composed essentially of twinned calcite crystals ranging in size from 0.25 to 0.7 millimeter, inclosed in a network

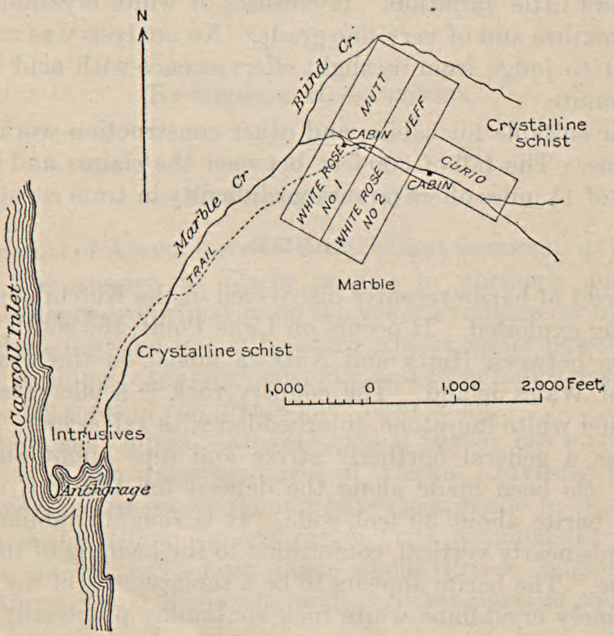


FIGURE 6.—Sketch map of Dickinson & Bell marble claims, on Carroll Inlet.

of finely granular calcite averaging about 0.05 millimeter in diameter and forming with the large calcite crystals an intersertal fabric. The large calcite crystals are bent and fractured. They are evidently crushed fragments around which the fine-grained calcite has recrystallized. The black stripes are composed of opaque particles of carbonaceous material, probably graphite. Associated with the striped marble are beds of medium-grained white marble of even texture and also beds of blue-clouded white marble with yellow patches. This rock takes an excellent polish.

On Gotsongni Bay marble occurs on the east shore three-quarters of a mile from the head. On the beach are outcrops of coarse-grained, even-textured white marble. A short distance back from the beach and separated from the white marble by a brush-concealed area is a large body of bluish-white marble with black stripes. The rock is medium grained and even textured. It takes a good polish and is apparently free from quartz.

A deposit of white marble is being developed near Carroll Inlet by G. E. Dickinson and B. Bell. The claims are located on Marble Creek, a stream entering a cove on Carroll Inlet from the east about 10 miles from its head. From this cove a trail leads to the claims, a distance of about 1½ miles. (See fig. 6.) The rock is exposed by surface cuts at several places and along Marble Creek for half a mile, the width covered by the claim locations. For this distance the rock shows little variation. It consists of white crystalline marble of even texture and of very fine grade. No analysis was made of the rock, but to judge from its slight effervescence with acid it is probably dolomite.

Timber suitable for cabins and other construction work grows on the claims. The fall of 300 feet between the claims and beach in a distance of 1½ miles offers no serious difficulty in tram construction.

BARITE.

A deposit of barite recently discovered in the Ketchikan district is now being exploited. It occurs on Lime Point, the south end of the peninsula between Hetta and Nutkwa inlets, on the west coast of Prince of Wales Island. The country rock is semicrystalline blue-weathering white limestone, interbedded with talc schist. The limestone has a general northerly strike and dips about 80° W. An opening has been made along the deposit for 100 feet, exposing a body of barite about 30 feet wide. It is roughly tabular in shape and stands nearly vertical, conforming to the bedding of the inclosing limestone. The barite appears to be a replacement of the limestone. It is a finely crystalline white rock containing practically no visible impurities. Some of the barite was shipped to San Francisco and tested with satisfactory results.

GYPSUM.

Details regarding the operations of the Pacific Coast Gypsum Co. at Gypsum, Chichagof Island, are lacking, but it is reported that the mine was operated on about the usual scale.

GARNETS.

The mine of the Alaska Garnet Mining & Manufacturing Co. on Stikine River near Wrangell was operated part of the year. The garnets are almandite, the iron-magnesium variety $(Fe, Mg_3)Al_2(SiO_4)_3$. The best stones are used for gems and the waste material for foundry powder. A shop for the sale of gem garnets from the mine is maintained on the wharf at Wrangell.

WATER-POWER INVESTIGATIONS IN SOUTHEASTERN ALASKA.[1]

By George H. Canfield.

INTRODUCTION.

The streams of Alaska have been important factors in its industrial growth. The success of placer mining in northern and central Alaska has depended primarily on the water available for hydraulicking and dredging, and in southeastern Alaska water power has long been used by mines, canneries, sawmills, and other industries, although until recently most of the plants have been small.

Since 1906 the United States Geological Survey has made systematic studies of the water resources of Alaska. Investigations with special reference to placer mining have been made in Seward Peninsula[2] and the Yukon-Tanana region,[3] and reconnaissance surveys for water powers have been made about Prince William Sound, Copper River, Kenai Peninsula, and in other parts of southeastern Alaska.

In the summer of 1914 Leonard Lundgren, central district engineer of the Forest Service, made a reconnaissance of water-power sites in southeastern Alaska to determine the possibility of establishing the pulp industry in the Tongass National Forest, which covers a large part of southeastern Alaska. In connection with this reconnaissance a census of water powers was taken (see following table), which has been revised by Mr. Lundgren to January 1, 1916, and is here published by courtesy of the Forester.

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[1] In cooperation with the United States Forest Service.

[2] Henshaw, F. F., and Parker, G. L., Surface water supply of Seward Peninsula, with a sketch of the geography and geology by P. S. Smith, and a description of methods of placer mining by A. H. Brooks: U. S. Geol. Survey Water-Supply Paper 314, 1913.

[3] Ellsworth, C. E., and Davenport, R. W., Surface water supply of the Yukon-Tanana region, Alaska: U. S. Geol. Survey Water-Supply Paper 342, 1915; A water-power reconnaissance in south-central Alaska, with a section on southeastern Alaska by J. C. Hoyt: U. S. Geol. Survey Water-Supply Paper 372, 1915.

Developed water powers in southeastern Alaska Jan. 1, 1916, in horsepower.

[Prepared by Leonard Lundgren, district engineer, U. S. Forest Service.]

Ketchikan region:			
Citizens Light, Power & Water Co		2,000	
New England Fish Co		2,200	
Miscellaneous plants		1,000	
			5,200
Wrangell region			0
Sitka region:			
Sitka Wharf & Power Co		350	
Chichagof Mining Co		500	
Miscellaneous plants		150	
			1,000
Juneau region:			
Alaska-Treadwell Mining Co.:			
Douglas Island plant	4,000		
Sheep Creek plant	4,100		
Nugget Creek plant	5,700		
		13,800	
Alaska-Gastineau Mining Co.:			
Salmon Creek plant, No. 1	4,000		
Salmon Creek plant, No. 2	4,000		
Annex Creek plant	5,000		
		13,000	
Alaska Electric Light & Power Co		1,000	
Miscellaneous plants		1,000	
			28,800
Skagway region			100
			35,100

During the last few years some large water-power plants have been installed near Juneau to supply power for mining, and attention has been called to the feasibility of improving other power sites in that region and elsewhere in southeastern Alaska, to meet the increasing demand for power to be used in mining, lumbering, and fisheries, and the possible future demand for its use in the manufacture of wood pulp and electrochemical products. The streams on which it is possible to develop power and the bays or other water bodies into which these streams discharge are listed in the following table and shown on the map (Pl. IV):

Streams affording power sites in southeastern Alaska, with position or water bodies into which they flow.

Mainland.

Porcupine River, near Porcupine.[1]
Endicott River, west coast of Lynn Canal.
Cowie and Davies creeks, Berners Bay.
Lemon Creek, near Juneau.[2]
Carlson Creek, Taku Inlet.[3]

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[1] Gaging station maintained in 1909 by Porcupine Gold Mining Co.
[2] Gaging station being maintained by mining company of Juneau.
[3] Gaging station being maintained by Alaska-Gastineau Mining Co. of Juneau.

Turner Lake outlet, Taku Inlet.[1]
Speel River, Speel River project, Port Snettisham.[2]
Grindstone Creek, north shore of Stephens Passage.[2]
Rhein Creek, north shore of Stephens Passage.[2]
Long Lake outlet, Speel River project, Port Snettisham.[3]
Crater Lake outlet, Speel River project, Port Snettisham.[2, 3]
Tease Lake outlet, Speel River project, Port Snettisham.
Sweetheart Falls Creek, south arm of Port Snettisham.[4]
Port Houghton, Stephens Passage.
Farragut Bay, Frederick Sound.
Mill Creek, near Wrangell.[4]
Bradfield Canal, upper end of Cleveland Peninsula.
Smugglers Cove, southeast shore of Cleveland Peninsula.
Helm Bay, southeast shore of Cleveland Peninsula.
Shelockham Lake outlet, Bailey Bay.[4]
Chickamin River, east shore of Behm Canal.
Rudyerd Bay, east shore of Behm Canal.

Baranof Island.

Port Conclusion, southeast coast.
Patterson Bay, east coast.
Red Bluff Bay, east coast.
Cascade Bay, east coast.
Baranof Lake outlet, Warm Spring Bay, east coast.[4]
Kasnyku Bay, east coast.
Green Lake outlet, Silver Bay, west coast.[4]
Necker Bay, west coast.
Deep or Redoubt Lake, west coast.

Chichagof Island.

Slocum Arm, west coast.
Suloia Bay, Peril Strait.
Khaz Bay, west coast.
Freshwater Bay, east coast.
Sitkoh Bay, southeast coast.
Basket Bay, southeast coast.

Admiralty Island.

Kootznahoo Inlet, west coast.
Hood Bay, west coast.

Kosciusko Island.

Davidson Inlet.

Prince of Wales Island.

Karta River, Karta Bay.[4]
Whale Passage, behind Thorne Island, northeast coast.
Myrtle Lake outlet, near Niblack post office.
Reynolds Creek, near Coppermount.[2]

Revillagigedo Island.

Orchard Lake outlet, at Shrimp Bay.[4]
Beaver Falls, George Inlet.

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1 Gaging station maintained in 1908 and 1909 by Alaska-Treadwell Gold Mining Co.
2 See list of miscellaneous measurements at end of report.
3 Gaging station maintained since January, 1913, by the Speel River project of Juneau.
4 Gaging station maintained by Geological Survey.

White River, George Inlet.
Creek, east shore near head of Carroll Inlet.[1]
Fish Creek, Thorne Arm.[2]
Gokatchin Creek, Thorne Arm.[1]
Ketchikan Creek, at Ketchikan.[2]

Annette Island.

Tamgas Harbor.

Lack of definite information in regard to the quantity of water available and other physical factors that determine the feasibility of a power site has been one of the principal impediments to development. For this reason a systematic investigation, designed to determine the location and the feasibility of water-power sites in southeastern Alaska, was begun by the Geological Survey, in cooperation with the Forest Service, in the spring of 1915.

The practicability of a water-power site depends on (1) the quantity of water available, (2) the fall, and (3) the possibility of storing water. Information in regard to fall and storage can be obtained by surveys at any time, but the volume and distribution of flow can be determined only by observations extending over several years, as future flow must be predicted from that of the past. In beginning the investigations, therefore, the collection of stream-flow data was given precedence and constituted the principal work of the year. Some general information, however, has been obtained, and in the fall of 1915 a few rainfall stations were established at higher elevations to supplement observations at mean sea level by the United States Weather Bureau. As a result of the investigations records of flow are now available for nine gaging stations, as shown by the following list, and indicated by corresponding numbers on Plate IV. The date of establishment is indicated in parentheses.

1. Fish Creek near Sea Level, Revillagigedo Island (May 19, 1915).
2. Ketchikan Creek at Ketchikan (established Nov. 1, 1909, discontinued June 30, 1912; reestablished July 1, 1915).
3. Karta River at Karta Bay, Prince of Wales Island (July 16, 1915).
4. Orchard Lake outlet at Shrimp Bay, Revillagigedo Island (May 28, 1915).
5. Shelockham Lake outlet at Bailey Bay (June 4, 1915).
6. Mill Creek on mainland near Wrangell (June 17, 1915).
7. Sweetheart Falls Creek near Snettisham (July 31, 1915).
8. Baranof Lake outlet at Warm Spring Bay, Baranof Island (June 28, 1915).
9. Green Lake outlet at Silver Bay, near Sitka (Aug. 22, 1915).

The available power sites in each area were carefully considered, and gaging stations were established at those which apparently afforded the greatest opportunities for development.

The records have been collected in accordance with the standard methods used elsewhere in the United States by the Geological Survey.

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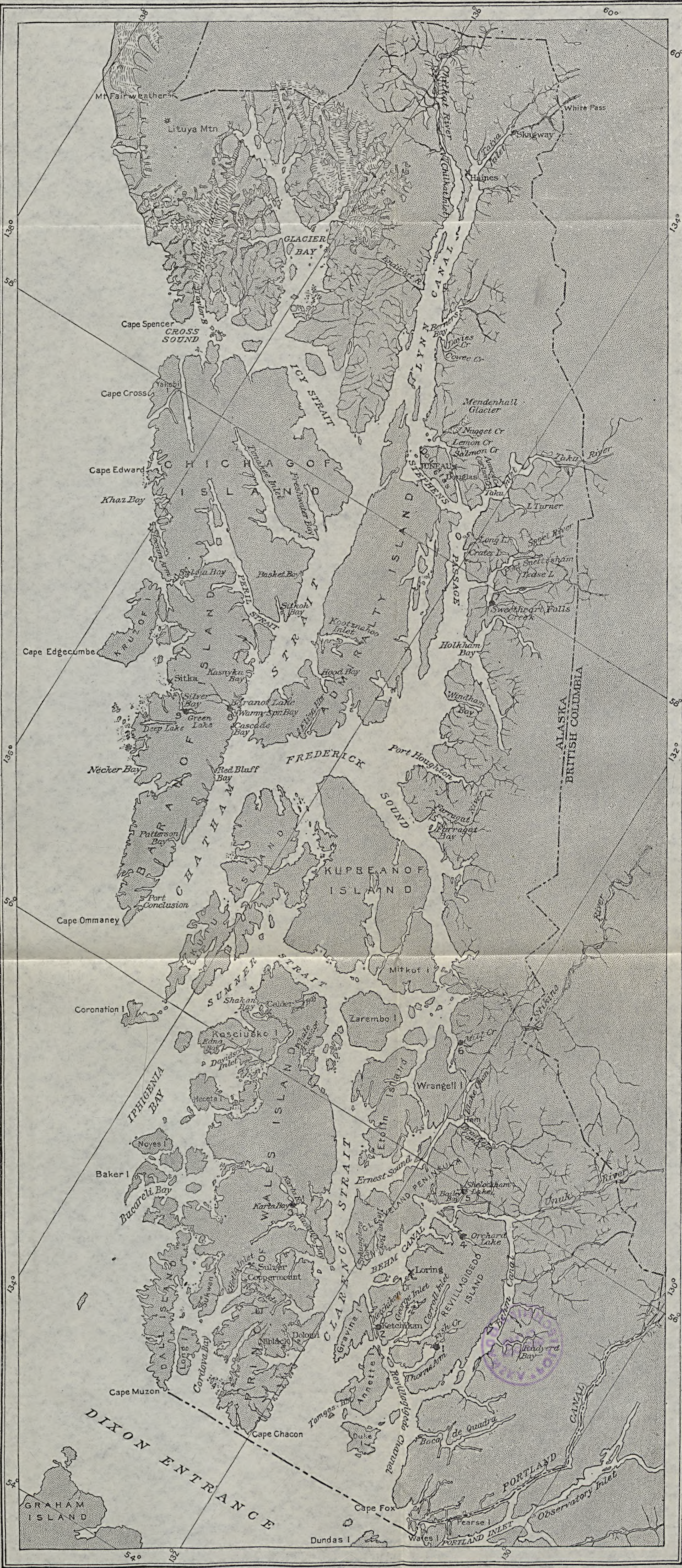
[1] See list of miscellaneous measurements at end of report.
[2] Gaging station maintained by Geological Survey.



MAP OF SOUTHEASTERN ALASKA SHOWING LOCATION OF GAGING STATIONS.

Owing to the inaccessibility of the stations, water-stage recorders were used at all the stations except that on Ketchikan Creek, and cables have been installed from which discharge measurements are made. Special arrangements were made for observations through the winter to obtain a record of the low-water flow which occurs at that season.

The data collected at the gaging stations are presented in the following pages, and include a general description of each station and tables showing the results of discharge measurements and the computed daily discharge.

Much of the work has been made possible by the use of the Forest Service launches, on which transportation has been furnished to the engineers and others engaged in installing and maintaining the stations. The local knowledge of the Forest Service employees has also been of great assistance in carrying on the work, and special acknowledgment is due to Mr. W. G. Weigle, forest supervisor at Ketchikan, who has represented the Forest Service in the cooperation; to Leonard Lundgren, district engineer; and to George L. Drake, J. W. Wyckoff, C. T. Gardner, George H. Peterson, James Allen, W. H. Babbitt, Lyle Blodgett, and Milo Caughrean, who have assisted in various ways.

Assistance in measuring streams in the vicinity of Speel River has been furnished by W. P. Lass. The gage readings for Ketchikan Creek were furnished by J. C. Barber, manager of the Citizens Light, Power & Water Co., of Ketchikan.

STATION RECORDS.

KARTA RIVER AT KARTA BAY, PRINCE OF WALES ISLAND.

LOCATION.—In latitude 55° 34′ N., longitude 132° 37′ W., at head of Karta Bay, an arm of Kasaan Bay, on east coast of Prince of Wales Island, 42 miles by water across Clarence Strait from Ketchikan.

DRAINAGE AREA.—49.5 square miles (U. S. Forest Service reconnaissance map of Prince of Wales Island, 1914).

RECORDS AVAILABLE.—July 1, 1915, to February 29, 1916.

GAGE.—Stevens water-stage recorder on left bank, half a mile above tidewater, at head of Karta Bay and 1¼ miles below outlet of Little Salmon Lake. Two per cent of total drainage of Karta River enters between outlet of lake and gage.

DISCHARGE MEASUREMENTS.—At medium and high stages made from cable across river 50 feet upstream from gage; at low stages by wading at cable section.

CHANNEL AND CONTROL.—From Little Salmon Lake, 1½ miles from tidewater, the river descends 180 feet in a series of rapids in a wide, shallow channel, the banks of which are low but do not overflow. The bed is of coarse gravel and bowlders; rock crops out only at outlet of lake. Gage and cable are at a pool of still water formed by a riffle of coarse gravel that makes a well-defined and permanent control.

EXTREMES OF DISCHARGE.—Maximum stage recorded during period, 4.4 feet, October 16 (discharge, 3,340 second-feet); minimum flow, estimated from discharge measurement, gage record, and climatic data, 21 second-feet, February 11.

WINTER FLOW.—Discharge relation affected by ice.

ACCURACY.—Results apparently good, as control is permanent and rating curve fairly well defined.

The combined area of Little Salmon Lake at elevation 180 feet, and Salmon Lake at elevation 185 feet, is 1,600 acres. The slopes along the right shore of lakes and at head of Salmon Lake are gentle, and the area included by the 250-foot contour above lake outlet is 5,500 acres. The drainage area to elevation 2,000 feet is heavily covered with timber and dense undergrowth of ferns, brush, and alders. The upper parts of the mountains are covered with thin soil and brush. Only a few peaks at an elevation of 3,500 feet are bare. This large lake and flat area and thick vegetal cover afford considerable natural storage, which, after heavy precipitation, maintains a good run-off. The snow usually melts by the end of June, and the run-off becomes very low during a dry, hot summer.

Discharge measurements of Karta River at Karta Bay during the period July 1, 1915, to Feb. 29, 1916.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
July 6	G. H. Canfield	....	90	Oct. 20	G. H. Canfield	2.94	1,500
16	.....do	1.00	85	Jan. 29	.....do	[a] 1.45	31
Sept. 7	.....do	1.49	283	Feb. 29	.....do	1.38	229
17	Hoyt and Canfield	1.06	109				

[a] Discharge relation affected by ice.

Daily discharge, in second-feet, of Karta River at Karta Bay for the period July 1, 1915, to Feb. 29, 1916.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1	....	48	150	540	1,920	1,020	206	30
2	....	46	200	385	1,340	1,330	172	29
3	....	44	300	290	1,000	1,540	152	29
4	....	44	400	285	987	1,330	138	29
5	....	44	510	305	1,000	1,390	128	27
6	....	44	350	296	834	1,980	121	27
7	....	118	283	258	631	1,860	112	26
8	....	356	278	416	489	1,100	106	26
9	....	695	253	650	375	720	106	24
10	....	1,200	215	643	316	517	103	22
11	....	1,080	180	750	299	387	103	21
12	....	1,170	160	750	278	305	100	32
13	....	1,170	138	882	1,090	253	100	172
14	....	1,130	125	1,000	1,680	215	100	132
15	....	987	115	2,120	1,400	206	97	278
16	88	695	109	3,000	960	351	97	580
17	88	524	103	1,960	870	375	94	679
18	83	419	100	1,240	843	475	88	566
19	76	328	91	1,150	671	601	83	608
20	74	268	88	1,490	653	852	81	679
21	69	220	81	1,310	987	987	74	566
22	74	184	78	1,010	852	915	71	447
23	76	156	76	1,000	843	738	66	363
24	76	135	71	1,050	746	679	60	334
25	71	121	74	960	655	531	54	328
26	66	112	120	1,170	531	426	48	299
27	64	97	197	1,170	440	433	44	273
28	60	88	360	1,620	432	363	39	253
29	58	81	830	1,460	789	305	32	224
30	54	88	770	1,050	754	268	30	....
31	52	135	....	1,350	....	238	30	....

NOTE.—Discharge determined from a rating curve well defined between 60 and 1,600 second-feet. Discharge July 1–15 estimated as 95 second-feet on basis of discharge measurement and climatic records. Sept. 1–6 and Sept. 23 to Oct. 18, gage clock not running; discharge estimated from maximum and minimum stages indicated by recording pencil and from comparison of hydrograph for this station with that for Fish Creek near Sea Level, Alaska. Jan. 8 to Feb. 16, discharge estimated because of ice, from climatic records and one discharge measurement.

Monthly discharge of Karta River at Karta Bay for the period July 1, 1915, to Feb. 29, 1916.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
July		52	82.5	5,070	B.
August	1,200	44	382	23,500	A.
September	830	71	227	13,500	C.
October	3,000	258	1,020	62,700	C.
November	1,920	278	822	48,900	B.
December	1,980	206	732	45,000	B.
January	206	30	91.5	5,630	C.
February	679	21	245	14,100	B.
The period				218,000	

FISH CREEK NEAR SEA LEVEL, REVILLAGIGEDO ISLAND.

Location.—In latitude 55° 24′ N., longitude 131° 12′ W., near outlet of Lower Lake on Fish Creek, 600 feet from tidewater at head of Thorne Arm, 2 miles northwest of mine at Sea Level, and 25 miles by water from Ketchikan.

Drainage area.—Not measured.

Records available.—May 19, 1915, to February 29, 1916.

Gage.—Stevens water-stage recorder on right shore of Lower Lake, 200 feet above outlet.

Discharge measurements.—At medium and high stages made from cable across creek, 1 mile upstream from gage and 500 feet above head of Lower Lake; at low stages made by wading at cable. Only one small creek enters Lower Lake, at point opposite gage, between the cable site and control section.

Channel and control.—The lake is about 500 feet wide opposite the gage. Outlet consists of two channels, each about 60 feet wide, separated by an island 40 feet wide. From the lake to tidewater, 200 feet, the creek falls 20 feet. Bedrock exposed at the outlet of the lake forms a well-defined and permanent control.

Extremes of discharge.—Maximum stage recorded during period, 4.94 feet at 3 a. m. October 15 (approximate discharge, computed from an extension of the rating curve, 3,700 second-feet); minimum stage recorded, 0.50 foot February 11 (discharge, 21 second-feet).

Winter flow.—Lower Lake freezes over, but as gage is set back in the bank ice does not form in well, and the relatively warm water from the lake and the swift current keep the control open.

Accuracy.—Results apparently good, as control is permanent, rating curve fairly well defined, and gage-height record nearly unbroken.

There are three large lakes in the upper drainage basin: Big Lake, 2 miles from beach at elevation 275 feet covers 1,700 acres, Third Lake, 250 acres, and Mirror Lake, at elevation 1,000 feet, 800 acres. Two-thirds of the drainage basin is covered with a thick growth of timber and brush interspersed with occasional patches of beaver swamp and muskeg. Only the tops of the highest mountains are bare. This large area of lake surface and vegetation, notwithstanding the steep slopes and shallow soil, affords a little ground storage and after a heavy precipitation maintains a good run-off. During a dry, hot period in summer, however, after the snow has melted, the flow becomes very low because of lack of ice or glaciers in the drainage basin.

Discharge measurements of Fish Creek near Sea Level during the period May 19, 1915, to Feb. 29, 1916.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
May 20	G. H. Canfield	1.48	328	Oct. 13	G. H. Canfield	2.53	1,120
July 10	.....do	1.01	118	Jan. 26	.....do	.64	42
Sept. 13	Hoyt and Canfield	1.04	129				

Daily discharge, in second-feet, of Fish Creek near Sea Level, for the period May 19, 1915, to Feb. 29, 1916.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1		270	143	84	127	632	1,010	660	158	34
2		312	134	78	150	455	1,070	804	143	31
3		324	134	73	250	346	780	764	134	31
4		384	130	69	590	329	660	668	124	30
5		425	127	67	700	362	639	625	114	28
6		413	124	69	569	351	583	780	107	27
7		401	124	73	425	334	455	772	102	26
8		548	124	152	334	488	413	569	91	25
9		507	124	340	285	764	285	425	84	23
10		407	120	1,190	235	756	230	334	76	22
11		351	117	1,720	190	876	199	265	73	22
12		312	117	1,470	174	876	178	217	71	35
13		285	112	1,620	143	1,030	340	178	69	204
14		255	104	1,170	124	1,120	455	154	67	190
15		250	99	1,060	117	2,510	527	154	65	488
16		285	96	892	124	3,160	455	158	65	1,110
17		296	91	632	130	1,950	500	204	64	1,170
18		270	84	474	130	1,230	534	250	64	740
19	362	245	82	378	127	999	488	290	62	576
20	340	270	78	307	117	1,320	455	329	60	724
21	356	660	76	250	112	1,520	494	395	58	604
22	356	716	117	204	101	1,220	407	462	55	488
23	334	541	178	170	96	884	362	437	51	407
24	307	413	204	140	91	732	318	425	48	351
25	285	340	194	127	94	668	270	340	45	302
26	290	285	170	104	166	812	226	285	41	260
27	334	245	147	101	235	945	226	340	40	230
28	362	199	127	107	445	1,120	260	275	38	204
29	351	178	112	104	945	1,170	312	226	38	174
30	307	158	96	96	900	884	520	204	37	
31	275		91	96		772		182	35	

NOTE.—Discharge determined from a rating curve well defined between 40 and 1,500 second-feet. Sept. 6–12, gage clock not running, and Nov. 23 to Dec. 1, Jan. 2–5, Feb. 7–11, Feb. 18–29, paper not feeding; discharge estimated from maximum and minimum stages indicated by recording pencil and from climatic records.

Monthly discharge of Fish Creek near Sea Level for the period May 19, 1915, to Feb. 29, 1916.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
May 19–31	362	275	328	8,460	A.
June	716	158	352	20,900	A.
July	204	76	122	7,500	A.
August	1,720	67	433	26,600	A.
September	945	91	274	16,300	A.
October	3,160	329	988	60,800	B.
November	1,070	178	455	27,100	B.
December	804	154	393	24,200	A.
January	158	35	73.5	4,520	B.
February	1,170	22	295	17,000	C.
The period				213,000	

SHELOCKHAM LAKE OUTLET, BAILEY BAY.

Location.—In latitude 56° 00′ N., longitude 131° 36′ W. on mainland near outlet of Shelockham Lake, three-fourths mile by Forest Service trail from tidewater at north end of Bailey Bay, and 52 miles by water north of Ketchikan.

Drainage area.—Not measured.

Records available.—June 1, 1915, to February 29, 1916.

Gage.—Stevens water-stage recorder on right shore of lake 250 feet above outlet.

Discharge measurements.—Made from cable across outlet of lake, 200 feet below gage and 50 feet upstream from crest of falls.

Channel and control.—Opposite the gage the lake is 600 feet wide; at the outlet bedrock is exposed and the water makes a nearly perpendicular fall of 150 feet. This falls forms an excellent and permanent control for the gage. At extreme high stages, the lake has another outlet about 200 feet to left of main outlet.

Extremes of discharge.—Maximum stage recorded during period, 6.5 feet (estimated) October 15 (discharge, 2,440 second-feet); minimum flow, estimated from gage record and climatic data 8 second-feet February 11.

Winter flow.—Ice forms on Shelockham Lake and at gage, but because of the swift current and relatively warm water from lake, the control remains open and discharge relation is not affected by ice.

Accuracy.—Rating curve well defined; results apparently fair.

Shelockham Lake, at elevation 344 feet, is only 350 acres in area. The drainage basin above the lake is rough and precipitous and is covered with little soil or vegetation. There are no glaciers or ice fields at the sources of the tributary streams. Therefore, as there is little natural storage, after a heavy rainfall, the run-off is rapid and not well sustained, and during a hot, dry summer the flow becomes very low. The large amount of snow that accumulates during the winter months maintains a good flow during April, May, and June.

Discharge measurements of Shelockham Lake outlet at Bailey Bay during the period June 1, 1915, to Feb. 29, 1916.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
June 4[a]	G. H. Canfield	2.78	294	Sept. 15	Hoyt and Canfield	1.75	86
July 9	.....do	1.78	87	Oct. 15	G. H. Canfield	6.32	2,280
Aug. 6	Gardner and Williams	1.20	22.5	17	.....do	3.47	484
Sept. 14	Hoyt and Canfield	1.35	42				

[a] Measurement made from boat at cable site.

Daily discharge, in second-feet, of Shelockham Lake outlet at Bailey Bay for the period June 1, 1915, to Feb. 29, 1916.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1	325	91	24	....	....	480	94	33	10
2	310	91	21	....	....	334	222	28	10
3	300	89	20	....	....	248	268	27	10
4	295	85	18	....	....	258	245	25	10
5	278	91	18	....	....	241	200	25	9
6	265	102	22	....	....	191	250	24	9
7	312	109	39	....	....	144	280	23	9
8	352	96	....	....	....	104	187	21	9
9	270	86	....	....	....	81	125	20	9
10	222	75	....	....	....	64	88	20	8
11	216	64	....	....	....	57	66	18	8
12	216	55	....	....	....	51	50	18	19
13	206	50	....	....	....	86	41	18	107
14	185	44	....	33	....	175	39	17	172
15	198	41	....	75	2,220	179	35	17	393
16	255	36	....	94	1,030	158	44	16	407
17	227	34	....	99	510	156	50	15	183
18	187	31	....	96	347	177	56	15	120
19	158	28	....	80	250	154	59	17	227
20	258	27	....	72	338	127	66	18	450
21	448	27	....	....	379	121	89	18	325
22	325	43	....	....	325	110	101	17	216
23	232	57	....	....	262	91	91	14	136
24	179	60	....	....	320	97	83	14	96
25	166	55	....	....	339	102	66	13	63
26	158	47	....	....	580	88	56	12	55
27	131	42	....	....	450	81	60	12	51
28	113	37	....	....	620	69	52	12	48
29	102	32	....	....	456	68	42	11	45
30	94	28	....	....	288	64	40	11	....
31	....	26	....	....	292	....	39	11	....

NOTE.—Discharge determined from a rating curve well defined above 25 second-feet. June 1-3, discharge estimated; Aug. 8 to Sept. 14 and Sept. 21 to Oct. 4, gage clock stopped; discharge estimated by comparison of hydrograph for this station with that for station at Orchard Lake outlet; Jan. 23 to Feb. 29, ice in gage well; discharge estimated from climatic records at Ketchikan and from comparison of hydrograph for this station with that for Orchard Lake outlet.

Monthly discharge of Shelockham Lake outlet at Bailey Bay for the period June 1, 1915, to Feb. 29, 1916.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
June	448	94	233	13,900	A.
July	109	26	57.4	3,530	A.
August	....	....	128	7,870	C.
September	....	....	100	5,950	C.
October	2,220	....	401	24,700	B.
November	480	51	145	8,630	A.
December	280	35	103	6,330	A.
January	33	11	18.1	1,110	B.
February	450	8	111	6,380	D.
The period	....	....	....	78,400	

BARANOF LAKE OUTLET AT WARM SPRING BAY, BARANOF ISLAND.

Location.—In latitude 57° 5′ N., longitude 134° 54′ W., at townsite of Baranof, at head of Warm Spring Bay, east coast of Baranof Island, 18 miles east of Sitka across island, but 96 miles from Sitka by water through Peril Strait.

Drainage area.—Not measured.

Records available.—June 28, 1915, to February 29, 1916.

Gage.—Stevens water-stage recorder on right bank 700 feet below Baranof Lake and 800 feet above tidewater at head of Warm Spring Bay.

Discharge measurements.—Made from cable across stream 100 feet below lake and 600 feet above gage.

Channel and control.—From Baranof Lake, at elevation 130 feet above sea level, and 1,500 feet from tidewater, the stream descends in a series of rapids and small falls and enters the bay in a cascade of about 100 feet concentrated fall. The bed is of glacial drift, bowlders, and rock outcrop. The gage is in an eddy 50 feet downstream from the foot of a small fall and 100 feet upstream from a riffle which forms a well-defined control.

Extremes of discharge.—Maximum stage recorded during period, 5.3 feet August 10 (approximate discharge, computed from extension of rating curve, 3,350 second-feet); minimum flow estimated by discharge measurement and climatic data, 28 second-feet on February 13.

Winter flow.—Because of the swift current and flow of relatively warm water from the lake, the stream remains open.

Diversions.—The flume to Olsen's sawmill diverts from the stream 200 feet below gage only sufficient water to operate a 25-horsepower Pelton water wheel.

Accuracy.—Rating curve well defined, control permanent and not affected by ice in winter; results apparently good.

The drainage area is rough and precipitous, and the vegetable and soil cover is thin, even on the foothills of the mountains. The run-off is rapid and the ground storage is small. During a dry, hot period, however, the flow is greatly augmented by melting ice from several small glaciers and ice-capped mountains.

Discharge measurements of Baranof Lake outlet at Baranof during the period June 28, 1915, to Feb. 29, 1916.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
June 28	Canfield and Drake.....	2.70	608	Sept. 28	Canfield and Gardner....	4.05	1,700
Sept. 4	Canfield and Peterson...	2.78	621	Dec. 9	G. H. Canfield..........	1.79	255
27	Canfield and Gardner...	3.12	833	Feb. 13	.....do..................	.35	28.5

Daily discharge, in second-feet, of Baranof Lake outlet at Baranof for the period June 28, 1915, to Feb. 29, 1916.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1		725	615	400	650	433	125	70	28
2		820	525	1,000	485	375	185	64	28
3		788	477	1,000	437	405	361	56	28
4		788	453	640	900	497	525	52	28
5		1,100	453	497	892	453	473	50	28
6		1,480	477	425	548	335	525	46	28
7		1,050	636	457	495	269	473	42	28
8		788	867	453	695	222	335	40	28
9		695	2,100	405	586	185	248	40	28
10		615	3,000	357	505	161	208	39	28
11		568		326	725	141	163	40	28
12		640		305	755	125	133	39	28
13		668		397	926	200	112	39	27
14		695		616	764	299	101	39	27
15		668		890	1,050	296	94	39	34
16		695		788	755	269	114	39	39
17		695		615	615	284	118	40	41
18		640		485	485	255	119	40	62
19		640		445	389	215	131	40	102
20		640		525	378	212	195	38	145
21		695		525	305	266	190	37	137
22		725		425	255	235	179	36	120
23		695		344	304	220	161	35	107
24		640		430	615	190	161	33	90
25		615		920	568	167	141	33	80
26		695		1,100	453	147	120	32	73
27		788		890	405	122	116	31	66
28	590	820		1,420	545	119	102	30	62
29	590	890		1,480	525	125	90	30	57
30	640	855		1,000	385	122	88	29	
31		725			344		80	28	

NOTE.—Discharge determined from a rating curve well defined below 800 second-feet. Aug. 11 to Sept. 3 gage clock stopped; discharge estimated by comparison of hydrograph at this station with those for other Alaska stations, from climatic data, and from minimum stage indicated by recording pencil. Aug. 11-31 estimated 886 second-feet. Jan. 20 to Feb. 13 water frozen in well; discharge estimated from climatic records and discharge measurement of Feb. 13.

Monthly discharge of Baranof Lake outlet at Baranof for the period June 28, 1915, to Feb. 29, 1916.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
June 28-30	640	590	607	3,610	
July	1,480	568	759	46,700	A.
August	3,000		910	56,000	C.
September	1,480	305	652	38,800	A.
October	1,050	255	572	35,200	A.
November	497	119	245	14,600	A.
December	525	80	199	12,200	A.
January	70	28	40.2	2,470	B.
February	145	27	55.3	3,180	B.
The period				213,000	

ORCHARD LAKE OUTLET AT SHRIMP BAY, REVILLAGIGEDO ISLAND.

Location.—In latitude 55° 50′ N., longitude 131° 27′ W., at outlet of Orchard Lake, one-third mile from tidewater at head of Shrimp Bay, and arm of Behm Canal, 46 miles by water from Ketchikan.

Drainage area.—Not measured.

Records available.—May 28, 1915, to February 29, 1916.

Gage.—Stevens water stage recorder on right bank 300 feet below Orchard Lake and 100 feet above site of timber-crib dam, which was built in 1914 for proposed pulp mill, and washed out by high water August 10, 1915. Datum of gage lowered 2 feet September 15. Gage heights May 29 to August 10 referred to old datum; August 11 to February 29, 1916, to new datum.

Discharge measurements.—At medium and high stages made from cable 50 feet downstream from gage; at low stages by wading near cable.

Channel and control.—From Orchard Lake, at elevation 134 feet above high tide, the stream descends in a series of rapids for 1,000 feet through a narrow gorge, then divides into two channels and enters the bay in two cascades of 100-foot vertical fall. Opposite the gage the water is deep and the current sluggish. At the site of the old dam bedrock is exposed, but for 30 feet upstream the channel is filled in with loose rock and brush placed during construction of dam. This material forms a riffle which acts as a control for water surface at gage and is probably permanent.

Extremes of discharge.—Maximum stage recorded during period, 8.4 feet at 2 a. m. October 16 (discharge, 6,230 second-feet); minimum, estimated, 20 second-feet February 11.

Winter flow.—Ice forms on Orchard Lake, but because of swift current and relatively warm water from lake the outlet and control remain open.

Accuracy.—Results apparently good. Rating curve for new datum well defined for all stages; position of curve for old datum estimated by means of the new curve; three discharge measurements made before dam went out.

The highest mountains on this drainage basin are only 3,500 feet above sea level and are covered to an elevation of 2,500 feet by a heavy stand of timber and a thick undergrowth of brush, ferns, alders, and devil's-club. The topography is not so rugged as that of the area surrounding Shelockham Lake, and the proportion of vegetation, soil cover, and lake area is greater, so that more water is stored and the flow in the Orchard Lake drainage basin is better sustained.

Discharge measurements of Orchard Lake outlet at Shrimp Bay during the period May 28, 1915, to Feb. 29, 1916.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
May 29	G. H. Canfield	2.88	444	Oct. 16	G. H. Canfield	7.58	5,280
July 8	Canfield and Gardner	1.96	248	16	do	6.78	4,270
Aug. 7	Gardner and Williams	.90	145	17	do	5.22	2,720
Sept. 15	Hoyt and Canfield	[a] 1.40	341	Jan. 20	do	— .34	36
16	do	1.71	428				

[a] Datum of gage lowered 2 feet Sept. 15 previous to making discharge measurement.

Daily discharge, in second-feet, of Orchard Lake outlet at Shrimp Bay for the period May 28, 1915, to Feb. 29, 1916.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1	....	362	271	170	159	640	1,260	320	122	29
2	....	362	271	161	239	406	1,000	974	118	28
3	....	373	280	151	488	299	710	1,130	116	28
4	....	422	263	145	610	372	710	930	112	27
5	....	450	263	135	570	478	690	690	108	25
6	....	495	271	134	453	385	630	975	103	24
7	....	580	263	146	374	336	551	944	98	23
8	....	620	252	240	310	806	460	611	94	22
9	....	528	242	792	257	1,280	412	403	88	22
10	....	480	227	3,480	208	930	382	299	84	21
11	....	480	219	4,700	188	1,400	382	232	79	20
12	....	495	209	2,550	180	1,260	368	192	75	62
13	....	480	202	1,980	159	1,520	570	157	70	150
14	....	436	196	1,200	161	1,300	710	138	65	240
15	....	450	193	1,250	317	4,140	532	124	60	781
16	....	800	194	1,020	427	4,990	421	135	54	1,040
17	....	700	197	616	368	2,430	444	142	48	672
18	....	580	191	418	329	1,170	551	174	43	478
19	....	480	183	334	276	830	460	208	41	726
20	....	465	178	272	232	1,260	412	283	37	1,130
21	....	700	176	228	202	1,320	525	434	36	780
22	....	680	262	198	178	1,010	444	450	36	570
23	....	545	385	178	155	880	346	403	36	418
24	....	465	373	159	138	930	344	354	35	336
25	....	410	318	150	232	955	336	290	35	301
26	....	410	271	142	354	1,570	294	235	35	272
27	....	350	248	136	385	1,260	241	232	34	239
28	465	308	224	133	1,010	1,840	204	214	34	212
29	450	280	208	126	1,720	1,480	218	174	33	184
30	422	271	195	133	1,090	951	239	157	32	....
31	373	....	183	198	....	805	....	140	30	....

NOTE.—Discharge May 28 to Aug. 10 determined from a rating curve well defined below 2,000 second-feet, and Aug. 11 to Feb. 29, from a well-defined rating curve, except as follows: Float resting in bottom of well Aug. 22 to Sept. 2; discharge estimated from precipitation records and slope of hydrographs for periods prior to Aug. 22 and after Sept. 2. Counterpoise caught Nov. 3-16; discharge estimated from climatic records and minimum stage indicated by the recorder. Ice in well, Jan. 3 to Feb. 13; discharge estimated from climatic records and one discharge measurement.

Monthly discharge of Orchard Lake outlet at Shrimp Bay for the period May 28, 1915, to Feb. 29, 1916.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
May 28-31	465	373	428	3,400	
June	800	271	482	28,700	B.
July	385	176	239	14,700	B.
August	4,700	126	699	43,000	B.
September	1,720	138	392	23,300	B.
October	4,990	299	1,270	78,100	A.
November	1,260	204	495	29,500	C.
December	1,130	124	392	24,100	A.
January	122	30	64.2	3,950	D.
February	1,130	20	306	17,600	B.
The period	....	....	....	266,000	

KETCHIKAN CREEK AT KETCHIKAN.

LOCATION.—One-fourth mile below power house of Citizens Light, Power & Water Co., one-third mile northeast of Ketchikan post office, downstream 200 feet from mouth of Schoenbar Creek, entering from right, 1¼ miles from mouth of Granite Basin Creek, entering from left, and 1½ miles from outlet of Ketchikan Lake.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—November 1, 1909, to June 30, 1912; June 9, 1915, to February 29, 1916.

GAGE.—Vertical staff fastened to a telephone pole near board walk on left bank at bend of creek 200 feet downstream from mouth of Schoenbar Creek; read once daily between 7 and 8 a. m. by employee of the Citizens Light, Power & Water Co. The gage used since June 9, 1915, consists of the standard United States Geological Survey enameled gage section graduated in hundredths, half-tenths, and tenths from zero to 10 feet. The original gage established November, 1909, and read until June 30, 1912, is at same location and same datum. It is a staff with graduations painted every tenth.

DISCHARGE MEASUREMENTS.—At medium and high stages from footbridge about 500 feet upstream from gage; measuring section poor, as the bridge makes an angle of 20° with the current, and at high stages the flow is broken by large stumps near left bank and at middle of bridge; at low stages, by wading 50 feet below bridge or at another section 100 feet above gage. The flow of Schoenbar Creek has been added to obtain total flow past gage.

CHANNEL AND CONTROL.—Gage is located in a large deep pool of still water at a bend in creek. The bed of the stream at the outlet of this pool is a solid rock ledge, which forms an excellent permanent control at the gage.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year (June 9 to December 31), 7 feet August 10 (discharge, 2,140 second-feet); minimum stage recorded, 0.28 foot September 24 (discharge, 34 second-feet).

1909–1915: Maximum stage recorded, 8.2 feet December 2, 1911 (discharge, 2,700 second-feet); minimum stage recorded, 0.28 foot September 24, 1915 (discharge, 34 second-feet).

WINTER FLOW.—Ice forms along banks but control remains open.

DIVERSIONS.—A small quantity of water is diverted above the station for the use of the town of Ketchikan, the New England Fish Co., and the Standard Oil Co.

REGULATION.—Small timber dam and headgates are located at outlet of Ketchikan Lake. Water diverted through power house is returned to creek above gage but causes very little diurnal fluctuation. During low water the flow is increased by water from the reservoir.

ACCURACY.—Results apparently fair. Control is well defined, but the conditions for making discharge measurements are poor. The rating curve is defined by discharge measurements only to gage height 3.0 feet but is extended to gage height 8.2 feet.

COOPERATION.—Gage read by the Citizens Light, Power & Water Co.

Discharge measurements of Ketchikan Creek at Ketchikan during the period June 9, 1915, to Feb. 29, 1916.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
June 9	G. H. Canfield	1.15	145	Oct. 30	Canfield and Wyckoff	1.58	232
July 17	Canfield and Drake	.60	64	Jan. 15	Canfield and Gardner	.35	38
Sept. 12	Hoyt and Canfield	.43	63	27	G. H. Canfield	.44	50
Oct. 27	Canfield and Wyckoff	2.82	522				

NOTE.—Discharge measurements include either measured or estimated flow of Schoenbar Creek.

Daily discharge, in second-feet, of Ketchikan Creek at Ketchikan for years ending Sept. 30, 1910–1912, and July, 1915, to February, 1916.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1909–10.												
1	....	635	77	54	77	40	146	155	255	266	300	213
2	....	518	77	54	224	44	98	155	277	234	1,320	164
3	....	300	60	54	155	70	90	174	255	213	635	137
4	....	200	50	44	174	100	80	174	234	244	323	184
5	....	200	49	77	323	130	70	244	234	369	255	164
6	....	121	44	70	193	160	60	260	193	369	203	155
7	....	84	44	49	121	190	44	288	193	277	193	213
8	....	70	44	59	91	200	70	213	518	244	203	105
9	....	59	40	59	85	213	105	184	492	266	164	98
10	....	49	40	80	84	270	77	234	323	277	137	98
11	....	44	44	244	60	323	44	234	277	323	121	77
12	....	44	44	105	49	442	105	288	277	865	121	77
13	....	44	64	77	45	323	121	417	442	1,690	137	77
14	....	44	266	60	44	288	98	266	544	635	213	64
15	....	44	288	50	40	320	277	417	442	346	213	64
16	....	44	203	40	40	369	210	417	467	234	213	70
17	....	44	129	137	36	518	155	266	442	203	213	174
18	....	44	98	70	36	520	137	255	277	193	213	234
19	....	44	77	60	38	518	105	203	255	184	137	244
20	....	44	54	50	40	369	121	234	277	184	121	193
21	....	44	50	49	40	266	160	266	277	193	121	155
22	....	44	49	45	36	213	203	255	300	467	121	193
23	....	44	44	44	36	137	277	266	255	417	105	146
24	....	44	40	40	36	160	137	266	300	288	91	121
25	....	44	40	36	36	193	121	255	288	442	91	193
26	....	100	40	49	36	137	137	312	300	234	91	164
27	....	193	40	113	38	113	174	492	266	288	155	164
28	....	300	40	64	40	91	203	442	255	213	137	234
29	....	200	77	224	....	137	164	417	277	234	417	467
30	....	105	64	98	....	121	146	369	323	234	442	635
31	....	....	54	70	....	155	....	300	....	203	277	....
1910–11.												
1	417	121	77	288	40	60	70	121	288	288	155	174
2	795	346	64	417	40	50	64	174	266	266	164	184
3	635	244	54	442	40	50	64	288	224	244	155	129
4	467	155	54	467	40	40	64	312	193	234	155	121
5	442	244	54	277	80	40	64	244	288	266	155	121
6	369	146	54	234	80	40	64	184	266	277	146	98
7	312	121	54	121	80	40	64	121	224	277	155	91
8	635	137	64	91	80	40	64	121	369	266	137	98
9	417	105	64	91	80	40	59	346	323	277	121	91
10	323	98	64	91	80	60	49	323	234	288	121	91
11	213	64	77	91	70	60	49	213	1,040	266	121	91
12	146	64	442	91	70	150	49	174	900	203	121	91
13	467	442	224	91	60	200	54	164	518	193	121	98
14	417	467	467	90	60	200	54	155	369	193	105	492
15	346	244	900	90	50	180	244	234	323	203	105	346
16	244	277	830	80	40	170	213	255	312	213	98	323
17	164	312	492	80	40	160	70	346	266	244	98	213
18	417	193	1,240	60	80	146	121	255	255	255	98	346
19	1,440	105	760	50	80	137	346	213	244	255	98	255
20	665	369	518	50	60	98	795	442	213	255	98	213
21	727	417	255	40	50	84	727	300	224	213	91	174
22	417	369	224	40	50	91	213	213	224	234	91	137
23	369	346	255	40	120	121	174	174	224	1,120	91	129
24	234	255	312	40	100	91	164	193	213	695	91	174
25	213	105	255	40	80	91	146	213	213	417	91	193
26	234	98	266	40	80	77	121	234	224	255	84	224
27	1,120	91	203	40	80	84	105	213	277	193	121	184
28	1,820	64	193	40	70	121	105	193	266	174	174	266
29	544	64	492	40	....	105	105	346	266	164	174	193
30	369	54	518	45	....	121	121	346	266	164	146	146
31	203	....	255	45	....	84	....	381	....	155	164	....

Daily discharge, in second-feet, of Ketchikan Creek at Ketchikan, for years ending Sept. 30, 1910–1912, and July, 1915, to February, 1916—Continued.

Day.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
1911–12.									
1	137	121	570	91	277	77	174	91	193
2	121	155	2,700	91	213	77	105	84	174
3	105	121	1,480	84	155	64	121	146	155
4	213	137	518	77	129	64	105	203	121
5	277	155	300	77	121	64	155	244	129
6	393	105	213	77	105	54	164	323	121
7	346	105	442	77	105	54	121	255	137
8	277	105	417	77	174	54	98	164	105
9	174	91	234	70	234	54	91	155	113
10	174	77	255	64	300	54	98	146	84
11	155	64	442	64	312	54	70	155	77
12	155	64	518	64	393	49	77	184	105
13	121	64	323	64	467	49	64	213	113
14	155	54	277	64	544	49	77	244	113
15	213	54	255	64	570	44	77	234	105
16	137	121	164	64	164	44	84	203	105
17	155	255	193	64	137	44	77	193	105
18	121	277	213	64	121	44	77	174	113
19	323	113	203	64	105	44	64	184	105
20	193	113	193	84	105	44	64	184	105
21	155	105	234	417	300	44	64	193	105
22	121	213	224	323	174	44	64	174	113
23	121	442	203	174	121	44	64	174	91
24	121	393	174	193	121	44	64	155	91
25	121	300	121	417	155	40	64	174	91
26	105	224	105	234	121	44	64	193	84
27	105	213	98	213	91	193	91	184	84
28	105	174	98	255	91	105	121	137	77
29	105	213	91	224	64	64	77	121	77
30	91	277	91	213	....	91	137	155	77
31	91	....	91	417	....	105	....	174	....

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1915–16.								
1	83	58	325	69	234	492	80	40
2	83	58	518	54	203	518	72	40
3	80	60	544	77	213	492	69	40
4	77	54	213	213	288	417	66	40
5	85	44	115	105	346	288	66	40
6	83	41	77	83	277	346	60	40
7	105	64	85	64	193	234	57	40
8	193	442	99	266	184	164	54	40
9	137	369	77	174	155	111	51	40
10	121	2,140	60	155	105	99	47	40
11	99	795	54	266	99	83	43	40
12	83	492	48	266	77	58	40	80
13	77	518	44	760	518	54	40	200
14	72	277	42	300	442	60	40	570
15	69	1,600	54	1,320	300	62	40	417
16	64	300	46	900	518	105	40	137
17	64	121	42	369	300	88	40	120
18	60	99	41	467	300	155	40	100
19	60	69	41	234	224	164	40	100
20	60	62	39	635	184	193	40	100
21	58	46	38	695	277	193	40	100
22	193	46	36	417	234	213	40	100
23	105	46	34	255	174	193	40	100
24	77	44	34	277	193	193	40	100
25	64	41	64	288	174	155	40	100
26	64	41	56	288	137	99	45	80
27	62	41	41	277	9[illegible]	94	48	80
28	60	41	56	467	10[illegible]	83	45	80
29	60	41	77	492	244	83	40	80
30	58	41	83	234	91	80	40	....
31	58	255	....	277	....	80	40	....

NOTE.—Discharge determined from a rating curve fairly well defined between 40 and 800 second-feet. No gage readings Nov. 3–5, 8, 13–15, 17, 20, 21, 23–26, 28, 29, Dec. 3, 4, 6, 7, 9, 21, 25, 26 and 28, 1909; Jan. 2, 10, 14, 15, 19, 20, 22, 24, Feb. 9, 11, 13, 15, 19, 26–28, Mar. 1, 3–8, 10, 15, 18, 24; Apr. 3, 4, 6, 8, 16, 21, and May 6, 1910; discharge estimated. Discharge estimated from climatic records as follows: Jan. 14 to Mar. 17, 1911; Jan. 2–14, 16–26, Jan. 28 to Feb. 13, Feb. 17 to Mar. 3, and Mar. 5–7, 1916.

Monthly discharge of Ketchikan Creek at Ketchikan for years ending Sept. 30, 1910–1912, and July, 1915, to February, 1916.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
1910–11.				
November	635	44	126	7,500
December	288	40	75.2	4,620
January	244	36	75	4,610
February	323	36	80.5	4,470
March	518	40	230	14,100
April	277	44	131	7,800
May	492	155	281	17,300
June	544	193	317	18,900
July	1,690	184	349	21,500
August	1,320	91	241	14,800
September	635	64	176	10,500
The period				126,000
1911–12.				
October	1,820	146	503	30,900
November	467	54	204	12,100
December	1,240	54	316	19,400
January	467	40	121	7,440
February	120	40	67.1	3,730
March	200	40	97.8	6,010
April	795	49	153	9,100
May	442	121	241	14,800
June	1,040	193	317	18,900
July	1,120	155	282	17,300
August	174	84	124	7,620
September	492	91	183	10,900
The year	1,820	40	219	158,000
1912–13.				
October	393	91	167	10,300
November	442	54	164	9,760
December	2,700	91	369	22,700
January	417	64	146	8,980
February	570	64	206	11,800
March	193	40	61.3	3,770
April	174	64	92.4	5,500
May	323	64	181	11,100
June	193	77	109	6,490
The period				90,300
1915–16.				
July	193	58	84.3	5,180
August	2,140	41	268	16,500
September	544	34	103	6,130
October	1,320	54	347	21,300
November	518	77	224	13,300
December	518	54	182	11,200
January	80	40	47.8	29,400
February	570	40	106	6,100
The period				109,000

SWEETHEART FALLS CREEK NEAR SNETTISHAM.

Location.—In latitude 57° 56½′ N., longitude 133° 41′ W., on east shore 1 mile from head of south arm of Port Snettisham, 3 miles south of mouth of Whiting River, 7 miles by water from Snettisham, and 42 miles by water from Juneau. No large tributaries enter river between gaging station and outlet of large lake, 2½ miles upstream.

Drainage area.—27 square miles, measured on the United States Geological Survey topographic map of the Juneau Gold Belt, 1905.

Records available.—July 31, 1915, to February 29, 1916.

Gage.—Stevens water-stage recorder on right bank 300 feet upstream from tidewater on east shore of Port Snettisham.

Discharge measurements.—Made from cable across river one-fourth mile upstream from gage.

CHANNEL AND CONTROL.—From the outlet of lake at an elevation of 520 feet above sea level and 2½ miles from tidewater, the river descends in a series of rapids and falls through a narrow deep canyon. Gage is in a pool at foot of two falls, each 25 feet high, which are known as Sweetheart Falls; outlet of pool is a natural rock weir, which forms a well defined and permanent control for gage.

EXTREMES OF DISCHARGE.—Maximum stage recorded during period, 4.2 feet August 14 (approximate discharge, computed from an extension of the rating curve, 2,100 second feet); minimum flow, estimated from discharge measurement and climatic data, 15 second-feet February 11.

WINTER FLOW.—Discharge relation not seriously affected by ice.

ACCURACY.—Results apparently excellent for stages below 2 feet, those for higher stages only approximate, as the rating curve is extended by estimation.

In the fall and winter the run-off is small because the precipitation is in the form of snow and because of the small amount of ground storage; during a hot, dry period the low run-off from the ground and lake storage is augmented by melting ice from one glacier.

Discharge measurements of Sweetheart Falls Creek near Snettisham, during period July 31, 1915, to Feb. 5. 1916.

[Made by G. H. Canfield.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1908.	*Feet.*	*Sec.-ft.*	1909.	*Feet.*	*Sec.-ft.*	1911.	*Feet.*	*Sec.-ft.*
July 31	1.95	520	Nov. 13	1.07	195	Feb. 5	[a] 0.33	17.8
Aug. 29	1.49	329	Dec. 14	.53	82			

[a] Discharge relation affected by ice.

Daily discharge, in second-feet, of Sweetheart Falls Creek near Snettisham for the period July 31, 1915, to Feb. 29, 1916.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1		478	298	825	180	105	55	22
2		412	595	545	188	140	50	21
3		361	1,060	424	234	145	48	21
4		335	955	585	280	136	48	19
5		328	661	639	260	124	49	19
6		328	495	466	240	134	47	18
7		324	412	380	220	161	43	18
8		316	335	346	200	132	42	18
9		335	284	284	180	106	45	18
10		453	247	324	160	87	47	18
11		535	222	530	140	94	47	18
12		955	202	617	130	87	45	18
13		1,740	194	717	188	82	46	18
14		1,940	247	922	270	81	43	18
15		1,740	432	1,460	247	82	42	20
16		1,460	612	1,160	205	82	39	23
17		890	606	825	170	87	38	26
18		622	510	545	165	99	38	29
19		482	515	400	140	105	36	33
20		400	722	316	130	97	34	36
21		354	922	257	143	99	31	40
22		316	666	211	138	108	30	45
23		291	474	180	124	116	29	56
24		284	453	158	114	99	29	54
25		354	678	147	105	86	29	47
26		420	825	147	101	82	29	36
27		384	678	151	97	90	28	29
28		354	922	163	94	79	26	29
29		335	1,500	194	87	69	25	32
30		328	1,300	180	99	70	25	
31	525	305		158		65	23	

NOTE.—Discharge determined from a rating curve well defined between 70 and 600 second-feet. Nov. 5-11, gage clock not running; discharge estimated. Jan. 19 to Feb. 29, discharge estimated because of ice, from one discharge measurement and climatic records.

Monthly discharge of Sweetheart Falls Creek near Snettisham, for the period July 31, 1915, to Feb. 29, 1916.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
July 31			525	1,040	
August	1,940	284	586	36,000	B.
September	1,500	194	601	35,800	B.
October	1,460	147	460	28,300	A.
November	280	87	168	10,000	B.
December	161	65	101	6,210	A.
January	55	23	38.3	2,360	B.
February	56	18	27.6	1,590	D.
The period				121,000	

MILL CREEK NEAR WRANGELL.

Location.—In latitude 56° 28′ N., longitude 132° 12′ W., near outlet of Lake Virginia on east shore of Eastern Passage, a narrow channel between Wrangell Island and mainland, 6 miles by water from Wrangell.

Drainage area.—48 square miles (measured on U. S. Coast and Geodetic Survey chart No. 8200).

Records available.—June 17, 1915, to February 29, 1916.

Gage.—Stevens water-stage recorder on left bank one-fourth mile below Lake Virginia and three-fourths mile above tidewater.

Discharge measurements.—Made from cable across creek, 10 feet upstream from gage.

Channel and control.—From the outlet of the lake, at an elevation of 100 feet above sea level and at a distance of 1 mile from tidewater, the creek descends in a series of rapids and falls. The bed is glacial drift and bowlders at the rapids and rock outcrop at points of concentrated fall. The gage is in a pool of still water created by a small fall at a contracted point of channel. This fall makes a well-defined, permanent, and very sensitive control.

Extremes of discharge.—Maximum stage recorded during period, 8.0 feet October 16 (approximate discharge, computed from extension of rating curve, 3,160 second-feet); minimum stage recorded, 0.02 foot February 11 (discharge, 15 second-feet).

Winter flow.—Ice forms on the lake, at gage, and along the banks, but the swift current and flow of relatively warm water from the lake keeps the control open.

Accuracy.—Records apparently fair. The rating curve is well defined to a stage of 2.5 feet, above which it is extended by estimation and the recorded discharge is only approximate.

The drainage basin is covered with a heavy stand of timber to an elevation of 2,500 feet and a dense undergrowth of ferns, brush, alders, and devil's club, but because of the steep slopes and thin soil the run-off after heavy rains is rapid and the ground storage is small. During a dry, hot period in summer the flow is augmented by melting ice from glaciers at the headwaters of two of the tributary streams.

Discharge measurements of Mill Creek near Wrangell during the period June 19, 1915, to Feb. 29, 1916.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
June 19	Canfield and Allen	2.54	477	Feb. 1	G. H. Canfield	0.10	19
July 1	.....do	2.30	421	24	.....do	1.32	164
Nov. 3	G. H. Canfield	1.94	318				

Daily discharge, in second-feet, of Mill Creek near Wrangell for the period June 17, 1916, to Feb. 29, 1916.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1	....	418	421	421	575	299	125	69	21
2	....	469	370	610	370	273	376	62	19
3	....	492	325	1,810	294	299	525	57	18
4	....	466	294	1,310	510	400	454	55	18
5	....	510	278	770	645	430	340	54	18
6	....	575	355	558	415	325	253	54	17
7	....	454	451	492	286	236	370	51	17
8	....	394	610	406	427	294	340	45	16
9	....	394	870	355	610	142	219	43	15
10	....	325	1,610	309	475	128	156	41	14
11	....	291	1,510	268	850	118	128	41	14
12	....	331	1,560	236	810	109	110	42	20
13	....	376	1,910	236	1,240	153	100	40	22
14	....	385	1,310	409	1,110	286	87	42	26
15	....	349	1,460	872	2,120	312	87	40	72
16	....	358	850	830	2,620	243	82	40	253
17	662	373	540	592	1,480	190	90	37	205
18	575	355	540	492	715	194	105	36	168
19	492	340	460	379	575	190	120	32	376
20	525	358	394	400	540	170	135	32	715
21	645	409	355	698	510	212	150	30	412
22	525	510	325	492	475	212	164	30	263
23	451	525	320	343	445	160	144	29	200
24	424	492	340	312	415	139	124	29	170
25	445	454	385	790	385	137	107	28	168
26	469	525	409	715	355	130	98	28	160
27	397	610	331	510	325	118	97	27	140
28	349	610	312	830	325	107	88	25	124
29	346	558	340	1,460	325	102	83	25	109
30	382	525	355	1,040	299	114	80	24	....
31	....	463	394	....	299	....	74	22	....

NOTE.—Discharge determined from a rating curve well defined below 600 second-feet. Gage not working properly Oct. 5 to Nov. 2 (paper not feeding); discharge estimated from maximum and minimum stages indicated by recorder, from comparison of hydrograph for this station with those for Orchard Lake outlet and Sweetheart Falls Creek, and from climatic records. Dec. 18–21 (paper wound on drum and clock stopped), discharge interpolated. Water frozen in well Jan. 23 to Feb. 11; discharge estimated from one discharge measurement and climatic records.

Monthly discharge of Mill Creek near Wrangell, for the period June 17, 1915, to Feb. 29, 1916.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).	Accuracy.
	Maximum.	Minimum.	Mean.		
June 17–30	662	346	478	13,300	A.
July	610	291	442	27,200	A.
August	1,940	278	647	39,700	B.
September	1,780	236	632	37,600	B.
October	2,620	286	672	41,300	D.
November	430	102	207	12,300	B.
December	525	74	175	10,800	B.
January	69	22	39.0	2,400	B.
February	715	14	131	7,540	B.
The period	....	....	....	192,000	

GREEN LAKE OUTLET AT SILVER BAY, NEAR SITKA.

LOCATION.—In latitude 56° 59′ N., longitude 135° 5′ W., at outlet of Green Lake, at head of Silver Bay, 10½ miles by water south of Sitka.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—August 22, 1915, to February 29, 1916.

GAGE.—Stevens water stage recorder on right bank at outlet of lake, reached by a trail which leaves the beach one-fourth mile north of mouth of stream, ascends a 600-foot ridge, and then drops down to the outlet of the lake.

DISCHARGE MEASUREMENTS.—Made from cable across outlet 30 feet below gage.

CHANNEL AND CONTROL.—From Green Lake, 240 feet above sea level and 1,800 feet from tidewater, the stream descends in a series of falls and rapids through a narrow canyon whose exposed rock walls rise perpendicularly more than a hundred feet.

EXTREMES OF STAGE.—Maximum stage recorded during period, 8.15 feet at midnight October 15; minimum stage, estimated from known stage January 15, and climatic data, −1.5 feet February 4.

WINTER FLOW.—Ice forms on lake and at gage, but because of current and flow of relatively warm water from the lake the control remains open.

Data insufficient for estimate of daily and monthly discharge.

In the fall and winter, the flow is low because there is little ground storage and on most of the drainage area the precipitation is in the form of snow. This accumulated snow produces a large run-off during the spring, and the melting ice from the glacier and the ice-capped mountains augment the run-off from precipitation during the summer. The area of Green Lake is estimated to be only 70 acres.

Discharge measurements of Green Lake outlet at Silver Bay, near Sitka, during the period Aug. 22, 1915, to Feb. 29, 1916.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
		Feet.	*Sec.-ft.*			*Feet.*	*Sec.-ft.*
Aug. 22	G. H. Canfield	[a] 2.39	259	Dec. 6	G. H. Canfield	2.15	261
Nov. 22	.....do	1.18	136	Feb. 16	.....do	.47	96

[a] A tree top lodged on the control caused backwater of 0.2 foot at gage.

Daily gage height, in feet, of Green Lake outlet at Silver Bay, near Sitka, for the period Aug. 22, 1915, to Feb. 29, 1916.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Feb.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Feb.
1		2.50	4.09		0.31		16		5.51	4.55		0.10	0.50
2		5.52	2.85		.98		17		3.88			.15	.12
3		4.75	2.78		1.90		18		3.18			.42	1.32
4		3.24	4.07		2.27		19		2.76			.72	2.42
5		2.47	6.00		1.80		20		3.70			1.40	2.39
6		2.12	3.56		2.00		21		3.54			.98	1.43
7		2.05	2.37		2.25		22	2.40	2.64		1.25	.83	.90
8		1.93	2.73		1.50		23	2.50	1.98		.97	.85	.58
9		1.79	3.04		.90		24	2.59	2.00		.82	.56	.41
10		1.60	2.60		.55		25	2.78	5.30		.67	.27	.40
11		1.50	5.28		.33		26	3.12	6.80		.55	.18	.36
12		1.46	5.12		.19		27	2.72	4.60		.40	.22	.32
13		2.50	6.10		.08		28	3.07	4.16		.27	.17	.22
14		5.37	5.88		.05		29	3.48	7.25		.24	.22	.08
15		7.30	6.40		.05	0.50	30	3.60	5.80		.26	.02	
							31	2.96				.00	

NOTE.—No gage records Oct. 17 to Nov. 21; gage clock stopped. Water below bottom of well Jan. 1 to Feb. 14; gage read −0.70 foot Jan. 15.

MISCELLANEOUS MEASUREMENTS.

Miscellaneous discharge measurements in southeastern Alaska, 1915–16.

Date.	Stream.	Tributary to or discharging into—	Locality.	Gage height.	Discharge.
				Feet.	*Sec.-ft.*
1915. July 14	Reynolds Creek	Copper Harbor	Just above stream entering from right near tidewater, three-fourths mile from Coppermount, Prince of Wales Island.		15
Aug. 3	Crater Lake outlet	Port Snettisham	Gaging station at outlet of Crater Lake, Speel River project.	2.49	397
4	Long Lake outlet	Speel River	Gaging station at outlet of Long Lake, Speel River project, on mainland.	2.82	981
1916. Jan. 11	Unnamed Creek	Carroll Inlet	1 mile upstream from beech, on east shore and 1 mile from head of Carroll Inlet, Revillagigedo Island.		64
26	Gokatchin Creek	Thorne Arm	Low tide at mouth of creek one-fourth mile east of Sea Level, Revillagigedo Island.		18
Feb. 4	Long Lake outlet	Speel River	New gaging station below Second Lake, Speel River project.		24
4	Crater Lake outlet	Port Snettisham	Low tide at mouth of stream from Crater Lake, Speel River project.		5
5	Speel River	do	Tide flats at Speel Point during low tide, one-half mile from cabins of the Speel River project.		150
7	Grindstone Creek	Stephens Passage	Low tide at mouth of stream between Point Salisbury and Point Bishop north shore Stephens Passage, 11 miles southeast of Juneau.		3.2
7	Rhein Creek	do	do		1.6

MINERAL RESOURCES OF THE UPPER CHITINA VALLEY.[1]

By Fred H. Moffit.

INTRODUCTION.

Upper Chitina Valley is a part of the Copper River drainage basin, which has been visited infrequently and concerning which not much is known. A few prospectors and hunters have gone into it nearly every year since gold was discovered in the Nizina district but have found little aside from game to reward their labor. In 1912 and 1913, however, members of the Alaskan Boundary Delimitation Commission, while determining and marking the international boundary between Mount Natazhat and Mount St. Elias, spent several months in the district. After carrying their system of triangulation from the upper White to the upper Chitina by way of Skolai Pass and Nizina River they established a base camp near the foot of Chitina Glacier, from which they completed their surveys of this section of the boundary. As part of the work they made a topographic map, still unpublished, of Chitina Glacier and part of Chitina River. The map includes Chitina Valley eastward from Canyon Creek to the boundary line but represents only a narrow strip of territory adjacent to the river and the three principal branches of the glacier. This survey constitutes the only work done by the Federal Government in the upper Chitina Valley until 1915.

The work that serves as a basis for this report was undertaken in order to extend the knowledge of this part of Alaska by a study of its geology and by making such additions to the topographic map just mentioned as were found necessary to represent the distribution of geologic formations and the mineral resources. Both the topographic and geologic mapping were of a reconnaissance nature.

The district examined has an area of about 900 square miles. It does not include all the territory shown on the map made by the Alaskan Boundary Delimitation Commission, but on the other hand it includes a considerable area not shown on that map. The addi-

[1] A more extended account of this district will appear in a future bulletin.

tions represent the topographic mapping done in 1915, which covered an area of about 360 square miles. Most of this newly surveyed area lies north of Chitina River at the head of Young Creek, on Canyon Creek, and in the glacier valleys east of Canyon Creek. High water made it practically impossible to cross Chitina River with horses during most of the summer, and the lack of time and equipment for traveling on glaciers prevented a visit to the higher parts of the valley later in the season.

The field party consisted of five men and was equipped with a pack train and with provisions for 90 days. The party landed at McCarthy June 14 and left that place, after completing its work, on September 22. It thus had a field season of nearly 100 days, 17 of which were spent in arranging packs at the beginning of the season and repacking at its end, in traveling to and from the Chitina, and in visiting the placer mines of Dan and Chititu creeks.

The weather during the summer was exceptionally favorable. The days were warm and clear and little rain fell. Conditions, however, were favorable for forest fires, and for two weeks in July topographic work was carried on with difficulty owing to the dense smoke that was brought up the valley by westerly winds.

Mr. R. M. Overbeck assisted the writer with the mapping in the field and with the preparation of this report.

GEOGRAPHY.

The map (Pl. V) represents the region under discussion and shows its location with reference to McCarthy and the Copper River & Northwestern Railway. A trail leads from McCarthy to Clarkins Road House at the mouth of May Creek on the east side of Nizina River, from which point either one of two routes to Chitina River may be chosen. The route commonly used follows Chititu Creek to Blei Gulch, crosses the ridge to Young Creek and then, after ascending Young Creek to the bend, passes over the mountains south of Young Creek to the bars of the Chitina. This trail is well marked and good, except that it necessitates crossing two high ridges. A second trail ascends Young Creek from the Nizina for 5 or 6 miles and there crosses a low wooded ridge to the Chitina. It has been used principally by prospectors going to or returning from Kiagna River, one of the southern tributaries of the Chitina. Because it is shorter and has easier grades this trail would probably become the principal route to Chitina River if any considerable travel should develop in that direction in the future. No well-defined trail connects the Chitina ends of these two trails, and although the river bars furnish good traveling for part of the distance the river swings in against its north bank in places so that considerable timber and brush would have to be cut if the connection were made. The only obstructions to travel on the north side of Chitina River above the Chitina-Young creek trail are glacial streams. Travel is not possible up the south side of the river above Canyon Creek.

The upper Chitina Valley is a region of rugged mountains. On the north the highest peaks rise to a height of 15,000 feet or more. To the east and southeast Mount Logan and Mount St. Elias reach heights of 19,539 feet and 18,024 feet respectively. Many lesser peaks stand well above the snow line. The relief of the region is great, for Chitina River at its source is only 2,000 feet above the sea.

All the larger valleys tributary to Chitina Valley above Canyon Creek are occupied wholly or partly by ice. For this reason it is impracticable or impossible to travel with horses any considerable distance away from the bars of the main river. For this reason, also, travel is difficult in warm weather, when the streams are flooded by the melting ice

Chitina River follows a course slightly north of west from the glacier almost to the Tana, its largest tributary above the Nizina. There it swings nearly to the northwest and so continues to the mouth of the Nizina. Kiagna River, Goat Creek, and an unnamed stream coming into the main valley near the glacier are the largest southern tributaries above Tana River. They are torrential streams, fed by melting snow and ice and flowing in deep, canyon-like valleys. Canyon Creek and the short streams flowing from beneath the "first" and the "second" glaciers are the principal northern tributaries above the Nizina. Canyon Creek flows out from its upper valley to the Chitina through a chasm more than 2,000 feet deep. This stream and the "first glacier" stream can be forded with little difficulty where they spread out on the bars just before joining the Chitina. The "second glacier" stream, frequently called Short River, is a raging torrent, wholly impassable with horses in times of high water like midsummer in 1915, though a crossing, difficult and at times somewhat dangerous for horses, can be made on the ice at its head.

The flood plain of upper Chitina River is from 3 to 4 miles wide and is broken only by a few spruce-covered islands, the tops of rocky points that project through the deep gravels. Nearly all this wide flood plain was covered by the river during high water in the late part of July and the early part of August, 1915. Along the margins of the plain are low benches, parts of an older flood plain, overgrown with pea vine and brush or with scrubby timber. The gravels of the flood plain and the low benches are saturated with water, which flows through them with a strong current and issues at the surface in numerous clear-water streams that unite to form deep channels and finally lose themselves again in the milky water of the river.

The experience of a few weeks in one summer does not warrant a very definite statement about the climate of this region. The valley is a basin hemmed in on all sides but the west by high mountains. The precipitation takes place in large part on the mountains themselves and there maintains the snow fields and supplies ice to the glaciers. No evidence was seen in the lower valleys to indicate much snowfall in winter or much rain in summer. On the other hand, it is believed that the precipitation is light in both winter and summer. The streams, however, are kept full in summer by water from melting snow and ice in the high mountains. It is reported that very little snow fell in Chitina Valley in the winter of 1914–15.

The summer of 1915 was remarkably dry and warm. Practically no rain fell till late in August, and for ten days in July the thermometer indicated a temperature near or above 85° F. in the middle of the day.

Spruce timber covers the lower slopes of the mountains to an elevation of more than 4,000 feet, fully 1,000 feet higher than the timber line in most of the Copper River basin. Probably no better timber can be found in the interior of Alaska than that which grows in parts of the upper Chitina Valley. Fine, straight trees from 18 inches to 2 feet in diameter and from 75 to 90 feet high were seen at a number of places. This timber seems to indicate that the winds are less severe here than on Copper River, but the members of the Alaskan Boundary Delimitation Commission's party report that they experienced such winds early in the spring. Spruce also grows on the benches bordering the river, but for the most part it is neither large nor of good quality. Areas of dead trees, untouched by fire, were noticed, and are thought to have resulted from the ravages of insects.

Grass is not at all plentiful in this part of Chitina Valley, even at timber line, where in most of the Copper River basin it grows abundantly, yet excellent feed for horses is provided by the pea vine that covers many acres of the old river flood plain. This plant furnishes forage not only in summer but throughout most of the year, so that horses are driven here and turned loose for wintering.

GEOLOGY.

The principal rocks in the upper Chitina Valley include shale, slate, arkose, limestone, conglomerate, sandstone, altered basaltic lava, tuffs, and granite. They range in age from Carboniferous to Cretaceous. Their general distribution is represented on the sketch map (Pl. V, p. 130). All the rocks are folded and much faulted. Some of them are locally schistose. Deformation and alteration, however, are much greater in the older formations than in the younger.

So far as known the oldest rocks are coarse fossiliferous arkose, more or less altered limestone, tuffs, and lava flows. Possibly some of the conglomerate should be included with them. They are the prevailing rocks east of Canyon Creek and north of Chitina River, and of them the lava flows and their associated tuff beds are the most abundant. The arkosic beds and much of the massive limestone are believed to underlie the lava flows and if this conclusion is correct are probably the oldest rocks of the region. Large exposures of the limestone are present near Chitina Glacier and along the "second glacier." In places the limestone is recrystallized and it nowhere yielded fossils. The arkose lies deep within the high mountains and is imperfectly known, although it must have considerable development there, for the glaciers bring down numerous fossiliferous bowlders derived from it.

The lava flows and closely associated rocks represent in part if not wholly the eastward continuation of the Nikolai greenstone of the lower Chitina Valley. They are well exposed between Canyon Creek and Chitina Glacier and show a lower part that consists of fine-grained basalts and tuffaceous beds overlain by an upper part made up of coarser-grained amygdaloidal flows. This corresponds well with the section of the Nikolai greenstone and underlying tuffs and basalts of the Kotsina-Kuskulana district. Like the greenstones in that district, these rocks are copper bearing.

The next younger rocks are limestone (the Chitistone limestone) and shale (McCarthy formation), both of which are of Upper Triassic age.

The known Jurassic rocks are gray and brownish sandstones, exposed in a few isolated areas. They were not distinguished in the field from the lithologically similar Cretaceous sandstones found near them and were separated from the Cretaceous rocks on the evidence of the fossils. Their principal exposures occur west of the mouth of Canyon Creek and on the tops of the high mountains between the "first glacier" and Chitina Glacier. They rest unconformably on the older rocks and are of unknown thickness.

The sandstones west of Canyon Creek are folded and faulted, but those east of the "first glacier" lie horizontally and appear to be little disturbed.

The rocks definitely known to be Cretaceous include brown and grayish sandstone and a great thickness of black and red shales. These rocks are best exposed on Young Creek. With them are included a succession of conglomerates, sandstones, arkoses, and shales that have their greatest development in the ridge between Young Creek and Chitina River but are exposed in some of the higher mountains north of Young Creek. These rocks overlie the black and red shales, but their age is not definitely determined. They have a thickness of not less than 2,000 feet south of Young Creek. This succession of coarse fragmental beds is the youngest of the hard-rock formations that has been recognized in the district.

The prevailing structural lines of the sedimentary rocks in this district in general parallel the course of Chitina River, but have a tendency to swing a little more to the northwest. The principal fault lines also have this direction.

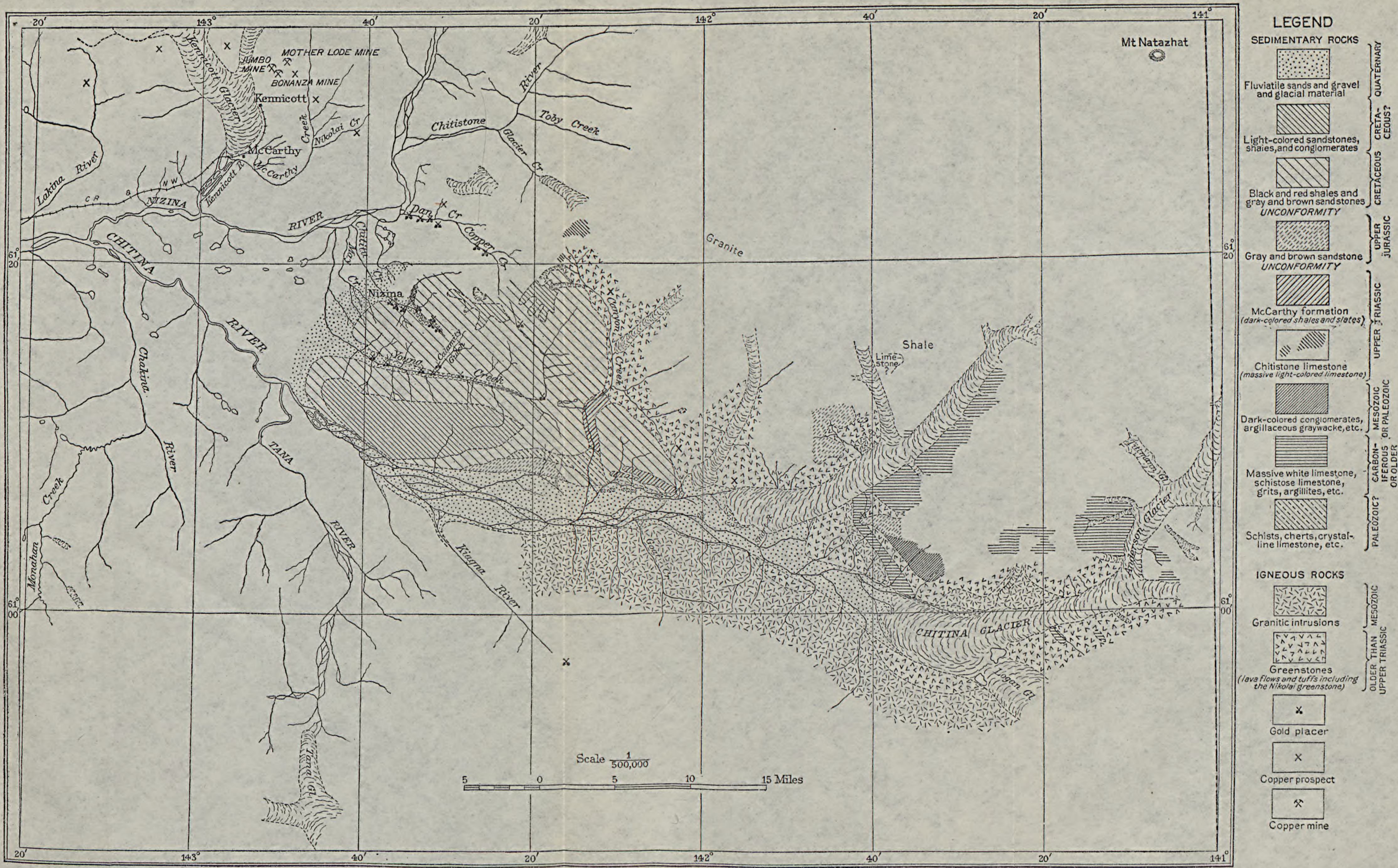
Granite is the prevailing rock south of Chitina River and east of the Kiagna. It forms most of the mountains there, but is associated in places with lava flows that are correlated with the basalts north of the river. Intrusions of granite in the sedimentary rocks and lava flows north of the river form several granitic bodies of large size. The numerous quartz porphyry dikes of Young Creek are of Upper Cretaceous or later age and are believed to be younger than the large granite bodies north and south of Chitina River to the east. They are thought to have a genetic relation to the gold mineralization of the Cretaceous shales.

Immense quantities of gravel have been spread over the floor of Chitina Valley, forming the present flood plain and older flood plains only a few feet above it. The larger tributary streams also have built up wide fan-shaped accumulations of gravel at their mouths, yet elevated bench gravels are singularly absent in the valley. It is evident that if they ever existed they were swept out by the former Chitina Glacier. Morainal deposits are present at the ends of the glaciers, but other than these are not conspicuous in the valley.

MINERAL RESOURCES.

Upper Chitina Valley has not given particular promise of becoming an important mineral-producing district, yet it should be stated that the valley has not been well prospected. Both gold and copper have been found there, but neither has been produced in paying quantity.

Native copper and copper sulphides, such as chalcocite, chalcopyrite, and bornite, are present in fracture planes and shear zones in the basaltic lava flows. These minerals were seen in places distant from the contact of the flows with the limestone and also near the contact. In their occurrence they resemble the deposits of the same minerals in the Nikolai greenstone farther west in Chitina Valley. Copper minerals were noted in greenstone on the west side of the "first glacier" near its foot, between the "first" and "second glacier," and east of the lower end of the "second glacier." A number of claims have been staked, but so far as the writer knows only those west of the "first glacier" have had assessment work done on them. Native copper and sulphides are found in fractured greenstone at this place.



GEOLOGIC SKETCH MAP OF UPPER CHITINA VALLEY.

By F. H. Moffit.

Gold is reported from at least three localities in the district—Kiagna River, the mouth of Canyon Creek, and the first southern tributary of Chitina River below the glacier. The writer was informed that float gold ore had been taken from the bars at the mouth of Canyon Creek, and that coarse gold had been obtained from the rim rock in the canyon. Efforts were made to sink a shaft to bedrock in the gravel a short distance below the mouth of the canyon. This was attempted both in winter and in summer, but was not successful.

The Indians who hunt in this region have reported gold in the gravel of the unnamed creek near Chitina Glacier, previously mentioned. It appears that no attempt has been made to confirm this report.

The presence of placer gold on Kiagna River has been known for a good many years, probably as early as 1904 or 1905, or shortly after the Nizina rush took place. A few men who crossed the glacier from Yakataga Beach worked on the head of Kiagna River for several summers after that time in the expectation of discovering gravel rich enough to be mined with profit. A small stampede took place to the Kiagna in the fall and winter of 1914, but these efforts met with disappointment and the men left the stream, so that it was deserted in the summer of 1915.

The prevailing rocks of the mountains east and south of Kiagna River are granite. The granite, however, is associated with greenstone and with shales, some of which are locally altered to schist. Most of the prospecting has been done on streams that cut the shales, yet gold is reported from the granite. The location of the shale suggests that possibly it may be the eastward extension of the gold-bearing sedimentary beds of Golconda Creek in the Bremner River district, but this, however, is no more than a conjecture.

A vein of molybdenite was found in the summer of 1915 about 8 miles up the glacier of the largest eastern tributary to Canyon Creek. The country rock is granite. The valley is narrow and inclosed by steep walls, so that the property is somewhat difficult of access. According to the statement of the locators, the vein is 8 feet wide and consists of quartz and molybdenite. The molybdenite occurs as a solid vein 12 inches thick between the quartz and the hanging wall, as stringers and bunches through the quartz, and as disseminated flakes in the quartz. There is no timber near the property, and the best source of supply is Young Creek, which is separated from Canyon Creek by a low, flat divide that is easily traversed. Any ore produced from this vein will have to be brought out in winter and hauled to McCarthy in sleds unless the value of the property should prove sufficiently great to warrant the construction of wagon roads or a railroad.

Although no mining projects have yet been established in upper Chitina Valley, it may be said that some important conditions are favorable to mining in this district. The transportation of freight into any part of Chitina Valley is now much simpler than it was before the railroad was constructed, and if there were traffic to warrant it a branch of the railroad could be built to the river and extended to the glacier without having to solve any unusual engineering problems. The chief difficulty probably would be found in crossing Nizina River. Excellent timber for mining is found all along the north side of the valley and would supply all probable needs for many years. The length of the summer season and the general climatic conditions also appear favorable.

MINING ON PRINCE WILLIAM SOUND.

By Bertrand L. Johnson.

GENERAL FEATURES.

The mineralization of the Prince William Sound region followed the intrusion of granitic rocks (Jurassic?) into the closely folded sediments (Mesozoic?) bordering Prince William Sound. These sedimentary rocks may be gathered into two great groups—one consisting dominantly of graywacke and argillite, and the other including black slates, dark-colored limestones, cherts, greenstones, argillites, jasper, and graywacke. The minerals introduced during this period of mineralization included gold, silver, chalcopyrite, pyrite, pyrrhotite, arsenopyrite, galena, sphalerite, stibnite, quartz, epidote, albite, chlorite, calcite, and siderite. The valuable metals of the ores are copper, gold, and silver. The gold is native. The copper occurs chiefly as chalcopyrite, but another copper-iron sulphide containing about 16 per cent of copper has been recognized at Landlock. Silver has been noted only as an alloy with the native gold.

The ore deposits of this region may be broadly grouped into two classes—copper deposits and gold-bearing quartz lodes. The mineral associations in both gold and copper deposits are in general the same, the dominant characteristics of the deposits depending on the relative abundance of the different minerals. The copper mines produce large amounts of gold or silver, or both, and chalcopyrite is present in small amounts in many of the gold quartz veins.

This separation of the valuable mineral deposits into two classes is carried further by the natural grouping of each of the classes in certain districts that correspond closely with the bipartite grouping of the rock formations of the region. The gold quartz lodes occur in the areas of folded and broken graywacke and argillite, whereas the sulphide ores are restricted to the areas of sheared slate, limestone, and greenstone. The gold quartz lode districts occur in a belt concave southward, bordering the inner shores of the Sound and surrounding the southern belt, which contains the copper camps.

The gold quartz ores are free milling. They are treated locally in small stamp or roller mills, with amalgamation. The concentrates are shipped to the smelter at Tacoma, Wash. The copper ores are base and require smelting, with or without previous concentration. No local smelters being available, the copper ores and copper-bearing concentrates are shipped to Tacoma by water. Their gold and silver content is recovered in the smelting process.

The productive mines on Prince William Sound in 1915 so far as known included four copper mines and five gold mines. A much larger tonnage of copper ore than of gold quartz was mined and treated, and the total value of the metals produced from the copper ores was about five times that obtained from the gold quartz ores. The value of the total mineral production of the Prince William Sound region in 1915 was $1,340,996, compared with $1,198,742 in 1914.

COPPER MINING.

GENERAL CONDITIONS.

An increased activity in copper mining over the preceding year was evident in 1915, and although no appreciable boom occurred there was also considerable interest manifested in copper prospecting, and it is reported that a few new discoveries were made in Passage Canal and in the district between Valdez and Port Wells. Some of the old copper properties on Knight Island were restaked. Both of the regular producers, the Beatson Copper Co., at Latouche, and the Ellamar Mining Co., at Ellamar, made large shipments as usual. The Threeman Mining Co., on Landlocked Bay, resumed shipments after two years, and the Fidalgo Mining Co., on Port Fidalgo, also shipped ore to the smelter. Development work was done on some of the nonproducing copper properties on Solomon Gulch, Landlocked Bay, Port Fidalgo, and Knights Island, and assessment work is reported on many others. All the copper ore shipped consisted of crude sulphide ore, in which the copper-bearing mineral was dominantly chalcopyrite. Much of the copper ore mined also carries either gold or silver, or both.

An increased quantity of copper ore was mined on Prince William Sound in 1915, but the average grade of the ore fell from $12.60 a ton in 1914 to about $8.07 in 1915. The total production of copper, gold, and silver from the copper ores was for each metal less than in 1914, but because of the high price of copper the total value of the metals recovered from the copper ores in 1915 was slightly greater than in the preceding year.

The future position of Prince William Sound as an important copper producer appears to depend on the successful treatment of the lower-grade copper ores by concentration or by a marked lowering of the mining or metallurgic costs through some radical change from the methods in use in the past. The completion and operation of a mechanical concentration process, chiefly by flotation, at the Beatson-Bonanza mine, on Latouche Island, for the recovery of the valuable metals in the ore marks a step in this direction.

LATOUCHE ISLAND.

The Beatson Copper Co. operated the Beatson-Bonanza mine, on Latouche Island, throughout the year. About 150 men were employed at the camp, half of whom were at work at the mine. Development work was continued as usual by open cuts, tunnels, and drifts, and more ore was mined than in previous years. A large plant for the concentration of the lower-grade ores, chiefly by an oil flotation process, is reported to have started operations early in the spring of 1915 and to have been in full operation during the later part of the year. Considerable crude sulphide ore was shipped to the Tacoma smelter, as in previous years, but a much larger quantity was put through the concentrating plant at Latouche, and the concentrates from this plant were shipped to Tacoma. One large cargo of concentrates was lost at sea on the way to the smelter.

On the property of the Latouche Island Copper Mining Co. (Ltd.), on Latouche Island, only assessment work was done in 1915, and this work was restricted to surface development.

KNIGHT ISLAND.

Development work is reported to have been started in August, 1915, on the Pandora property, on the Bay of Isles, and to have continued steadily during the fall with a crew of several men. The work done in 1915 included the deepening of the shaft 66 feet and the driving of 10 feet of crosscuts and 14 feet of drifts on the 90-foot level. The total underground developments now are reported to include a 90-foot shaft, 132 feet of drifts, and a 75-foot adit. A wide chalcopyrite-bearing ore zone is said to be developed by these workings.

On a copper property on Drier Bay considerable open-cut work is said to have been done and 60 feet of tunnel driven during 1915.

Only open-cut assessment work was done in 1915 on the property of the Knight Island Copper Mining Co.

PORTAGE BAY.

The discovery of a copper lode on the north side of the Portage Glacier Pass is reported, but no development work is known to have been done on it.

UNAKWIK INLET, WELLS BAY, LONG BAY, AND GLACIER ISLAND.

Only assessment work is reported on the copper prospects on Unakwik Inlet, Wells Bay, Long Bay, and Glacier Island.

VALDEZ DISTRICT.

No development work was in progress at the Midas mine of the Granby Consolidated Mining, Smelting & Power Co. (Ltd.), on Solomon Gulch, during the winter of 1914–15. Such work as was necessary to complete the aerial tramway, the mine terminal of the tramway, and the buildings at the mine and to fill in about the pile foundations of the shipping bins at the wharf was started in April, 1915, and was about completed at the end of the season. The aerial tramway was completed late in August and run intermittently during the fall. Considerable ore from the mine and dump was sent down on the tramway and stored in the ore bunkers on the wharf, but no shipments to smelters were made. About 50 men were employed on the property. Underground development work at the mine started late in June, and an average force of 10 men were at work in the mine during the rest of the season. Two shifts were at work all summer, the night shift consisting of two men. The lowest tunnel on the lode was extended to a length of about 410 feet (Oct. 21, 1915), and a 50-foot crosscut was driven on the next higher level. The buildings at the mine, besides the mine terminal of the tramway and the ore bunkers and blacksmith shop, include a large cook and bunk house, three cottages, three sheds, and an air-compressor building.

A large low-grade copper prospect, known locally as the Addison Powell property, situated on Sulphide Gulch about 4 miles from its junction with Lowe River, was relocated in the spring of 1915. About 150 feet of open cuts and stripping and 100 feet of tunnel are reported to constitute the development work done during the year. The principal copper mineral in the ore from this property is chalcopyrite, but some malachite is found. A little gold is also reported.

A copper lode is said to have been found on the south side of Lowe River about 15 miles east of Valdez.

ELLAMAR DISTRICT.

Only assessment work was done in 1915 on the property of the Galena Bay Mining Co., near the head of Galena Bay.

At Ellamar the plant of the Ellamar Mining Co. was operated throughout the year, and a large quantity of ore was mined and shipped. The underground work included the driving of additional crosscuts. Raises in the slate country rock at this mine in recent years are reported to have encountered explosive gases, the exact composition of which has not been determined.

The Threeman Mining Co. carried on operations from June to December and made several shipments of ore. Crosscuts were also driven on the Keystone and A. C. claims. A force of 10 men are reported to have been working for this company.

Two men are said to have been engaged in development work at the mine of the Landlock Bay Copper Mining Co. (Dolan & Rystrom property), on Landlocked Bay, but no shipments are known to have been made during 1915.

No work was done on the Standard Copper Mines ground on Landlocked Bay.

PORT FIDALGO.

Some development work was in progress in 1915 at all three of the copper mines on Port Fidalgo. The Fidalgo Mining Co. worked a small crew of men from June 1 to December 15, and shipped several hundred tons of ore to the Tacoma smelter. Mining was restricted to the footwall pay shoot.

Underground development work was started in the fall on the Schlosser property. The wharves and ore bunkers are reported to have been rebuilt, and a shipment of ore is said to have been sent to Tacoma near the end of the year.

The Mason & Gleason mine, now the property of the Dickey Copper Co., was operated only during November and December, 1915. Ore bunkers and a wharf were erected on Irish Cove.

GOLD MINING.

GENERAL CONDITIONS.

The gold produced in the Prince William Sound region, other than that from the gold-bearing copper ores, comes from both gold quartz lodes and gold placers. The placer deposits, because of the recent intense glaciation of the region and the consequent lack of concentration of the widely distributed gold, are few, small, and irregularly distributed. They are worked only intermittently, on a very small scale, and contribute little to the gold production. The producing gold quartz lodes are in the Port Wells and Port Valdez districts. In 1915 the Port Wells district was the larger producer, although most of the producing properties are in the Port Valdez district. The Granite mine, on Port Wells, made the largest contribution to the gold output of the region, and second place was held by the Ramsay-Rutherford mine, in the Port Valdez district.

PORT WELLS DISTRICT.

The geology and economic features of the gold deposits of the Port Wells district, together with the developments up to and including 1914, have been described in recent reports.[1] The Granite mine is the most productive property in the district and the largest

[1] Johnson, B. L., The Port Wells gold lode district: U. S. Geol. Survey Bull. 592, pp. 195–236, 1914; Mining on Prince William Sound: U. S. Geol. Survey Bull. 622, pp. 131–139, 1915.

producer among the gold quartz mines of the Prince William Sound region. Underground development and assessment work was done on several other properties in this district in 1915, and a few new lode discoveries are reported. Ocean-going steamers continued their visits to Port Wells, and a regular mail and passenger service was maintained between Valdez and several points on Port Wells. The district was not visited by Survey parties in 1915, and few notes have been obtained regarding the developments of the year.

The Granite mine was under development throughout the year. Besides the work necessary to take out ore for the mill, a crosscut tunnel, reported to be 800 feet in length, was run at a lower level, and a long raise was made from this tunnel to the vein. In addition to the underground work at the mine, a substantial wharf was built for large boats, a new oil-burning power plant was installed on Hobo Bay, and a power line 4,800 feet long was erected between this plant and the auxiliary power plant near the mill. A 10-stamp mill, added to the milling plant in the spring of 1915, was in operation about seven months. The Lane mill was also reported in operation for several months. From 50 to 70 men were employed on the property during the year.

Considerable development work is reported on properties adjacent to the Granite mine.

Development work is reported on the North Star claim, on Avery River.

The Cordova Mining & Development Co. started the installation of a 5-stamp mill and an aerial tram on the Nugget and Golden Wonder No. 9 claims, near Golden, with a force of about 25 men. Some underground development work is also reported to have been done by this company on these claims. Later in the year, after the erection of the mill house, operations were discontinued, and the plant is reported to have been moved off the ground.

The Golden Eagle mill, at Golden, was idle in 1915, but some underground development work is said to have been done on this claim during the preceding winter. A tunnel was driven on the Wagner prospect near Golden, and in the spring a crew of 15 men started to sink a shaft on the Keynote claim.

On Hummer Bay surface stripping and opencut work is reported on the prospect of Bennett, Bailey & Heinz. On Pigot Bay 100 feet of tunnel is said to have been driven on the Hamilton property. Other properties on this bay were under development.

The Thomas Culross Mining Co. did some underground development work on its claims on Culross Island and is reported to have made a small shipment of ore to Tacoma.

PORT VALDEZ DISTRICT.[1]

The number of producing gold quartz properties in the Port Valdez district in 1915 was less than in the preceding year, but the total value of the bullion produced appears to have been about the same. The mills operated included only the Ramsay-Rutherford, Cliff, and Gold King. A small additional output is reported to have been obtained by mortar from the National claim, on the Columbia Glacier. Only assessment work was done over most of the Port Valdez district, but a small amount of additional development work is reported on a few of the properties. In all only about 45 men were employed at the producing properties throughout the year, but numerous others were employed for short times in the annual assessment work on the many claims scattered throughout the district.

The mill and plant at the Ramsay-Rutherford mine were operated from June 2 to December 31, 1915. After the completion of a 742-foot mill-level crosscut tunnel, which cut the vein about 310 feet below the outcrop, and the connection of the shaft from the upper workings to this level a change was made in the method of handling the ore, which is now lowered to the mill-level tunnel and trammed to the mill. The aerial tram connecting the shaft house with the surface tram to the mill was taken down, and this surface tram is no longer used. Underground work was in progress throughout the winter of 1914–15 and in 1915. The principal work was the completion of the long crosscut tunnel at the mill level. Early in July, 1915, the underground developments consisted of the 742-foot crosscut tunnel with 80 feet of drifts and a 25-foot raise on the 300-foot level, 50 feet of drifts on the 150-foot level, 210 feet of drifts and a crosscut on the 100-foot level, about 220 feet of drifts on the 50-foot level, a 70-foot crosscut tunnel, a raise from the 300-foot level to the surface, and stopes between the 50-foot and 100-foot levels and between the 50-foot level and the surface. At the end of the year it was reported that additional drifting was done on the 300-foot level. A total of 480 feet of drifts were opened in 1915. An average force of 16 men were employed on the property during the year.

The Valdez Mining Co. extended its lower tunnel 83 feet, drove a 40-foot crosscut, and after cutting the vein drifted along the footwall for 34 feet and then crosscut the vein again. Where first crosscut the vein is reported to have had a width of 10½ feet. The work was done under two contracts, four men being employed on the first and three men on the second.

On the Pinochle claim the lower tunnel is said to have been extended 60 or 70 feet and to have cut the vein. No work was done in the upper tunnel. Three men were at work on the property in July.

[1] A detailed report on the Port Valdez district is now in preparation.

Only assessment work was done on the Mineral Creek lodes in 1915, and the mills on the Mountain King and Big Four properties, which had been in operation the previous year, lay idle.

On Gold Creek some underground development work was done on the McCallum claims, near the head of the creek, where the owner was at work during part of the summer.

The upper workings of the Cliff mine were under lease to John E. Hughes, and the property was operated from May to December. A new vein, occupying a well-defined fissure and showing from 1 to 6 inches of quartz, was discovered on the crest of the hill. An adit 175 feet in length was driven, and the vein was stoped for about 75 feet. Several tons of the ore were milled in the Cliff mill, three stamps and two tables being used. Some underground work was also done under the original discoverer of the property, H. E. Ellis, in the old workings on the 100-foot and 200-foot levels, and some ore from these workings is said to have been milled. An average force of 20 men were employed during the season.

No work was done on the Three in One group during the first half of the year, but late in the summer two men were at work developing the property.

On the Sealey-Davis Mining Co.'s claims, on Shoup Bay, one man was at work during the summer and is reported to have done 200 feet of drifting in the middle tunnel, extending this tunnel to a total length of about 815 feet.

Four men were engaged in driving a 25-foot raise near the end of the long tunnel on the property of the Seacoast Mining Co. in the summer of 1915. A 4½-foot vein was cut in this raise about 18 feet above the tunnel.

On the Bald Mountain group one man was engaged in development work.

On the claims of the Cameron-Johnson Gold Mining Co. from two to six men were employed for a short time during the later part of the summer. The mill on the property was not operated during the year and no production was made. In the fall the company was placed in a receiver's hands and later was reorganized as the Valdez Gold Co.

Assessment work is reported on the Alice, Nymond, and Bence-McDonald claims.

The Gold King claims reverted to the original owners, and the property was worked by them during the summer. The mill was run for about a month during the spring, and seven or eight men were employed on the property at that time. During most of the summer, however, but one man remained on the property, and the development work was restricted to the driving of a crosscut in the long lower tunnel. In October three men were reported at work on the property.

Assessment work is reported on the Mayfield and National claims.

A 160-foot tunnel is said to have been driven during the winter of 1914–15 on a gold quartz property on the south side of Port Valdez, about a mile back from the Eight Mile Beach.

The entire valley of Lowe River from Keystone Canyon to the head of the river was located in the spring of 1915 as possible placer ground, and some of the claims were tested with a churn drill, apparently with unsatisfactory results, as no further work is reported to have been done. The Bud Mining Co. on Gold Creek did not operate in 1915, and only assessment work is known to have been done on the Mineral Creek placers.

ANTIMONY MINING.

Some prospecting for antimony was in progress on Prince William Sound in 1915, and some new stibnite-bearing prospects are said to have been located in the Port Valdez and Port Wells districts. No antimony shipments are known to have been made, and no extensive developments of antimony lodes were in progress.

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THE TURNAGAIN-KNIK REGION.

By Stephen R. Capps.

INTRODUCTION.

LOCATION.

The Turnagain-Knik region, as here defined, includes the area bordered on the north and northwest by Knik River and Knik Arm and on the south by Turnagain Arm, Portage Creek, and Portage Glacier. As thus outlined the region is roughly triangular in shape and lies between latitude 60° 45′ and 61° 30′ and longitude 148° 30′ and 150° 5′. (See Pl. VI.) On its eastern edge the area studied is bordered by rugged unexplored mountains with glacier-filled valleys, in which travel is slow and difficult. The area of the present investigation was limited in that direction to the more accessible valleys, with the object of covering as much ground as possible within the field season.

PREVIOUS INVESTIGATIONS.

The first geologic investigation in this region was made in 1898, when W. C. Mendenhall,[1] who was attached to a War Department expedition in charge of Capt. E. F. Glenn, crossed from Portage Bay over Portage Glacier and descended Portage Creek for a few miles before returning by the same route. A few weeks later he traveled up Glacier Creek and its tributary Crow Creek to the divide and descended Raven Creek and Eagle River (Yukla Creek) to its mouth. In 1904 F. H. Moffit, while studying the gold placers of the Turnagain Arm region[2] visited the placer mines on Crow Creek and prepared a full description of the mining developments at that time. In 1911 B. L. Johnson and later A. H. Brooks, G. C. Martin, and B. L. Johnson made observations from Kern Creek to the head of Crow Creek and for a few miles into the head of Raven Creek valley. The information then obtained by them and procured from other sources was embodied in a description of the mining

[1] Mendenhall, W. C., A reconnaissance from Resurrection Bay to Tanana River, Alaska: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 265–340, 1900.

[2] Moffit, F. H., Gold fields of the Turnagain Arm region: U. S. Geol. Survey Bull. 277. pp. 7–52, 1907.

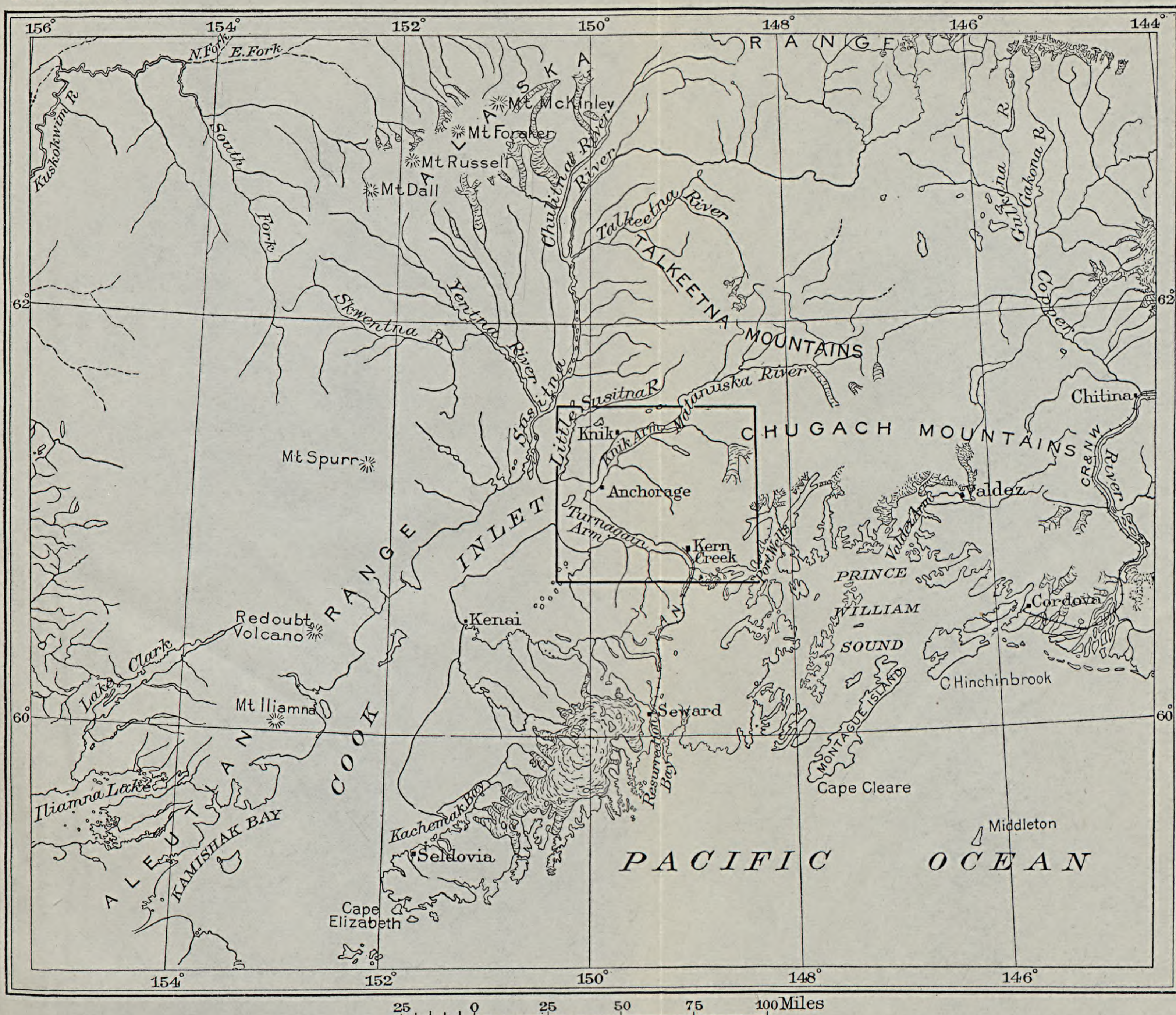
operations in the Glacier Creek basin.[1] Topographically a large part of this district is still unmapped. In 1898 Mendenhall[2] sketched the topography along his route, and in later years R. A. Hamilton, R. H. Sargent, and T. G. Gerdine sketched the portions of the mountain front that were visible from tidewater. B. L. Johnson also elaborated Mendenhall's mapping of the Crow Creek basin.

FIELD WORK.

With the announcement that the Seward-Fairbanks route had been chosen for the Government railroad, attention was immediately attracted to those portions of Alaska that would be directly served by this railroad. The route, following the north side of Turnagain Arm and the southeast side of Knik Arm, will bring railroad transportation within easy reach of the entire Turnagain-Knik region, and a large influx of people attracted both by the work incident to building the railroad and by the agricultural possibilities was readily foreseen. It was determined, therefore, to survey the entire region, both topographically and geologically. For this purpose two parties were organized, one in charge of J. W. Bagley to conduct the topographic surveys, and the other in charge of the writer to carry on the geologic work. Mr. Bagley landed at Ship Creek on June 3, 1915. At that time a tent town had already sprung into existence, and active construction on the railroad had begun. In burning the timber and vegetation on the right of way, however, a great amount of smoke was formed, and this was increased by numerous forest fires. The smoke was so serious a detriment to topographic work that on June 13 Mr. Bagley transferred his party to the Talkeetna Mountains. He returned to Anchorage in September and succeeded in extending the topographic mapping up Ship Creek, down Indian Creek to Turnagain Arm, eastward along the arm to Glacier Creek, up that stream and its tributary Crow Creek to the divide, and thence down Raven Creek and Eagle River to Knik Arm.

The writer, with a party consisting of a packer and a cook and five pack horses, arrived at Anchorage June 14, 1915, and remained in the district until September 1. Although the thick smoke caused considerable annoyance and delay, an area of about 1,400 square miles was mapped geologically. Unfortunately no topographic base map was available for a part of this area, and the mapping of the rock formations, as shown on Plate VIII, is the result of work on sketch maps made under unfavorable conditions. The outlines are therefore subject to modification when a more accurate base map

[1] Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, pp. 173–176, 188–193, 1915.
[2] Op. cit., map 16.



INDEX MAP SHOWING THE LOCATION OF THE TURNAGAIN-KNIK REGION.

becomes available. The microscopic study of the rocks here described was made in the office by J. B. Mertie, jr.

GEOGRAPHIC FEATURES.

The Turnagain-Knik region may be divided into two provinces of distinctive and sharply contrasting topography. The smaller province consists of the lowland that borders Knik Arm throughout its length and Turnagain Arm for 12 miles southeast of Point Campbell. The lowland area has a maximum width of about 10 miles at its southwest border, near Point Campbell, but narrows gradually northwestward to the mouth of Knik River, where the river flows directly against the base of the mountains. This lowland is in fact an extension of the great lowland of the lower Susitna Valley, though separated from it by the shallow waters of Knik Arm. It consists of tidal flats near the water's edge and terraces and low rolling hills, commonly not exceeding 500 feet in elevation, farther inland. The tidal flats may be divided into two classes—those inundated at ordinary flood tides and those covered only at extreme tides but generally above tide level. The flats within the range of the average tides are expanses of blue-gray, sticky silt, bare of vegetation and cut by canyon-like gullies. In this area the extreme tidal range is great, being 33.6 feet at Fire Island and 38 feet at Anchorage, and as both Knik and Turnagain arms are shallow, wide areas along their shores are laid bare at low tide. Above the height reached by ordinary tides but below the level of the extreme tides there are, especially near the mouths of streams, flats that are inundated only at long intervals. These flats form grassy meadows or marshes but carry little or no timber. The remainder of the lowland area consists of flat-topped terraces and rolling hills, which gradually increase in elevation toward the mountains but show a sharp topographic break along the mountain face. They are generally timbered, though the forests are broken by marshes and meadows in the areas of poor drainage.

The other topographic province, which is much the larger of the two, consists of the mountainous part of the area. Turnagain Arm, on its south border, is a glacial fiord along which the mountains descend precipitously to sea level, there being practically no lowland except along the lower courses of the larger streams. However, a considerable area of bare tidal flats is exposed during low tide. The mountains are the westward extension of the Chugach Mountains, which reach from Cook Inlet to Mount St. Elias and which are continued to the east by the St. Elias Mountains and to the southeast by the Kenai Mountains. They are distinctly alpine in character, all the larger streams that flow from them heading in glaciers. The higher peaks in the center of the district reach elevations of 5,000 to 7,000 feet or more.

As the district is bordered on the south and northwest by tidewater, the streams in general have direct courses to the sea, are of steep grade, and have few tributaries. The valleys all show plainly the effects of severe glaciation. Knik River is much the largest stream, although only about 30 miles long. It heads in the great Knik Glacier and flows in a westerly direction to the head or Knik Arm. All its tributaries from the south, except one unnamed stream 7 miles below the glacier, are comparatively small. Eklutna Creek, Peters Creek, and Eagle River (Yukla Creek) all flow northwestward to Knik Arm. Each heads in ice fields, and the waters of Eklutna Creek and Eagle River are predominantly of glacial origin. A few smaller streams, the largest of which is Ship Creek, flow from this mountain mass into either lower Knik Arm or Turnagain Arm. Turnagain Arm has several large tributaries from the north and east. Portage Creek drains Portage Glacier and several smaller ice tongues and, although only 6 miles long, carries at times a large volume of water. Twentymile River emerges from two large ice tongues and joins Turnagain Arm at its head from the northeast. Glacier Creek, as its name implies, is fed by a number of small glaciers, and Bird and Indian creeks also carry portions of the drainage from the mountain mass to Turnagain Arm. In general the streams tributary to Turnagain Arm are much shorter than those flowing to the northwest.

ROUTES OF TRAVEL.

This part of Alaska is accessible only by ocean steamship, and two lines maintain regular schedules between Seattle and ports on the Gulf of Alaska. During the summer season steamships make regular calls at Anchorage, on Knik Arm, and although no docks had yet been constructed in 1915, passenger and freight were discharged at receiving barges and taken ashore by small boats. From Anchorage small launches connect with all upper Cook Inlet points and make trips up Susitna River as far as the mouth of Talkeetna River. Anchorage is the summer terminus of the new Government railroad from the coast to Fairbanks, by way of Susitna Valley. The rails on this line were laid from Anchorage to Eagle River in 1915. The ultimate coastal terminus of this railroad is Seward, and during the winter, when ice forms in upper Cook Inlet and navigation is closed, all travelers bound for the Knik-Turnagain district land at Seward. The old Alaska Northern Railroad, now incorporated into the Government railroad system, extends from Seward northward for 71 miles to Kern Creek, on the north side of Turnagain Arm, beyond which it had not been completed in 1915. When in operation this road could be used by travelers from Seward to Kern Creek, but for the last two or three years it has not been regularly operated. The route of the railroad line was used, however, by winter travelers journeying afoot or by dog sled from Seward to upper Cook Inlet and thence across the Alaska Range to Kuskokwim and lower Yukon rivers, and the mail was carried by dog sled over this route. From the terminus of the railroad at Kern Creek the winter trail follows the north shore of Turnagain Arm eastward to Indian Creek, ascends that stream to its head, crosses the divide to Ship Creek, follows that stream down to the base of the mountains, and thence goes around the shore of Knik Arm to the town of Knik. The old winter trail ascended Glacier and Crow creeks to Crow Creek Pass and thence followed Raven Creek down to Eagle River and that stream down to Knik Arm. This trail was well graded, at the cost of much labor, but the high winds prevailing at Crow Creek Pass in the winter led to its abandonment in favor of the Indian Creek and Ship Creek route. In the fall of 1915 the work of reopening the railroad from Seward to Kern Creek was begun, and as soon as the line is built between Kern Creek and Anchorage the district will have rail communication with Seward the year around. A telephone line from Seward to Anchorage is already in operation.

As throughout the winter foot travel to this district has been slow and difficult and the cost of transporting freight almost prohibitive, and as even water transportation during the summer has until recently been irregular and unreliable, the completion of a railroad with continuous service to the region will be of inestimable value in the development of its agriculture and mineral resources.

VEGETATION.

Within the area here described timber occurs throughout the lowlands, in the valleys of the larger streams, and on the lower slopes of the mountains. No general statement of the height of timber line can be made, for it varies greatly from place to place. The lowland between Point Campbell and the head of Knik Arm consists of timbered areas interspersed with treeless meadows and marshes. Timber in general extends up the mountain slopes to altitudes between 1,500 and 2,000 feet. The prevailing trees are spruce and birch 18 inches or less in diameter. Locally there are cottonwood groves, some of the trees in which attain a diameter of 4 or 5 feet. Timber is found along the lower slopes of Knik River valley almost to the glacier and also extends up the valleys of Eklutna, Peters, and Ship creeks and Eagle River for many miles above the mountain front. In general it may be said that the timber of the Knik Arm basin is too small to furnish lumber for other than local needs. In the Turnagain Arm basin the timbered area is small, but the trees are of much greater size. Along the lower slopes of the mountain and in the larger tributary valleys there is a good stand of spruce and hemlock, in which individual trees attain 4 feet in diameter. Plate VII shows the distribution of timber in this region.

A list of the trees and larger bushes seen includes spruce (two species), birch, hemlock, cottonwood, aspen, several varieties of willows, alder, and mountain ash, and the smaller bushes include devils club, currant, high-bush cranberry, raspberry, buck brush, blueberry, and roses.

Grass for forage is abundant on the highest tidal flats but is scarce in the timbered and marshy lowlands. On the timbered mountain sides sufficient grass of the variety known as red top can nearly everywhere be found and near timber line is usually present in great abundance. At still higher altitudes bunch grass is to be found locally, so that pasturage for stock is plentiful in all the larger mountain valleys.

GAME.

Some big game still exists in this district, although it is not particularly abundant. Moose range the Knik lowland and its tributary valleys, although it is to be expected that they will rapidly disappear from the vicinity of the railroad. Mountain sheep were seen in the rugged mountains at the heads of Peters and Eklutna creeks and of Eagle and Knik rivers, and goats occupy much the same range as the sheep. Black, brown, and grizzly bears are occasionally seen. Trout may be caught from nearly any clear stream, and grouse are fairly abundant in the spruce forests. Both willow and rock ptarmigan occur in great numbers above timber line; the willow ptarmigan haunt the areas of willow brush and high grass, and the rock ptarmigan prefer the high, nearly barren talus slopes and glacial moraines.

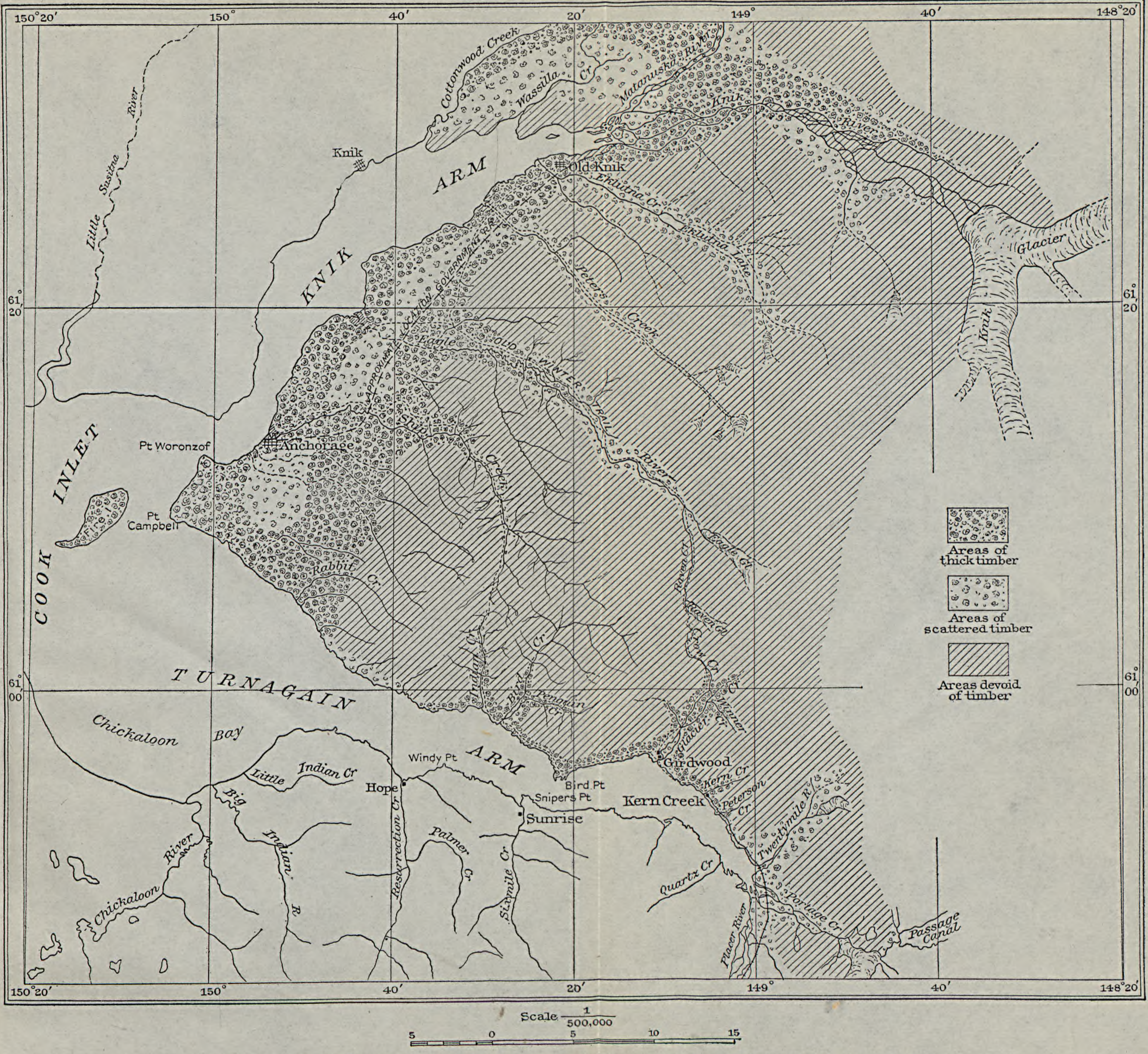
NATIVES.

Very few Indians were seen during the summer, as at that season they move to their favorite streams to catch and dry salmon for winter use. At Old Knik, near the head of Knik Arm, there is a village containing a few dozen houses and a church, all deserted at the time of the writer's visit. The natives are said to return to their homes in the fall and to spend the winter in trapping and hunting.

GEOLOGY.

PRINCIPAL FEATURES.

The rocks of the Turnagain-Knik region comprise a wide variety of materials and include sedimentary rocks in large volume and also abundant material of igneous origin, ranging from coarsely granular



SKETCH MAP SHOWING THE DISTRIBUTION OF TIMBER IN THE TURNAGAIN-KNIK REGION.

intrusive rocks to surface lava flows and beds of fragmental volcanic material. A study of the field relations of the rock formations has yielded some definite data in regard to their relative age, but actual age determinations have not yet been made. The accuracy with which any rock formation can be placed in its proper position in the geologic time scale must depend upon the fossils found in it or upon its relation to other fossil-bearing rocks. Unfortunately, the rocks of the region here discussed are peculiarly barren of fossils. Fossils have been found in only one formation and only a small area where specimens of a single species of doubtful diagnostic value were obtained. The age of the hard-rock formations is therefore still uncertain and must remain so until either satisfactory fossil collections are procured or the structural relations to some other associated formations, the age of which has been determined, are made out.

Plate VIII (p. 188) is a sketch map showing the geology of the region here discussed.

What are apparently the oldest rocks of the region occur along the west end of the mountains, in a belt that varies in width from north to south, being narrowest at its north end, near the mouth of Knik River, and widest toward Turnagain Arm. This belt probably continues southward on the south side of Turnagain Arm, but its extension in that direction is only surmised. The rocks in this belt can not be referred to any single rock type, for they comprise a wide variety of materials, all more or less metamorphosed. They include basic intrusive rocks, locally altered to serpentines, and altered intrusive rocks of a more acidic character, associated with much altered and crushed materials that are probably of sedimentary origin and some less altered slates. This whole assemblage has apparently been metamorphosed together, so that its structure is obscure. It comes into contact with both the slate and graywacke series and the greenstone tuffs described later and appears to be older than either.

Succeeding the metamorphic series is a great aggregation of argillites, slates, and graywackes, with minor amounts of conglomerate. These beds prevail along the north shore of Turnagain Arm from Indian Creek eastward to Portage Glacier and extend northward to the basins of Peters and Eklutna creeks and Knik River. They commonly strike in a northeast direction, have steep dips, and have locally been closely folded and faulted. They are known to contain beds of Mesozoic age, but their age limits have not been determined.

Next younger than the argillites and graywackes is an assemblage of greenstone and rhyolite tuffs, agglomerates, and flows, with some included clastic sediments. They occupy an area in the headward basins of Eagle River and Peters and Eklutna creeks and also occur on the south side of lower Knik River. These rocks are several thousand feet thick and lie with apparent unconformity upon both the argillite and graywacke series and the older undifferentiated rocks.

The youngest deposits of the region consist of unconsolidated materials, including morainal and outwash deposits laid down by the greater glaciers that formerly occupied the region and by the existing ice streams and also the gravels, sands, and silts of the present streams and the silts now accumulating in Knik and Turnagain arms. The unconsolidated deposits are most abundant in the lowlands of Knik River and Knik Arm, where they mantle the surface and attain a considerable thickness. It is not unlikely, however, that bedded materials of Tertiary age occur within this area, although for the most part covered by younger beds. Reports have been received that coal beds crop out along the shore of Knik Arm between Ship Creek and Point Woronzof, but these reports have not been confirmed.

UNDIFFERENTIATED METAMORPHIC ROCKS.

DISTRIBUTION AND CHARACTER.

The western part of the mountainous province of this region is occupied by an undifferentiated assemblage of rocks all of which show the effects of regional metamorphism. The area in which they occur is widest at the south and narrows gradually toward the north, ending in a point along the south side of lower Knik River. It includes all the mountainous portions of the basins of Rabbit, Campbell, and Chester creeks, most of the basin of Ship Creek, and parts of the lower basins of Eagle River and Peters and Eklutna creeks. The south shore of Turnagain Arm, west of Hope, has not been studied geologically, but such information as could be obtained indicates that this belt of undifferentiated rocks extends southwestward across Turnagain Arm. It is entirely possible that the area of these rocks shown on Plate VIII includes also some rocks that should properly be classified with the greenstones and greenstone tuffs described on pages 161–165, for time was not available in the investigation on which this report is based to follow out accurately the contracts of the several lithologic units.

The undifferentiated rocks of this assemblage comprise a wide variety of materials. They include altered igneous rocks of acidic composition that under the microscope prove to be altered andesites and andesite porphyries and basic rocks consisting of peridotite, dunite, serpentine, pyroxenite, altered gabbros, and tuffs and agglomerates of igneous origin. They also include altered argillites, graywackes, and cherts of sedimentary origin. This whole assemblage has been cut by both basic and acidic dikes and probably by the bosses of diorite that project through the unconsolidated deposits near the mouth of Knik River.

STRUCTURE AND THICKNESS.

As a whole this assemblage of rocks is difficult to study in the field, for even in the members of sedimentary origin the structure is obscure, and the igneous members have apparently no consistent relation to the sediments. Furthermore, all the rocks are generally so altered and weathered that determinable specimens are not easily obtained. As seen from a distance, however, the mountains composed of these rocks locally display a semblance of structure, due in part to jointing and possibly in part to the bedding of the included sediments, that seems to parallel in strike the line of contact with the younger bordering formations. On close inspection this structure is less evident. Along the shore of Turnagain Arm west of Indian Creek the contact between this assemblage of rocks and the argillites and graywackes to the east has been the site of intense deformation, with shearing and brecciation. Bunches of argillite and graywacke are apparently squeezed and infolded into the metamorphic rocks, and the linear arrangement of these included materials is roughly parallel to the line of contact.

No definite figures for the thickness of these materials were obtained. The belt which they occupy has a maximum width of 10 to 12 miles, and near Turnagain Arm mountains composed entirely of them reach altitudes of 5,000 feet. The rocks certainly have a thickness of several thousand feet, even though the present surface area is the result of reduplication by faulting and folding.

AGE AND CORRELATION.

The age of this assemblage of undifferentiated rocks is still undetermined. The most that can now be said concerning their age is that they lie with apparent unconformity below rocks of the Sunrise group, which are known to be in part of Mesozoic age. The Sunrise group may, however, contain also some Paleozoic sediments, though as yet no Paleozoic fossils have been certainly identified. As the Sunrise group is known to contain fossils of either Jurassic or Cretaceous age, the undifferentiated rocks here discussed may be said to be certainly older than the late Mesozoic, and so far as the evidence now available goes they may be Paleozoic or even older.

UNDIFFERENTIATED ARGILLITES, SLATES, AND GRAYWACKES.

GENERAL CHARACTER.

That part of the Turnagain-Knik region lying east of a line connecting the mouth of Indian Creek and the mouth of Knik River consists predominantly of metamorphosed sedimentary rocks, including argillites, slates, and graywackes, with minor amounts of conglomerate, quartzite, and limestone. (See Pl. VIII.) Within this area there are some smaller areas of younger igneous rocks, but the sediments form the base upon which the igneous rocks were poured out or the host into which they were intruded, and the sedimentary series is believed to be continuous throughout the area outlined, although it is locally covered by the younger deposits.

The materials of this great sedimentary series were laid down in comparatively shallow water, and with the exception of a very small amount of impure limestone, they represent the clastic materials derived from some old land mass, the position of which is not now definitely known. The sediments as deposited consisted of muds, feldspathic sands, and gravels, but these materials were later converted through the agencies of heat and pressure, by cementation and by regional metamorphism, into shales and slates, graywackes, and conglomerates, with here and there small areas of schist.

The commonest member of this series consists of thinly interbedded argillites and graywackes. The graywackes are of lighter color than the argillites and the two present a banded, ribbon-like appearance. Locally the alternating bands are thin, ranging from a fraction of an inch to a few inches in thickness, but every gradation from thinly bedded materials to massive beds of argillite or of graywacke 100 feet or more in thickness may be found. Within certain small areas either the argillite or the graywacke may predominate, but the series as a whole contains argillites and graywackes in approximately equal amounts.

The sediments of this series have been metamorphosed in varying degrees and are now all hard rocks. The metamorphism is mostly that resulting from cementation and from regional folding and tilting, and only locally has there been notable contact metamorphism along the margins of bodies of intrusive rocks. The rocks resulting from the metamorphism of the originally incoherent shallow-water sediments are quite different in appearance from the materials as they were first laid down. The feldspathic sands have been changed by cementation to hard graywackes, the muds to dense argillites, and the gravel beds to conglomerates. Deformation has produced in places a secondary slaty cleavage, and the group term "slates and graywackes" has been much used to describe this great series of rocks. Taken as a whole, however, rocks with a well-developed slaty cleavage form only a small proportion of the series, so that the term "slates" as applied to this series is not well chosen. The term "argillite," used to denote a hard siliceous mud stone, without well-developed slaty cleavage, is believed to be more appropriate, and the group term "argillites and graywackes" is therefore here used to describe this series of sediments. The local development of slaty cleavage in rocks within this region can in most places be attributed to the position of the slaty bed in relation to folds. In general, the fine-grained mudstones have received a secondary cleavage more readily than the coarser graywackes, and a well-developed bed of slate may be bordered, both above and below, by massive graywacke beds that show no such cleavage. Within small areas, however, all the rocks have become somewhat schistose, and a secondary cleavage is present in the slates, graywackes, and conglomerates.

GRAYWACKES.

The graywackes of the Turnagain-Knik region are similar in all essential characteristics to those in the Prince William Sound and Kenai Peninsula regions, which have been so often described. They consist chiefly of angular grains of quartz and a variety of feldspars with fragments of other minerals and of bits of rock of various kinds, inclosed in a matrix of clayey material and containing more or less secondary silica as a cement. In texture they grade imperceptibly from the finer argillites through fine and medium grained sands to coarse gritty beds and conglomerates. The freshness of many of the particles of feldspar and ferromagnesian minerals and the relative abundance of particles of these rather easily decomposed materials indicate that the detritus from which these clastic deposits were derived came from a land mass in which erosion was more active than chemical decay. From particles of rock found in the graywackes and from pebbles in the interbedded conglomerates it is known that this land mass contained andesites, diorites, banded argillites, graywackes, and a good deal of quartz. The graywackes are generally of a grayish color.

In some places within this region the graywacke beds are so numerous and are individually so thick that the argillites form only an inconsiderable proportion of the beds exposed. In working out the structure of the rocks the attempt was made to use certain massive graywacke beds as horizon markers and by following their outcrops to decipher the structure of the whole series of sediments, but the result was disappointing, for each massive bed of graywacke was found not to be continuous along the strike for any great distance but to thin out laterally, giving place to other similar lenticular beds. Presumably the argillite beds also are lenticular. Along the edge of the stream flat south of Knik River, near Knik Glacier, graywacke beds are present in great abundance and form prominent bluffs. At this place, however, as well as along other stream valleys and on the north shore of Turnagain Arm, the graywacke beds are more conspicuous with relation to the argillites than their actual proportion in the series would justify, for they resist erosion more strongly than the softer argillites and stand out in prominent cliffs and bluffs, whereas the argillites have been eroded, and their areas are now represented by depressions.

The graywackes contain secondary calcite, both as a constituent of the rock mass and in the form of veinlets filling fractures. Quartz occurs also as a vein filling, and some veinlets consist of an intergrowth of quartz and calcite. At the locality near the head of Knik River already mentioned, the massive graywacke bluffs are cut by an intricate network of veinlets of quartz and calcite. In places the graywacke carries scattered grains of sulphides, chiefly pyrite and arsenopyrite.

ARGILLITES AND SLATES.

The argillites and slates of this group of sediments consist of the finer clastic materials driven from the same source as that which yielded the graywackes, and in composition they are not unlike the coarser associated sediments. In general the argillites and slates are darker than the graywackes, ranging in color from dark gray to black, and the contrast in color is especially conspicuous where rocks of the two types are interbedded in thin layers. The darker color is due to the fact that the typical argillites and slates contain more carbonaceous material than the graywackes. They also contain more clayey material, but they grade imperceptibly through increasingly coarser phases into fine graywackes, so that no sharp lines of distinction can be drawn.

The proportion of argillites and slates to graywackes necessarily varies from place to place. Locally the argillites are predominant and the graywackes almost or entirely absent. At other places the argillites and slates are present only in thin, widely spaced beds, the graywackes forming the greater part of the series. Considerable areas were seen in which the slates or argillites were almost unmixed with the coarser sandy materials, and in this respect the rocks of the Turnagain-Knik region are like those of adjoining areas in the Prince William Sound region, to the east.

The bedding of the argillites is usually distinct wherever they are well exposed. In the slaty phases, however, the secondary cleavage generally obscures the bedding, and the structure of the series at places where these phases occur must be determined from the more massive graywackes. The metamorphic processes that have caused the development of slaty cleavage in the fine, clayey sediments have generally left the more resistant graywackes little altered, and it is apparent that the rock flowage has taken place primarily along the less resistant fine-grained beds. The cleavage planes in the slates in many places run at angles across the bedding and terminate against an adjoining graywacke bed.

Both the slates and the graywackes are cut at many places by dikes and intruded by sills of acidic crystalline rocks. They also carry many veins and veinlets of quartz and calcite, which are especially abundant in the vicinity of the intrusive masses. A very few veins whose thickness can be measured in feet were seen, but most of the veins are small stringers varying from the thickness of a knife blade to an inch or more and reticulated through the whole mass of rock. At some places the argillites and graywackes are mineralized with small disseminated specks of sulphides, principally pyrite.

CONGLOMERATES.

The less prominent elements of the series, the conglomerates, quartzites, and limestones, constitute a very small proportion of the total volume. Of these the conglomerates are most abundant and occur in many parts of the district, but usually in beds of no great thickness. They are generally of a gray color, and most of their pebbles are argillite, but quartzite, quartz, and various igneous rocks are also represented. In most of the conglomerates seen the pebbles are less than 2 inches in diameter, although at a few places conglomerates with pebbles having a maximum diameter of 8 inches were seen. The matrix in general consists of a sandy argillite. The conglomerates apparently represent no important unconformities in the series, for wherever their relations to the adjacent beds could be made out they lie parallel to the underlying argillites and graywackes and show a gradation from the underlying bed, by a gradual increase in the abundance of pebbles, to a distinct conglomerate, and a similar gradation, by a decrease in the number of pebbles, to the overlying bed. As the whole series consists of distinctly shallow-water sediments, in which the coarseness of the beds depends largely on depth of water and nearness to the shore, the presence of a conglomerate bed at any locality does not necessarily mean an interruption in the deposition of the sediments and an unconformity, but it may mean only the deposition of unusually coarse materials near shore, without stratigraphic break.

Although conglomerates are by no means abundant in this district, they have been noted in place at a few localities and occur in the stream or glacial gravels in other valleys in which the actual outcrops were not observed. On the west side of Glacier Creek, about half a mile south of the mouth of Crow Creek, there are outcrops of a somewhat sheared conglomerate, composed of small, flat pebbles of shale and graywacke in a sandy matrix. On lower Crow Creek some conglomerate occurs in association with the argillites and graywackes. In the Eagle River basin half a mile above the mouth of Raven Creek there is a conglomerate composed of small fragments of slate in a coarse, gritty matrix. About 2 miles east of Kern Creek, along the railroad, there is an outcrop of massive conglomerate composed of argillaceous and cherty pebbles as much as 6 inches in diameter inclosed in a matrix of graywacke. The moraines of Raven Creek Glacier contain blocks of conglomerate composed of small pebbles of graywacke, argillite, quartz, and several types of igneous rocks inclosed in a matrix of argillite. Similar conglomerate bowlders were seen in the basin of Peters Creek, both in the valley of the main stream and on several tributaries.

STRUCTURE AND THICKNESS.

Structurally the beds of the argillite, slate, and graywacke series are tilted, folded, and faulted, and in general they have high dips. The best line of nearly continuous exposures across the beds is that offered by the wave-cut cliffs and steep mountain slope just north of Turnagain Arm. From a point 2 miles west of the mouth of Indian Creek to the head of the Arm and thence up Portage Creek, across Portage Glacier, and down to Passage Canal, a straight-line distance of 23 miles, the beds have a fairly uniform northeasterly strike and an average dip of about 70° either to the northwest or to the southeast. At many places small folds in the beds may be seen, but these are minor wrinkles on much larger folds that probably involve several thousand feet of beds. The prevailing high dips also show that the major folding was close, the two limbs of the fold approaching parallelism. Many small faults were observed, and larger faults of great displacement might well be present without being conspicuous. Great difficulty has been encountered by all geologists who have studied these rocks in attempting to work out the structure of the beds, for the series contains no beds sufficiently distinctive to serve as horizon markers, but appears to be monotonously alike in all parts; little assistance can be obtained from fossils, which are almost entirely lacking; and the normal attitude of the beds has been greatly altered by faulting, folding, and tilting. The mountains composed of these rocks have a relief of over 5,000 feet, and the beds along the 23-mile section above referred to have average dips of about 70°. As both faulting and folding have disturbed them, it is not possible now to estimate the total thickness of the beds involved other than to say that the original thickness must have been several thousand feet.

In the northern half of the Turnagain-Knik region the structure of the argillite and graywacke series is not so irregular as along the southern border. The average dip of the sediments is more moderate, folding has been less intense, and there is less uniformity in the general structural trend. In the Peters and Eklutna creek basins the dominant structure trends nearly east, but at the west edge of Knik Glacier the trend is north.

AGE AND CORRELATION.

The age of this group of sediments has not yet been determined. Mendenhall,[1] who in 1898 studied the rocks within the region here considered, named them the Sunrise series. Other geologists, working in the Prince William Sound region, have divided the rocks there into two groups, the Valdez and the Orca. It is now known that the rocks of these two groups extend westward into Kenai Peninsula and that in part, at least, they are the equivalent of the Sunrise "series." The Sunrise "series" can, therefore, be considered an undifferentiated group of rocks, probably containing parts of both the Valdez and Orca groups and possibly also materials not represented by either of these groups.

Neither the age of the Sunrise group nor that of any of its subdivisions has been definitely determined. The rocks are largely devoid of fossils, and although a few localities have furnished collections of invertebrate remains, these have been so imperfectly preserved or are so lacking in diagnostic value that no definite age determinations have been made by the paleontologists. Fossils procured by G. C. Martin and B. L. Johnson from the rocks at the heads of Crow and Raven creeks were identified by T. W. Stanton as follows:[2]

> These consist entirely of imprints of a small Inoceramus, which is possibly identical with the Yakutat fossil described by Ulrich as *Inoceramya concentrica*. There is also a closely related form in Martin's [Upper] Cretaceous collections from the Matanuska region. * * * There is no essential difference in general type between the Jurassic species of Inoceramus and some of those in the Cretaceous, hence it is impossible to make positive discriminations on the evidence of Inoceramus alone, unless species of known stratigraphic range can be positively identified.

It appears, therefore, that at least a part of the Sunrise group is of Mesozoic age, though it can not yet be stated positively whether this part is Jurassic or Cretaceous. On the other hand, on purely stratigraphic grounds it appears that the Sunrise includes some rocks of the Valdez group, believed to be probably of Paleozoic age. In the present investigation no further evidence was procured that throws light on the age of these sediments, and the problem of differentiating this great group of rocks of similar lithology but perhaps of a wide range in age is likely to be finally solved only when determinative fossils are discovered.

VOLCANIC TUFFS.

DISTRIBUTION AND CHARACTER.

An area including the central basin of Eagle River and the upper basins of Peters and Eklutna creeks and a smaller area along the

[1] 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.

[2] Johnson, B. L., The central and northern parts of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, p. 118, 1915.

south side of lower Knik River are occupied predominantly by fragmental volcanic materials, here referred to as tuffs. These areas are shown on the accompanying sketch map (Pl. VIII), but the tuffs doubtless extend eastward into the unmapped area. Bowlders of these characteristic rocks have been found along the shores of Port Wells, showing that they occur in the Prince William Sound basin, though the outcrops there have not been observed.

Although this series of rocks contains minor amounts of slate and graywacke and doubtless also some lava flows, it consists essentially of the products of violent volcanic eruption, the material having been ejected from the vents by explosions and the comminuted fragments having fallen into bodies of water in which they sank and were laid down as thick beds of tuff. In general the supply of volcanic material was so abundant that the ordinary forms of sediments, such as the sands and muds derived from stream erosion upon the land and brought down to be deposited in the waters to which the streams were tributary, constituted only a small percentage of the material being laid down, and these normal sediments form only an inconspicuous element in the series. In places thin shaly beds separate the tuff layers and so indicate the water-laid character of the tuffs. Here and there shale beds several feet thick were seen interbedded with the tuffs, but in most of the sections observed the tuffaceous materials are present almost to the exclusion of the ordinary sediments.

The tuffs vary in appearance from fine-grained rocks of green or gray color to coarser materials that might well be called agglomerates. Most of the exposures examined had a decided dark-green cast, although locally lighter shades prevail. At some places the rock is gray and its finer phases closely resemble graywackes. In fact, some of the tuffs resemble certain graywackes so closely in appearance, both in the hand specimen and under the microscope, that it is difficult or impossible to distinguish them. The most common phase of tuff, however, is so characteristic in appearance that it can be immediately identified. It consists of a fine to coarse grained matrix through which are scattered abundant angular fragments of black argillite or slate. In different beds or in different parts of the same bed the argillite fragments may vary greatly in size, but in any one block of rock the fragments show a general uniformity of dimensions. The uniformity in size of these fragments and in the way in which they are distributed throughout a great thickness of the tuffs and over large areas is not easily explained. The argillites and slates probably formed the vents through which the explosive material reached the surface, and no doubt quantities of such rocks were broken and thrown out with the materials of igneous origin, but it is interesting to speculate how the supply of these materials should have been maintained so steadily throughout what must have been a considerable period of time, and how they should have been broken to so nearly a uniform size and distributed so evenly through many cubic miles of tuffs.

As examined in thin section under the microscope the fragmental rocks prove to be dominantly greenstone tuffs and in minor degree rhyolite tuffs. The constituent particles consist of angular to subangular or rounded fragments of igneous rock in which are commonly inclosed fragments of argillite, slate, graywacke, and other materials. In the greenstone tuffs the rock minerals composing the particles are commonly altered, but in the groundmass original plagioclase feldspar, hornblende, pyroxene, and quartz have been identified, and secondary quartz, calcite, chlorite, serpentinous products and zeolites are generally present. The rhyolite tuffs show some quartz and orthoclase phenocrysts in a fine-grained, feebly polarizing groundmass.

Some rhyolite flows are associated with the rhyolite tuffs, and some basaltic flows occur with the greenstone tuffs, but the fragmental rocks preponderate greatly over the lavas.

STRUCTURE AND THICKNESS.

The rocks of the tuff series have been somewhat folded and faulted, but as a whole they are less deformed than the underlying formations. The beds are generally massive, interbedded clastic sediments are present only in small amounts, and in most places the jointing is more conspicuous than the bedding, so that the structure is not easily determined. From a study of the contact relations with the underlying rocks and of such sediments as are present in the series, however, it appears that the large area of tuffs that occupies the central part of this region is in the form of a rather simple synclinal basin, in which the prevailing strike is parallel to the outer border of the tuff area and the beds dip from the margins toward the center of the basin. This relation exists in Eagle River valley and in both Peters and Eklutna creek basins, where the dips near the border range from 20° to 30°. At some places the tuffs seem to lie conformably upon the slates and graywackes, but at other places there is a distinct angular unconformity, and the two series are believed to be generally unconformable. On account of the great variety of strikes and dips observed in the argillites and graywackes it is probable that in some places the bedding of the tuffs parallels that of the underlying argillites and graywackes, although the unconformity doubtless represents an erosion interval between the two formations. Furthermore, if the fragments of argillite and slate found so abundantly in the tuffs were derived from the underlying formation it is certain that they had been indurated and somewhat metamorphosed before the beginning of the period of volcanic activity that gave rise to the tuffs.

In the smaller area of tuff bordering lower Knik River on the south side the tuffs are either nearly flat or dip to the north. This area was apparently once continuous with the larger area to the south and has been separated by the erosion of the tuffs from the intervening district.

It is impossible now to estimate accurately the thickness of the tuffs. In the center of the main area of tuff, mountains having a relief between 4,000 and 5,000 feet are made up entirely of these rocks, and as no overlying materials are present, an unknown thickness of tuffs has been removed from these mountains by erosion. Even if allowance is made for possible reduplication by folding, the series can not well be less than a mile thick.

AGE AND CORRELATION.

Although no fossils were found in the rocks of the tuff series, certain conclusions respecting their age may be made. The tuffs overlie argillites and graywackes in the upper basin of Eagle River and are therefore younger than those beds. As already stated (p. 161) fossils have been collected from the argillites and graywackes at the heads of Crow and Raven creeks, and these fossils have been provisionally assigned to the Jurassic or Cretaceous. Apparently the sediments lying beneath the tuffs of upper Eagle River are continuous with and a part of the same group of rocks as those from which the fossils were obtained. If this is true, then the tuffs are at least of post-Jurassic and possibly of post-Cretaceous age.

In several places around Cook Inlet and the Susitna basin there are lignite-bearing beds of Eocene age, known as the Kenai formation. These beds consist largely of shales, sands, arkoses, and conglomerates, with lignite. In their induration, metamorphism, and general character they seem quite clearly to be younger than the tuffs here under consideration, although so far as known the two formations nowhere come into contact. If it is assumed that the tuffs are older than the Kenai and are younger than the argillites and graywackes of Crow Creek Pass, then they must be placed somewhere in the geologic column between the Jurassic and the part of the Eocene represented by the Kenai. It should be added, however, that the only formations found in this general province which resemble these volcanic rocks are some partly altered breccias, agglomerates, and tuffs described by Martin and Katz[1] as occurring in the Matanuska basin. These rocks carry Lower Jurassic fossils. The nearest

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, pp. 17–19, 1912.

known outcrop of these beds is about 30 miles northeast of the Turnagain-Knik region, and the intervening area has not been mapped. A definite correlation between these two volcanic formations is therefore not justified, especially as the local evidence indicates that the volcanic rocks of the Turnagain-Knik region are of post-Jurassic age.

INTRUSIVE ROCKS.

Intrusive rocks occur within all the hard-rock formations of this region. The oldest group of rocks, which in this report is not differentiated into its constituent elements, contains a large proportion of intrusive materials, including diorites and quartz diorites, peridotites, pyroxenite, dunite, and their altered equivalents. These have already been briefly described. The series as a whole, as well as the overlying argillites and graywackes, have in places been intricately cut by younger dikes and sills of acidic character. These younger intrusive rocks have been found on microscopic study to include andesite porphyry, dacite, and diorite. Projecting through the unconsolidated deposits near the village of Old Knik are some small hills of coarsely crystalline quartz diorite. No other considerable bodies of granitic intrusive rocks were observed in this district, but in not far distant areas on Prince William Sound, in the Talkeetna Mountains, and at many other places in Alaska there are similar granitic intrusives that are generally believed to be of Mesozoic age. It was probably during this general period of granitic intrusion and in relation to larger masses of granitic rocks, some of which did not penetrate near enough to the surface to be yet revealed by erosion, that the numerous acidic dikes and sills of this region were injected.

QUATERNARY SYSTEM.

PREGLACIAL CONDITIONS.

The youngest hard rocks that have been recognized in this region are the greenstones and greenstone tuffs, and they are very old compared with the unconsolidated Quaternary materials, the next younger deposits. It may be that after the deposition of the greenstones and greenstone tuffs the region was submerged and covered with younger sediments, but in the absence of younger rocks it is unlikely that such a submergence took place. During early Tertiary time a great lowland is known to have existed along the present Cook Inlet and Susitna Valley depression, and from this lowland valleys reached back into the surrounding upland. In the lowland and its tributary valleys much sedimentary material, comprising muds, sands, gravels, and arkoses derived from the surrounding highlands, and considerable beds of peat were laid down as lowland or estuarine deposits. Locally, these materials accumulated to a thickness of several thousand feet. They were thickest in the lowest depressions and thinned out laterally as they overlapped the lower slopes of the bordering hills. Their accumulation was ended by the uplift of the surrounding mountains, and the beds were in many places tilted, folded, and faulted. Deposits representing this period of Tertiary deposition are present in Matanuska Valley; in the Willow Creek district, only 10 miles north of the region here considered; at many places on the east shore of Cook Inlet; and in the areas bordering the Susitna lowland. The major uplift and tilting of the Tertiary beds, which doubtless affected the mountains of the Turnagain-Knik region also, was followed by a long period during which the ordinary processes of land erosion were active. Great trunk valleys were formed or reexcavated, and the mountains were dissected to a mature topography. It is believed that at the end of this period of stream erosion all the main valleys now present were established. The streams in removing the rock waste from their basins had handled great quantities of material, and in some of this material there was a small quantity of native gold, contained in quartz veins and veinlets. The gold, being chemically inert and of high specific gravity, remained in the stream beds, and in those basins in which gold-bearing veins were especially abundant gold-placer deposits were formed.

GLACIAL EPOCH.

ADVANCE OF THE ICE.

The glacial epoch was ushered in by a change in climatic conditions that resulted in increased snowfall. The accumulation of snow and ice naturally took place first in the higher mountains, and small glaciers were formed. These grew and lengthened down the valleys, tributary glaciers joined the main drainage lines, and the larger ice streams pushed onward as they increased in thickness until all the mountain valleys contained vigorous glaciers. As the ice advance approached its climax the mountains were so deeply submerged by glacial ice that only the higher peaks and ridges projected above its surface. The ice streams from Turnagain Arm and from Knik and Matanuska river valleys pushed into upper Cook Inlet, there joined the southward-moving glacier from the Susitna basin, and advanced down Cook Inlet an unknown distance but at least as far as the forelands. Some idea of the magnitude of these great glaciers may be gained from the facts that at the mouth of Glacier Creek the Turnagain Arm depression was filled with ice to a height of at least 3,400 feet above sea level, and at the point where Peters Creek leaves the mountains the surface of the Knik Arm glacier stood nearly

3,000 feet above sea level. From these surfaces the slopes of the tributary valley glaciers upstream were steep, probably more than 100 feet to the mile, so that little of the mountain mass was visible above the ice surface.

The last great period of glaciation in Alaska is believed to have been contemporaneous with the Wisconsin stage of glaciation in the United States and Canada. In the main body of the continent there were several periods in Quaternary time during which the glaciers reached large size and moved southward into the Northern States. It is now known that in Alaska also there were at least two and possibly more distinct stages of glaciation, and the last great ice advance has been rather definitely correlated with the Wisconsin stage.[1]

In the Turnagain-Knik region evidences of only one great ice advance have been recognized. There may have been earlier glacial stages, but the last great glaciers became so large and their erosive effects were so profound that they went far toward obliterating the evidence of any former glaciers that may have been present.

The flooding of a mountain region, such as that here discussed, by glacial ice involves great changes in the shape of the land surface. The preglacial topography of this region was of the type resulting primarily from stream erosion. The valleys were broadly V-shaped in cross section; the streams flowed in somewhat devious courses around the ends of the mountain spurs that projected into the valleys from either side; chemical decomposition and physical disintegration had joined forces in breaking down the rocks and in causing the accumulation of extensive deposits of residual soils and of products of rock disintegration; and each stream flowed over a bed in which the gradient was adjusted to the size of the stream and to its load.

When the glacial epoch had begun the newborn mountain glaciers in advancing down the valleys found them adjusted to stream cutting and degradation but not at all adjusted to occupancy by glaciers. To these glaciers, therefore, fell the task of remodeling the valleys to shapes best suited to ice movement, and for this work they were well equipped. In their forward and downward progress they pushed before them or overrode such loose materials as they encountered and rapidly stripped away soil, talus, and stream gravels. Much of this detritus was incorporated into the body of the glaciers themselves, and each fragment, held firmly in the ice, served as a tool with which the moving glacier could attack its bed. By the removal of obstructing spurs and by undercutting the valley sides the glaciers tended

[1] Capps, S. R., An estimate of the age of the last great glaciation in Alaska: Washington Acad. Sci. Jour., vol. 5, pp. 108–115, 1915; Two glacial stages in Alaska: Jour. Geology, vol. 23, pp. 748–756, 1915.

to develop straight, wide-floored, troughlike valleys. Cirques were formed at the valley heads, and as the cirques were cut headward the divides within the higher mountain masses were attacked and reduced to sharp-peaked ridges.

Although the topography was greatly modified by the glacial erosion, nevertheless it is believed that most of the glaciers, in spreading downward from the higher mountains, followed the preexisting valleys. Locally ice poured over divides and reduced them, so that new valleys having courses at variance with those of the preglacial streams were formed, but in the main the present drainage lines, although bearing unmistakable evidence of ice erosion, are believed to follow the valleys established by the streams before the glacial epoch.

Within the lowlands beyond the borders of the mountains the effects of the ice invasion were also notable, but of a very different character. No longer confined within restraining walls, the glaciers spread out laterally to form great, comparatively flat ice plains. With lower gradients and greater width the rate of movement was also decreased, and the ice, no longer able to erode vigorously, began to deposit its burden of detritus as a sheet of glacial till. Still farther down, at the ice front, the surface débris and that within the main ice mass was dropped as a terminal moraine or supplied to the streams to be deposited as glacial outwash.

RETREAT OF THE ICE.

After the glaciers had reached their greatest development there came about another change in climate, with increase in mean annual temperature and decrease in snowfall. As the supply of snow in the headward portions of the glaciers became less, they became progressively shorter and thinner. The lower ends shrank back and bared ground previously covered by ice. The upper valley walls, scored and smoothed by glacial erosion, began to emerge along the flanks of the ice tongues. As melting and shrinkage continued the valley glaciers became separated from the lowland glaciers and from one another, the lowlands gradually became free from ice, and glaciers were able to maintain themselves only in the high mountains and in basins somewhat protected from the sun's rays.

As the glaciers retreated, streams fed by the melting ice at once began to flow over the uncovered areas. The valleys were, however, no longer adjusted to stream drainage, and the streams immediately commenced to make this adjustment, which is still far from accomplished. Low, ice-eroded basins became lakes, many of which were later filled with stream gravels. Rock barriers were intrenched and now form canyons. The amount and character of this readjustment are discussed under the heading "Postglacial erosion" (p. 172).

The higher mountains of this region still support vigorous glaciers. The largest of these is Knik Glacier, at the head of Knik River. It is 3 miles wide at its terminus, and about 4 miles above that point it divides into two large tributaries, one heading eastward and the other southward. The upper portion of this glacier is unsurveyed and its area is unknown, but without doubt it includes the ice from part of the northern front of the high mountain range that supplies so many southward-moving glaciers to College Fiord. It is likely also that it receives ice from an extensive glacial field lying southeast of the heads of Peters and Eklutna creek basins and northeast of the head of the Eagle River basin. Natives and prospectors report a lake many miles long that occupies a valley along the east side of the southwest fork of Knik Glacier. This lake fills gradually and at intervals of six or seven years breaks out through Knik Glacier and sends great floods of water down Knik River and Knik Arm. Such a flood took place early in September, 1915, deeply inundating the flat valley floor of Knik River and causing considerable damage at the construction camps of the Government railroad, at the Knik River crossing.

No facts were observed that would indicate any great amount of recent retreat of Knik Glacier. In July, 1915, there were no large streams flowing along the western edge of the ice front, yet the dump moraine was very small, indicating that there may have been a recent readvance of the ice. The rock bluffs on the valley wall 200 feet from the ice edge and below the level of the frontal ice cliffs are covered with brush, and scraggy old dead spruce trees stand on the bluffs 50 feet above the gravel bars and 200 yards beyond the ice edge. The presence of these bushes and trees so near the ice front shows conclusively that the glacier is now almost as far advanced as it has been for many years.

Eklutna Creek above the lake forks into two branches, both of which are glacier fed. The south fork emerges from beneath a long, narrow ice tongue, and the volume of the stream indicates that the headward portion of the glacier is much larger than the lower portion, which can be viewed from the terminus. The southeast fork of Eklutna Creek is also large, and its turbid waters are certainly of glacial origin, though the glacier at its source was not seen.

The Peters Creek basin contains at least four glaciers, all small.

Eagle River heads in Eagle River glacier, an ice field 10 or 15 miles long and between a quarter and half a mile wide at its lower end. It shows white ice throughout its length, but has one prominent and another less conspicuous line of surface moraine on its lower portion. From half to three-quarters of a mile below the glacier there are two distinct crescentic lines of terminal moraine crossing the valley, and a strong lateral moraine appears along the northeast margin of the glacier. Within these moraines there is little vegetation, and the ice has apparently retreated, possibly as much as three-quarters of a mile, within recent years.

Raven Creek, the largest headward tributary of Eagle River, heads in a small but vigorous glacier. The bare slopes along its lower flanks and beyond its terminus indicate a moderate amount of recent retreat.

The southeast fork of Ship Creek and the main branch of Bird Creek originate in small glaciers, the westernmost within this district. Glacier Creek, as its name implies, has its source in several small glaciers, as has also its principal tributary, Crow Creek.

The Twentymile River basin contains two vigorous ice streams, and Portage River is fed by several small ice tongues and by Portage Glacier, which also sends some of its drainage eastward to Passage Canal.

The eastern, unsurveyed portion of the district includes the highest mountains and the largest glaciers, a number of which flow eastward into Harriman Fiord.

GLACIAL DEPOSITS.

Within the mountain valleys the ancient glaciers had comparatively steep gradients and were confined within abrupt valley walls, and their movement was consequently more rapid than in the lowlands. The characteristic effect of glaciation upon the mountains is therefore to be observed from the erosional results produced rather than from the constructional topographic forms built from the deposits of glacial débris. There are, however, certain distinctive glacial deposits left by the ice during its retreat or built by the glaciers after they had taken their stands near the positions in which they now remain. The most easily recognizable glacial deposits in the mountains are the lateral and terminal moraines. They form dumps of great blocks and bowlders mixed promiscuously with finer materials and having an irregular surface. They are not present in all the glaciated valleys, but are well developed at the edges of some of the existing glaciers and may be seen at some distance from the ice edge in a few valleys, notably in Crow Creek basin and near the head of Eagle River. The more prevalent but less conspicuous glacial material occurs as a sheet or veneer of glacial till coating the floors and sides of many valleys but presenting no easily recognizable topographic form. It can be best identified in the cut banks of streams and gulches; elsewhere it is likely to be obscured by a covering of vegetation.

The lowland areas received the greater part of the detritus removed from the mountains and transported downward by the moving ice, and practically all the surface deposits in the lowlands are composed of material supplied directly by the ice or by streams that issued from the glaciers and brought down the products of glacial erosion. Thus the flat valley of Knik River, from the glacier to the point at which the tides are effective, is floored with heavy deposits of gravel and sand. The material supplied to the river by the ice is so abundant that the stream is constantly loaded to its capacity, and it is slowly aggrading its valley floor. The finer materials, consisting of some sand and abundant silt, are carried down to tidewater in Knik Arm and deposited as mud flats. Like Knik River, all the other glacier-fed streams have more or less extensive flood-plain deposits of glacial outwash gravel. Similar gravel deposits occur throughout much of the Knik Arm lowland, though locally they attain altitudes of several hundred feet above sea level. This outwash gravel could not have been deposited in its present position under the existing drainage conditions, but was laid down in front of the retreating glacier that once filled Knik Arm, in much the same way as the present deposits in Knik River valley. The grading operations along the line of the new railroad through the lowland show that the gravels are present in great abundance. In the basin of Eklutna Creek, between Eklutna Lake and the rock canyon, 5 miles below, the stream is intrenched to a depth of several hundred feet in stratified gravels, probably deposited at a time when the mouth of this valley was blocked by the great glacier in the basin of Knik Arm and when Eklutna Glacier had retreated to about the present position of the lake. The next stream southwest of Eklutna Creek shows similar thick deposits of gravel. Glacial till, laid down directly by the ice, is also present in the lowland and probably occurs in extensive sheets beneath the covering of gravel outwash. Both the gravel-covered areas and those occupied by glacial till have fertile soils and give promise of productive farms along the railroad.

The results of the ice invasion, including erosion in the mountains and deposition in the lowlands of the material removed from the mountains, have had a very great influence on the economic development of this district. Within the mountains the ice, in overriding the preglacial stream gravels, removed them and the gold placer concentrations that they contained, and the gold was scattered far and wide in the morainal and outwash deposits of the lowlands. In a few especially protected localities some small areas of the preglacial stream gravels, with their included gold, may have been preserved and may some time add to the gold production of the district. In most of the stream basins, however, no preglacial placers were left, and such placer deposits as are now present are the result either of postglacial stream concentration of gold from the glacial deposits or of original concentration from bedrock.

In the lowland areas the results of glaciation, although of a different character, will exercise an even greater influence on the economic development of the district. The future development of the lowlands is largely concerned with their agricultural possibilities. From the mouth of Knik River to Turnagain Arm the lowland lying southeast of Knik Arm is covered with gravels, silts, and glacial clays deposited directly by the ice or in the rivers and embayments beyond the ice front. In general these materials are fertile, are well drained, and afford good soil for the production of crops. Climatic conditions also appear to be favorable, so that there is a strong probability that this lowland, now tapped by the new Government railroad, will support a considerable agricultural population.

POSTGLACIAL EROSION.

Upon the final retreat of the glacial ice from any part of the area which it had covered, the agencies of subaerial erosion immediately became operative, and these agencies have continued to be effective in greater or less degree ever since. Nevertheless, in terms of earth history, the period since the waning of the ice has been short, and in its larger features the land surface now to be seen is that developed and modified by the action of the glaciers. As the ice first retreated from the lowlands of upper Cook Inlet and gradually withdrew up each tributary valley, the lowlands and the lower parts of the valleys have been subject to postglacial erosion much longer than the upper parts. In fact, as the remnants of the old ice sheet still occupy considerable areas in the higher valleys, these areas may be considered to be still in the glacial epoch, and beneath the ice there has been no postglacial erosion.

Naturally erosion has been greatest along the lines of the major streams and along the margins of tidewater. The glacial widening and deepening of the floor of Knik Arm and Knik River valley left all the tributary streams from the south and southeast occupying hanging valleys, with very steep gradients at the mountain front. In these oversteepened portions the streams have cut canyons in the unconsolidated materials and in bedrocks, in their efforts to reestablish normal gradients. Higher up the valleys there are also places at which the streams, in crossing rock barriers, have cut canyons, and their minor tributaries likewise, occupying hanging valleys of the second order, have cut their beds deeply in readjusting their grades. Locally between the oversteepened and canyoned portions of the valleys there are basins that now contain lakes, as, for example, Eklutna Lake, or are filled with stream gravels.

The larger tributaries of Turnagain Arm from the north and east generally lie in valleys the lower portions of which were eroded by the ice to or below tide level, and the typical hanging valleys are not abundant. In fact, the lower valleys of Glacier, Twentymile, and

Portage creeks were fiords when first bared of ice, as Turnagain Arm is now, but were filled to sea level by detritus from the glacial streams that discharged into them.

Marine erosion has succeeded in postglacial time in cutting back the unconsolidated deposits between Point Possession and the mouth of Knik River, so that the shore line is generally bordered by steep gravel bluffs. At Point Woronzof the bluff stands 200 feet above mean tide. At the town of Anchorage the top of the bluff has an altitude of 110 feet. The distance horizontally that the bluffs have retreated before the cutting of the waves is not known. On Turnagain Arm similar gravel bluffs extend from Point Campbell southeastward for 12 miles, and thence to Twentymile River there are nearly continuous sea cliffs cut into the hard slates and graywackes. It is apparent, however, that wave cutting has done no more than to notch the base of the rocky walls that border this basin.

In addition to the work of streams and waves, the mechanical disintegration of the rugged mountains, especially in those places where they reach altitudes above the line to which vegetation grows freely, has been rapid, and considerable quantities of talus have accumulated at the bases of steep slopes. Chemical decay, however, has been relatively ineffective in postglacial time. No residual soils have been formed, and many glacially scoured rock surfaces still show the smoothness of contour given to them by the ice.

PRESENT STREAM AND MARINE DEPOSITS.

Most of the large streams within this region have their sources in glaciers, and their gravels are derived in part from material supplied by the ice, and in part from material supplied by the direct erosion of the streams upon their beds and banks. On such streams it is impossible to separate the present stream gravels from those of glacial origin, and no attempt has been made to discriminate between them on the accompanying map (Pl. VIII). Likewise the marine or estuarine silts and sands now accumulating so rapidly in Knik and Turnagain arms are in part of glacial origin and in part the product of stream erosion. The amount of fine material brought down to tidewater by the larger glacial streams is great, and the filling in of these arms of the sea must be proceeding at a rapid pace. The estuarine deposits now accumulating, if consolidated and somewhat metamorphosed, would yield a group of sedimentary rocks resembling in many ways the argillites and graywackes so abundantly represented in this general region.

The tidal variation in Knik Arm is great, and the waters are shallow, so that at low tide many square miles of tidal flats are laid bare. In addition to the areas within range of the daily tides there are mud flats, particularly at the mouth of Knik River, between the Indian village of Old Knik and Knik River, at the mouths of Peters Creek and Eagle River, and on Turnagain Arm along lower Glacier Creek, Twentymile River, and Portage Creek, that are covered by the sea during periods of extreme high tide but are dry most of the time. These flats support a luxuriant growth of grass and in summer would afford valuable pasturage for live stock.

MINERAL RESOURCES.

GENERAL FEATURES.

The mineral resources of the Turnagain-Knik region that have so far received the attention of miners and prospectors are the gold placers and the gold quartz lodes. From 1896 to 1898 a large number of placer claims were staked on the streams tributary to Turnagain Arm from the north, and on a few of these claims, notably those on lower Crow Creek, mining has been carried on each year since. The entire output of placer gold has been derived from the Turnagain Arm slope of the mountains. In 1915 some placer claims were staked on tributaries of lower Knik Arm, but none of these have yet been demonstrated to contain workable ground. Development work on gold quartz lodes has also been confined largely to the Turnagain Arm basin, although a few claims in the valley of Peters Creek and in the upper basin of Eagle River have received attention. In 1915 no gold had been produced from any of the gold quartz lodes.

The following description of the mines and prospects is based on observations made by the writer in 1915, with additional material already published in the reports of W. C. Mendenhall, F. H. Moffit, and B. L. Johnson, to which reference has already been made.

GOLD PLACERS.

GLACIER CREEK BASIN.

GENERAL FEATURES.

Glacier Creek is one of the larger tributaries of Turnagain Arm from the north and joins the Arm about 10 miles below its head, at a point 75 miles from Seward by way of the Alaska Northern Railroad survey. The main valley is a straight, broadly U-shaped trough and heads in a wide basin into which several small glaciers drain. A number of these glaciers are plainly visible from Turnagain Arm and have given the stream its name. Below the mouth of Crow Creek the stream flows through a gravel-floored valley, bordered in its lower reaches by a lowland in which marshes alternate with heavily timbered areas. Its larger tributaries are California and Crow creeks, from the northwest, and Winner Creek, from the southeast. Virgin Creek flows into the same broad valley but joins Turnagain Arm a short distance southeast of the mouth of Glacier Creek.

Crow Creek is economically the most important tributary of Glacier Creek. The mountains at its head are high and rugged and form the divide between the waters that flow to Turnagain Arm and those tributary to Knik Arm. They are broken at the head of Crow Creek by Crow Creek Pass at an altitude of about 3,400 feet, which affords a fairly good route from Crow Creek to Raven Creek, a tributary of Eagle River. From its source in the pass to its mouth Crow Creek is about 5 miles long. Near its head it is precipitous, descending in waterfalls and rapids for a vertical distance of over 1,000 feet within 1 mile of the pass. It is fed by several small glaciers, and during the summer its waters are turbid. Below the pass the stream emerges from its narrow stream-cut gorge into a gravel-filled basin. The basin is bordered at its lower end by a terminal moraine from a lateral valley, and the gravel fill is the result of the lessened gradient behind this morainal dam. Through its bowldery channel across the moraine the stream descends in rapids, to emerge into a narrow gravel-floored valley bordered by benchlike terraces of gravel and showing no rock outcrops. These conditions prevail to a point within half a mile of the mouth of the valley, where the stream enters a rock canyon, with nearly vertical walls, that extends to its mouth.

Throughout the basin of Crow Creek the bedrock consists predominantly of interbedded argillites or shales and graywackes, with some conglomerates, cut by numerous granitic dikes and sills. Locally the shale beds have been metamorphosed, with the development of slaty cleavage, and in places the metamorphism has been intense enough to produce a somewhat schistose structure. The prevailing strike of the beds in this basin is northeast, but locally the beds diverge considerably from this general trend. Near the mouth of Crow Creek they dip prevailingly at high angles to the southeast, but at the head of the valley folding has occurred, and the general trend of the structure swings around to an easterly direction.

PHYSIOGRAPHY.

The physiographic history of Crow Creek is highly complex, but fortunately the deep excavations made during the progress of mining have yielded much valuable information concerning it. As the distribution and concentration of placer gold are in large measure dependent on the erosional history of the areas in which they occur, and as the basin of Crow Creek contains the most productive mining camp of this region, it seems proper to discuss here in some detail the main physiographic events that have had an influence on the development of this stream basin and on the formation of its gold-bearing gravels.

For about half a mile above its mouth Crow Creek flows through a very narrow, steep-walled canyon cut into bedrock. The cutting of this canyon is, however, a very recent event in the erosional history of the valley, for the canyon is conspicuously younger than the valley above it. Its history is discussed on page 179. The rock canyon is bordered on the northeast by high benches of unconsolidated material, and for over a mile above the head of the canyon the stream flows over gravel bars and between high gravel benches. Prospecting above the canyon has shown that the stream bed throughout this distance lies 50 feet or more above the rock floor of the valley.

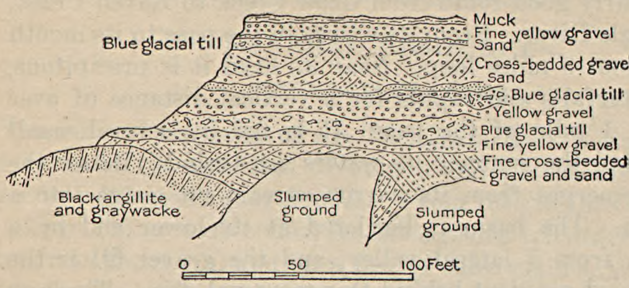


FIGURE 7.—Section exposed in placer workings of lower Crow Creek, showing interbedded stream gravels and glacial till overlying steeply tilted argillite and graywacke.

During the season of 1904 mining developments near the middle of the rock canyon showed the lower end of a distinct gravel-filled channel east of the present channel and joining it from above.[1] Since that year this old channel has been sluiced out to obtain a water grade to the bedrock valley floor above the canyon. This cut required the removal of materials having a maximum thickness of over 230 feet and forming a complicated section composed of assorted beds of coarse and fine gravels and glacial till. Some of the gravel beds are horizontally bedded, some are cross-bedded, and others are contorted. (See fig. 7.) The excavations also show that this buried rock channel itself is joined by other old channels in bedrock. (See figs. 8 and 9.) Mining in one of these has exposed a section (fig. 10) which differs considerably from that shown in figure 7 but which also shows deposits of glacial origin interbedded

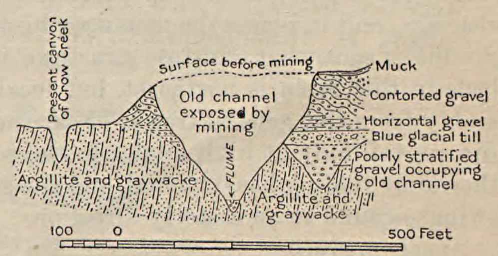


FIGURE 8.—Cross section of a part of lower Crow Creek valley, showing size and position of present canyon, the deepest buried canyon (now excavated), and another smaller buried canyon. This section is at right angles to that shown in figure 10.

[1] Moffit, F. H., Gold fields of the Turnagain Arm region: U. S. Geol. Survey Bull. 277, p. 41, 1906.

with water-laid sands and gravels. The erosional history at this place is important, as it has been largely influential in determining the location and richness of gold placer deposits, but data are not yet available for a complete interpretation of the succession of events. Apparently the old channel through the "big cut" is the deepest rock channel draining the Crow Creek valley, though this has not yet been definitely established. Moreover, it has not yet been determined whether this old channel was the preglacial course of the stream or whether it was carved in the interval between two glacial advances. Its steep sides and high gradient, however, indicate that it was formed after the Glacier Creek valley had been deepened by glacial scour and that it was cut by Crow Creek in its endeavor to reduce its valley to grade with Glacier Creek. This suggests at least the possibility that there may have been two distinct periods of glaciation, separated by an interglacial period long enough for the cutting of the deepest old channel.

The history of the drainage changes in lower Crow Creek, as made out from the facts now available, is given below. In details the description of the succession of events here given may be open to some question, but it is believed that this description reasonably accounts for the conditions as they now appear. With further mining additional facts will be obtained that will throw more light on the complex drainage history of this place, and the necessary modifications in the interpretation can then be made.

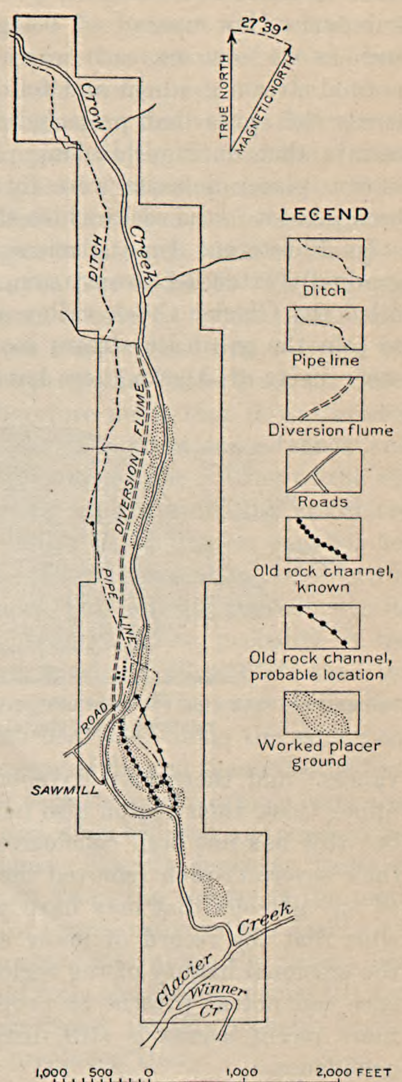


FIGURE 9.—Sketch map of claims of Alaska Crow Creek Mining Co. Adapted from sketch by Frank H. Lascy.

Before the earliest of the Pleistocene glacial advances had taken place the ordinary processes of stream erosion had carved deep valleys into the mountains. These valleys lay in much the same positions as those now occupied by Glacier and Crow creeks and their tributaries, but instead of being wide, straight V-shaped troughs such as we now see, each was a narrower V-shaped valley with a normal stream gradient and followed a somewhat sinuous course between the spurs that projected into it from either side. It seems certain that during this long period of preglacial stream erosion stream placer deposits were formed containing the gold that had been present in the rocks which the stream had removed.

In Pleistocene time glaciers formed in the valley heads and gradually extended downstream, uniting to form an ice tongue that filled the Glacier Creek valley and reached Turnagain Arm, there to join the great ice stream moving westward to Cook Inlet. In other parts of Alaska there have been at least two distinct ice ad-

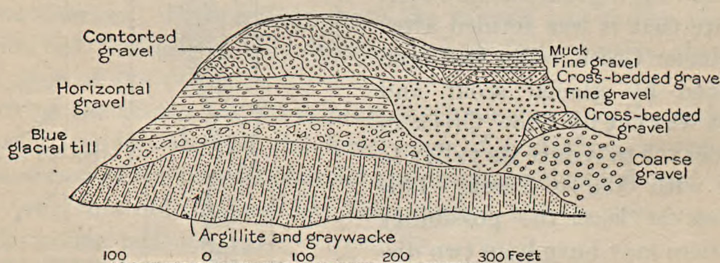


FIGURE 10.—Section on northeast side of the "big cut," lower Crow Creek, showing the relations of the glacial till and gravels to bedrock.

vances,[1] and there may have been more. It is probable that the upper Cook Inlet region also has been glaciated two or more times, but this has not been conclusively proved, for the last glaciers by their severe erosion removed the conspicuous evidences of the work of any glaciers that may have preceded them. It is therefore possible that the record of many early events of great importance in the erosional history of the region is now so obscure that their influence can not at present be properly estimated. The record of the more recent events is still distinct enough to be read with some confidence.

The first glaciers by their erosion profoundly altered the shape of the basins through which they moved. They widened and straightened the valley floors and steepened the side slopes, giving the valleys a broadly U-shaped cross section. They also had a tendency to erode more rapidly at the basin heads than below, thus developing cirques, and left the gradient flattened below the cirques. During

[1] Capps, S. R., Two glacial stages in Alaska: Jour. Geology, vol. 23, pp. 748, 756, 1915.

the glacial erosion and reshaping of the valleys the unconsolidated stream gravels were readily removed by the ice, and with them the contained placer gold, which was scattered among all the glacier-borne débris. It is presumed that such alterations were made in the Glacier and Crow creek valleys before the present rock canyon of lower Crow Creek was cut and also before the cutting of the old bed-rock channels now exposed by the placer workings.

With the retreat of these earlier glaciers the valley floors were again exposed to stream erosion. Apparently the floor of the Glacier Creek basin had been deepened by glacial scour at the mouth of the Crow Creek valley, and Crow Creek thus had an oversteepened gradient in its lower course and began to intrench itself in that portion of its valley and cut a deep canyon into bedrock. That canyon now appears as the deepest old channel uncovered by the placer-mining operations. It appears to be too steep walled and to have too narrow a floor to be the bottom of the preglacial outlet from the Crow Creek basin. The suggestion is therefore made that it was eroded in the interglacial stage between the last great ice advance and another that preceded it. Evidently, however, the cutting of the old canyon was not accomplished without interruption, for associated with it are other buried channels, similar to the deepest one, but not so well developed or so continuous. They represent episodes in the development of the main old channel, but indicate that during its erosion it was at times dammed somewhere below, probably by the oscillating edge of the Glacier Creek glacier. When obstructed the bedrock canyon was filled by stream gravels. When the obstruction was removed the stream again intrenched itself along the same general course, first cutting through the gravel fill and then into the bed-rock. Throughout most of its course each successive canyon coincided in alignment with the original one, and when bedrock was reached the deepening of the old canyon continued. Locally, however, loops of the later canyons departed somewhat from the course of the main channel, and in this way a network of buried canyons was developed. (See fig. 9.) Within these rock canyons and along the stream bed above and below them the placer gold from the eroded glacial till and the outwash gravel was again concentrated, though probably in deposits much less rich than those of preglacial time.

After the deepest old channel was eroded to its present dimensions this region was again subjected to intense glaciation, in which the ice further modified the land forms, in some places widening and deepening the valleys and in others depositing quantities of glacial débris either as morainal material or as stream-borne outwash gravel. Under the influence of the advancing Crow Creek glacier and impeded by a dam formed by the ice tongue in Glacier Creek valley, the rock canyons on lower Crow Creek were filled with stream gravels and later completely overridden by the great glaciers that filled this whole basin.

The final retreat of the glaciers to their present positions was not a single continuous process but consisted of a long series of oscillations backward and forward, the sum total of the recessions being greater than that of the advances. The critical stage during this retreat, so far as the unconsolidated deposits of lower Crow Creek are concerned, was the time during which the Glacier Creek and Crow Creek glaciers had separated but were still not far apart. At this time an advance of only moderate extent by the ice in Glacier Creek was sufficient to impede the drainage from Crow Creek, and similarly a moderate recession of that ice tongue allowed the free escape of the Crow Creek waters. That such oscillations actually occurred is plainly shown by the section exposed on lower Crow Creek. (See fig. 7.) There the deposits of glacial till can mean only that the ice advanced over this area at least three times and that in the intervals between the advances stream gravels were laid down. Furthermore, it is believed that the unconsolidated materials there represent only the deposits made during the last great glaciation, and most of them were doubtless laid down during the final stages of retreat of the glaciers, the successive till deposits representing minor oscillations of the ice tongues. Whether the till beds were laid down by the ice lobe from Glacier Creek or by that from Crow Creek, or whether they came in part from one of these sources and in part from the other, can not now be determined. The included bowlders and blocks of rock might have come from either basin, as rocks of all the observed types are present in both Crow Creek and Glacier Creek basins.

Upon the final withdrawal of the glaciers Crow Creek flowed over a broad valley floor of gravels and glacial materials that completely filled the bedrock channel of that stream and buried the rock canyons near its mouth. These unconsolidated materials locally had a thickness of over 250 feet. As the former obstruction to Crow Creek caused by the ice in Glacier Creek had been permanently removed, lower Crow Creek had a very steep gradient to its junction with Glacier Creek and descended in a series of rapids and falls. Erosion by the swift stream was rapid, the channel was soon cut to bedrock, and the excavation of the present bedrock canyon began. Except in that portion of its course which lies in the present rock canyon, Crow Creek had the same alignment as it had before the channel was deeply filled with glacial till and gravels. In reducing its valley again, under the stimulus of a lowered and unimpeded outlet, it quickly cleared away the surficial deposits near its mouth, but in the hard rock of its canyon it made slower progress, and that canyon at its upper end still lacks about 80 feet of being cut down to the level of the adjoining buried rock channel. Above the canyon the stream gravels could be removed only as fast as the canyon bed was lowered, and the presence of a heavy fill of gravel in the valley bottom, extending from the head of the canyon up to the mouth of Crow Gulch, is the result of the protection from erosion given to it by the resistant rocks of the canyon.

UNCONSOLIDATED DEPOSITS.

The unconsolidated deposits of Crow Creek basin may be roughly divided into three classes, which differ in age as well as in appearance. The oldest deposits are the lowest gravels found in the valley bottom above the canyon and in the bottoms of the old, buried rock canyons, and are observable only in the excavations made during the progress of placer mining. They consist primarily of rather coarse stream gravels and represent the material in process of transportation by the stream at the time when it occupied the deepest buried channel. They are thought to be older than the time of the last great ice advance, or at least to have been laid down during periods of temporary retreat during that glaciation. Next younger and lying immediately above the lowest gravels is a thick, irregular series of gravels, sands, and morainal materials. These materials form the bulk of the unconsolidated deposits, were laid down as glacial outwash or by the ice directly, and are to be correlated with the last stage of glaciation. Above the rock canyon they now appear at the surface as high benches on both sides of the stream channel which has been eroded into them and in one place as a distinct morainic ridge.

The third class of deposits comprises the gravels of the present stream. In general they are only a few feet thick and form the floor of the trench cut by the stream into the high bench gravels. They consist of a mixture of reworked bench gravels with whatever new material the stream has derived by erosion in its upper basin or from the glaciers in which it heads.

MINING.

A few claims have been staked in the main valley of Glacier Creek, but little or no actual mining has been done on them. The economic importance of this basin now lies in the tributaries of Glacier Creek, three of which—Crow, Winner, and California creeks—have produced gold in commercial quantities, and Crow Creek has been the scene of extensive mining.

Crow Creek.

The first claims to be located on Crow Creek are said to have been staked in 1897, near the mouth of the stream and on the site of the present placer workings. The early history of this ground is not clear, but it is known that eight partners, locally known as the "Crow Creek boys," were mining in 1904 in the vicinity of the rock canyon on the lower portion of the stream. Later the Crow Creek Consolidated Mining Co. was organized and operated until 1906. In 1907 the property was sold to the Nutter-Dawson Co., and in 1914 this concern was reorganized into the Alaska Crow Creek Mining Co. The sixteen claims now included in this property extend in a double tier from Glacier Creek, at the mouth of Winner Creek, up Crow Creek for the length of seven claims, with two additional overlapping claims above. (See fig. 9.)

In the years preceding 1903 most of the mining was done by pick and shovel on the most easily accessible gold-bearing gravels. The ground mined included the so-called Eagan bar, near the mouth of the stream, the present rock canyon, and some of the surface gravels above the canyon. In 1903 and 1904 hydraulic methods were used, but difficulty was experienced in reaching bedrock above the rock canyon. Late in 1904 an old, deeply filled rock channel lying northeast of the present canyon was discovered, and from 1905 to 1914 the efforts of the several companies operating at this place were in large part directed to removing the gravels above and in this old channel for the purpose of obtaining a bedrock drain to the gravel basin above the present canyon. This was a large undertaking, for the gravel filling contained little gold and the necessary excavation had a length of over 1,000 feet and a maximum depth of nearly 250 feet. During the work of clearing this old channel other buried rock channels branching from the main one were disclosed, and these have not yet been completely excavated.

The areas of gravels that had been mined by the fall of 1915 are shown in figure 9. At the time of visit mining was being done at but two localities—the lower at the junction of two subsidiary buried channels and the upper in the gravel-filled basin of Crow Creek, a few hundred feet above the camp. The underlying bedrock consists of black slates interbedded with graywacke and conglomerate, and these beds strike in a general northeasterly direction and dip at angles approaching the vertical. In the lower workings the unconsolidated materials above the bedrock form a complex series of interbedded gravels, sands, and glacial till. The upper workings in the present creek bed show 80 feet of gravels and sands.

Mining is now carried on by hydraulic methods. The water is obtained from Crow Creek near the upper end of this group of claims and conducted for about a mile to the penstock through an open ditch having a capacity of 4,500 miner's inches. From the penstock it is distributed by a 24-inch steel pipe to the workings. A head of about 300 feet is available at the upper cut and about 360 feet at the lower workings. In 1915 and for several preceding years the creek was carried around the edge of the valley floor by a diversion ditch that emptied into the upper end of the rock canyon. Mining in 1914 and 1915 lowered the cut so far below the level of this ditch that there was danger of its breaking over into the placer workings. Furthermore, it was found that the richest gravels extended over beneath the ditch. It was therefore decided to build a long diversion flume to remove the water permanently from the stream flat for a distance of about three claim lengths. To obtain the necessary lumber a sawmill was installed in the spring of 1915 at a point in the canyon southwest of the big cut. A dam 37½ feet high was built across the canyon, giving a head of 19 feet to a 24-inch turbine wheel. Over 250,000 feet of lumber was sawed in 1915, and the diversion flume was completed. It has a length of about 3,400 feet, is 8 feet wide and 3 feet deep, and has a 2.2 per cent grade. It is built on 4 by 6 inch sills and is 2 inches thick on the bottom and 1 inch on the sides. This flume is thought to be amply large to carry the stream even during floods. It discharges into the canyon about 500 feet above the sawmill. The sluice line and discharge flume for the mines extends from a point near the upper end of the workings down through the big cut and discharges into the canyon at its junction with the main old channel, covering a total distance of over 1,800 feet. The boxes are 5 feet wide and 4 feet deep. For the lower 400 feet the sluice line is set on a grade of 9½ inches to the 12-foot box length, and above this stretch a grade of 7 inches to the box length is maintained. The upper ten lengths of boxes are lined with 40-pound railroad rails as riffles, and the lower portion of the sluice line with hemlock block riffles cut to a height of 13 inches. The arrangements for the disposal of the tailings are ingenious and are said to work in a highly satisfactory manner. As often as the tailings accumulate below the end of the sluice line in sufficient quantity to threaten to impede the discharge the gate in the mill dam is opened and the waters from the mill pond rush down through the narrow canyon and quickly remove the accumulated tailings.

The gravels are moved almost altogether by hydraulic means, hand methods being used only for cleaning bedrock. Between 20 and 30 men were employed throughout the season of 1915, but the greater part of their labor was expended in getting logs to the mill, in sawing and transporting lumber, and in building the diversion flume. The working day is 10 hours, and the men receive from $105 to $120 a month and board.

At the upper workings two hydraulic giants were used. The larger, equipped with an 8-inch nozzle, was placed at the head of the cut and was used in caving down the gravels and driving them forward to the wings. A smaller giant, with a 5-inch nozzle, was placed on the high bank a short distance above the wings and was used for moving the gravels directly into the boxes. At this place the stream gravels have a maximum thickness of about 80 feet in alternating beds of varying coarseness. Bowlders over 2 feet in diameter are sent through the sluice boxes, but some coarser bowlders are broken with powder and then handled by the giants. Everything in the cut is disposed of through the boxes. Three distinct pay streaks are reported in this ground. The lowest, on bedrock, is only a few feet thick, but is said to be the richest. It consists of rather coarse materials and contains considerable sticky clay that breaks up with difficulty and is likely to resist disintegration in the sluice boxes, and so fail to give up some of the placer gold it contains. A second pay streak is 8 to 12 feet thick, and its bottom is 15 feet above bedrock. The third comprises the upper 10 feet of the stream gravels and is the result of concentration by the present stream. The excavation discloses the fact that at the time the stream flowed over its bedrock floor, during the erosion of the deepest buried channel, it occupied a steep-walled rock canyon, and its gravel deposits were small. Upon the obstruction of this canyon by the Glacier Creek ice tongue a deep gravel deposit filled the old excavation, and the stream has since been able to remove these gravels only to a depth controlled by the rock floor in the present canyon. The bedrock thus far uncovered consists of steeply tilted beds of slate, graywacke, and conglomerate. In general it affords a rough surface well adapted to retain the placer gold, but locally it has been cut into potholes and worn so smooth that little gold has remained upon it. The gold penetrates to a depth of 2 feet or more in the cracks of the slate, and the broken surface of the bedrock must be removed to a considerable depth in order to obtain this gold.

At the lower workings on this property, on a branch of the deepest old channel, one giant with an 8-inch nozzle was used in caving down a high bank of gravel, sand, and glacial till and in driving it into the main sluice line.

The gold is bright in color and assays about $15 an ounce. It would certainly be classed as coarse gold, although only a small proportion is in nuggets having a value of 50 cents or over. Although Mendenhall[1] reports a nugget worth $50 from this stream, the largest two nuggets that have been found by the present operators had values of $26 and $25. Pieces worth from $1 to $10 are common. The sluice-box concentrates show abundant black sand.

At the close of the mining season of 1915 a large amount of tedious and expensive dead work had been completed. The diversion flume was finished and ready to be opened, the sluice line had been reset and

[1] Mendenhall, W. C., op. cit., p. 320.

relined, and the pipe lines were in position. The owners stated that within a few hours after the stream opened in the spring active mining would be under way, and they confidently expected the most prosperous season in the history of these claims.

Plans have been drawn and bids called for by the owners of this ground on specially constructed high-carbon steel plates to be used instead of block riffles in the sluice boxes. With the large volume and bowldery character of the gravels mined at this place, block riffles, although comparatively inexpensive to install, have so short a life that maintenance charges are high. It is believed that plates 1 inch thick of very hard steel, although of much higher first cost, will ultimately effect a great saving. Furthermore, they are thought to offer a great advantage in that they will render it unnecessary to shut down the mine for some three weeks in midseason in order to reblock the sluice boxes, as has been done in past years.

A second group of claims on Crow Creek, known as the Girdwood property, begins at the upper end of the Alaska Crow Creek Mining Co.'s ground, about 2 miles above the mouth of the creek, and extends northward to the head of a moraine-dammed, gravel-filled basin. The most complete description of the workings at this place is that of Paige and Knopf,[1] written as the result of their examination in 1906, at a time when the mine was in operation. The claims at this place have been patented, and in recent years no mining has been done. The plant is provided with several buildings, still in good condition, and considerable equipment, including steel hydraulic pipe and derricks. Cables, sluice boxes, and other apparatus are scattered over the property in various stages of preservation. A brief summary of the mining done is given here. The data are for the most part taken from the published descriptions by Moffit and by Paige and Knopf, to which reference has already been made.

The ground to be mined was the gravel filling of a basin lying behind a well-defined glacial moraine that stretches across the valley, its convex side downstream. This moraine impounded the waters of the stream and caused them to deposit their load of gravels until the basin was filled to the level of the stream outlet across the moraine. According to Moffit, the filling consists of interbedded layers of fine sand, angular wash, and coarse bowlders. The angular material had been brought down and deposited during freshets. The beds abut against the upper side of the moraine, and in order to mine the gravels in this basin it was necessary to make a 60-foot cut through the moraine. This was a slow and expensive undertaking, as the rock piles on either side of the old cut still testify, for the

[1] Paige, Sidney, and Knopf, Adolph, Reconnaissance in the Matanuska and Talkeetna basins, with notes on the placers of the adjacent region: U. S. Geol. Survey Bull. 314, pp. 121–122, 1907.

moraine was composed of exceedingly abundant and large bowlders and blocks of rock, with a relatively small amount of fine material. Many of the bowlders were hoisted from the cut by a derrick and stacked at the sides, but those too large to be handled required blasting. Paige reports that about 50,000 cubic yards of gravel was washed in 1906, but in this operation bedrock was not uncovered. It is said that a number of holes to bedrock were made with a Keystone drill and that highly encouraging amounts of gold were found in the drill holes, but the expense of opening the cut to bedrock proved too great, and mining there was discontinued in 1906. In 1907 and 1908, it is reported, sluicing was done on the upper end of the property with fairly satisfactory results. Since 1908 little actual mining has been done.

Winner Creek.

Two claims on lower Winner Creek have been mined in a small way for several years by one man. The first gold was recovered from this creek in 1898, when two men took out 36 ounces. The present owner first located the ground in 1902, but soon relinquished it. It was later staked by another man and then abandoned, to be finally restaked by the present owner in 1908. A cut 150 feet long, 14 feet wide, and 8 feet deep was first worked out, and later an area 100 feet long, 34 feet wide, and 5 feet deep was mined on a high rim. Difficulty has been experienced in conducting water to the gold-bearing gravels under sufficient head for hydraulic mining. A ditch to acquire such a water supply is in process of construction.

Other prospects in Glacier Creek basin.

California Creek received a good deal of attention from prospectors in the years between 1898 and 1902 and yielded some gold. Since 1902 no mining has been done there, but tentative plans have been made to continue prospecting in 1916. Paystreak Creek, the first tributary of Glacier Creek above Crow Creek, has also been prospected, but no paying ground was found. The main valley of Glacier Creek below the mouth of Crow Creek has been staked for several years, though nothing more than assessment work has been done.

PROSPECTS IN TURNAGAIN ARM BASIN.

It is reported that some placer claims are held on the west side of Twentymile River, about 4 miles above its mouth, but no mining has been done on them. Peterson Creek, the first tributary of the Arm west of Twentymile River, is said to have yielded some placer gold many years ago, and one man is still doing the assessment work on some claims in the upper basin of that stream. Kern Creek was prospected both in 1898 and in 1903, and some gold was found on it, but not enough to warrant mining. The gravels on Bird Creek have been prospected by different persons at different times since 1898. One outfit is said to have found ground that would yield as high as $6 a day for each man employed, but the bowlders were so large and so abundant that mining was discontinued. Two men were engaged in 1915 in driving a tunnel on the east side of Bird Creek, about 8 miles above its mouth, in the hope of opening an old gravel-filled channel there. In August, 1915, the tunnel was reported to be 144 feet long, driven through slate, and the old channel had not yet been reached.

Considerable work was done a number of years ago on lower Indian Creek. A flood dam was built and a cut ground-sluiced out, but the operators were unable to reach bedrock, and the ground was abandoned.

At a point near the beach, 1 mile west of Indian Creek, one man has been engaged in prospecting for a number of years. An open cut, extending northward for about 270 feet from the beach and from 15 to 20 feet deep at the face, has been excavated by ground sluicing. The bedrock, a black slate striking S. 6° W. and standing nearly vertical, was encountered 170 feet back from the beach. At the face of the cut the section comprises 2 feet of mucky soil underlain by 2 feet of blue glacial till, between which and bedrock there is 12 to 15 feet of well-rounded, rather fine gravel, with a few bowlders. No sampling of the ground was done, but the owner reports abundant black sand, with some gold. A lack of water has retarded prospecting, but a ditch 1½ miles long, to take water from Indian Creek, has been laid out, and the lower mile has been completed.

PROSPECTS ON TRIBUTARIES OF KNIK ARM.

Prospecting for gold placers on the tributaries of Knik Arm was stimulated by the beginning of construction on the Government railroad. Gold strikes were reported on Ship, Chester, and Campbell creeks and on other streams near Anchorage, and a few persons stampeded to these streams, but the small amount of prospecting done by them failed to confirm the rumors. At only one place was any actual attempt to mine noted. At a point where one of the tributaries of Ship Creek from the southwest emerges from the mountains one man had built a small flood dam and had ground-sluiced a small open cut, but had not uncovered bedrock. He reports small amounts of gold, but at the time of visit, late in August, 1915, he had found no workable placer.

GOLD AND SILVER LODES.

TURNAGAIN ARM.

GLACIER CREEK BASIN.

As a result of the early discovery of workable gold placer deposits in the Glacier Creek basin, that locality was also chosen by prospectors in search of the lodes from which the stream gold was originally derived. The first discovery of a gold-bearing quartz lode was not made until 1909, more than 10 years after the first placer gold was mined. The only lode prospects in the basin on which any considerable amount of development work has been done lie in the upper valley of Crow Creek and in Crow Creek Pass, about 9 miles from Turnagain Arm. They include two separate groups of claims. At the time of the writer's visit, in August, 1915, no one was seen on these claims, though one man was said to be prospecting there. The principal workings were visited by B. L. Johnson in the fall of 1911, and at that time active work was underway. Developments were discontinued the following year, so that Johnson's description [1] is still essentially correct and is here quoted.

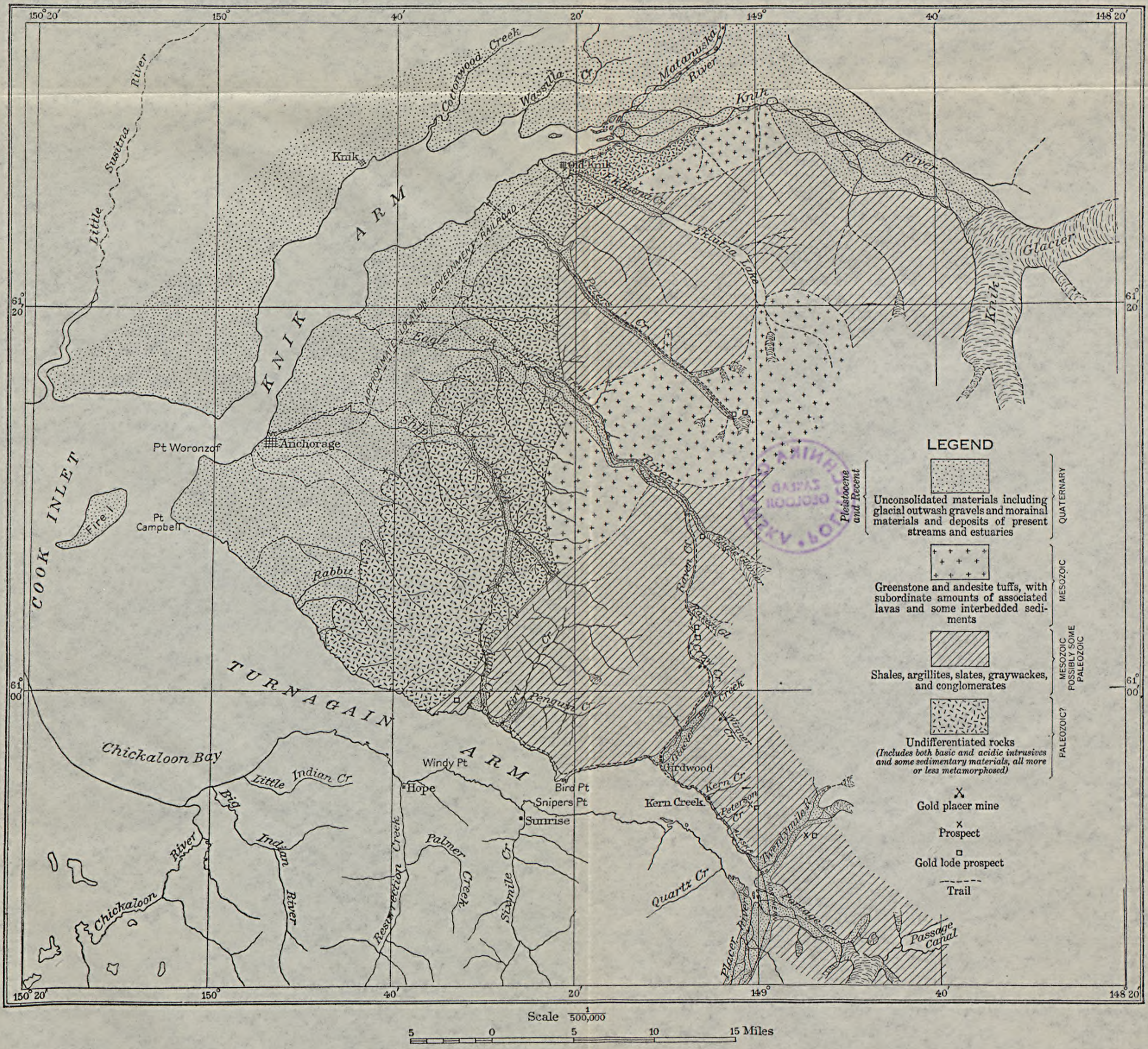
BARNES PROPERTY.

Location.—The property of the Alaska Gold Exploration & Development Co., known locally as the Barnes property, is at the head of Crow Creek, 9 miles from Girdwood, at the mouth of Glacier Creek. (See fig. 11.) * * *

History and development.—Although the first discovery of gold-bearing quartz on this property was made in September, 1909, by Conrad Hores, little work was done to open up the veins prior to August 1, 1910. Since that date, however, underground development has been actively carried on, all of it on the Stella claim. Three veins had already been found at the time this property was visited, and a fourth was discovered on the Ruth claim late in the fall of 1911. The developments on the Stella claim to January 1, 1912, consisted of 560 feet of adit levels, 56 feet of crosscut tunneling, 14 feet of drifts, and 52 feet of winzes, together with several open cuts on the different veins. These developments include three adit levels, two of which are on the south vein, one 100 feet vertically above the other. The upper of these two tunnels was 267 feet in length; two winzes, 42 and 10 feet in depth, have been sunk on the vein in this tunnel. The lower tunnel, started late in the fall, was only 50 feet long. On the northern vein, which is nearly parallel to this one, an adit level, 243 feet in length has been driven. A 56-foot tunnel intersects the third or crosscutting vein on the Stella claim. (See figs. 12 and 13.) Very little work has been done on the Ruth lode. Development work on this property ceased early in the spring of 1912.

Country rock.—The country rock of the ore deposit consists of dark slate, banded argillite, fine-grained graywacke, and conglomerate, folded and later intruded by several bosses of light-colored fine-grained granites and fine-grained to aphanitic acidic dikes, offshoots from the granitic masses. The strike and

[1] Johnson, B. L., The central and northern parts of Kenai Peninsula: U. S. Geol. Survey Bull. 587, pp. 173–176, 1915.



1916

GEOLOGIC SKETCH MAP OF THE TURNAGAIN-KNIK REGION.

S. R. Capps.

dip of the sedimentary beds vary, but in general the strike is easterly and the dip northerly. Fossils are not abundant. Imprints of a small Inoceramus of Jurassic or Cretaceous age were found during 1911 on the bedding planes of the banded argillite in bowlders on the moraines of the Crow Creek and Raven Creek glaciers and in place on the west side of the Raven Creek glacier.

Inclusions of the banded argillite are found in some of the granite bosses, sharp contacts appearing between the igneous and sedimentary rocks. No development of contact minerals is noticeable. The angularity of the fragments of the talus, the appearance of the weathered surfaces, and the density of the rocks, as well as the reddish, rusty discoloration of the sedimentary rocks

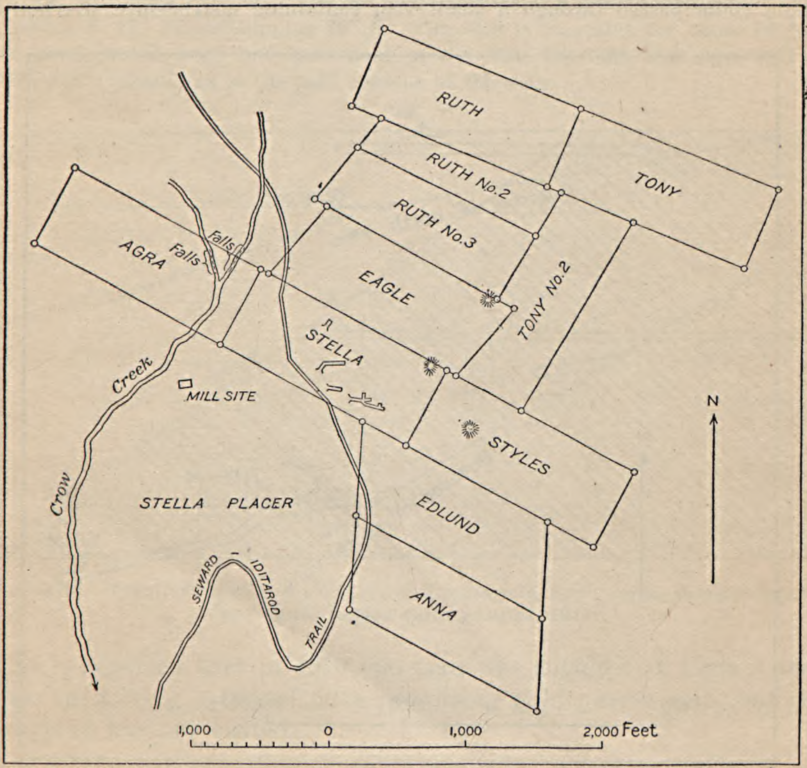


FIGURE 11.—Map showing location of mine workings on the Barnes property, Crow Creek. From map by C. H. Ballard (August, 1911).

of the area, suggests considerable heat action and mineralizing activity. Faults are numerous, the displacement, however, being usually only a few feet.

Ore deposit.—The ore body on the Stella claim consists of two parallel veins, a little over 100 feet apart, striking eastward, and a third vein crossing these with a strike of S. 18° E. The southernmost of the two parallel veins strikes S. 83° E., dips 55° N., and varies in width from 8 to 46 inches. The northern vein varies in width from 10 inches to 3 feet, strikes N. 87° E., and dips 68° N. The outcrops of these veins have been traced only a few hundred feet. The third or crosscutting vein ranges in width from 2 to 10 inches and dips 80° W. The vein on the Ruth claim is reported to strike eastward and to have a width of 6 to 8 inches.

Ore.—The gangue mineral of the gold veins is predominantly quartz, but it includes also some calcite. The vein quartz varies slightly in character. In some places it is coarsely crystalline and the vein contains numerous small vugs. Secondary banding parallel to the walls is noticeable in places, and sulphides have been deposited along some of the fractures. The quartz is jointed in some parts of the vein.

Arsenopyrite, pyrite, sphalerite, and galena are the principal sulphides. Chalcopyrite also occurs in small quantities. Pyrite and arsenopyrite occur as disseminated crystals in the metasomatically altered wall rock of the veins, as well as in association with the other sulphides in the vein quartz. In the open cuts the galena is often altered to cerusite. The crosscut tunnel on the Stella claim passed through a small vein containing molybdenite, pyrrhotite,

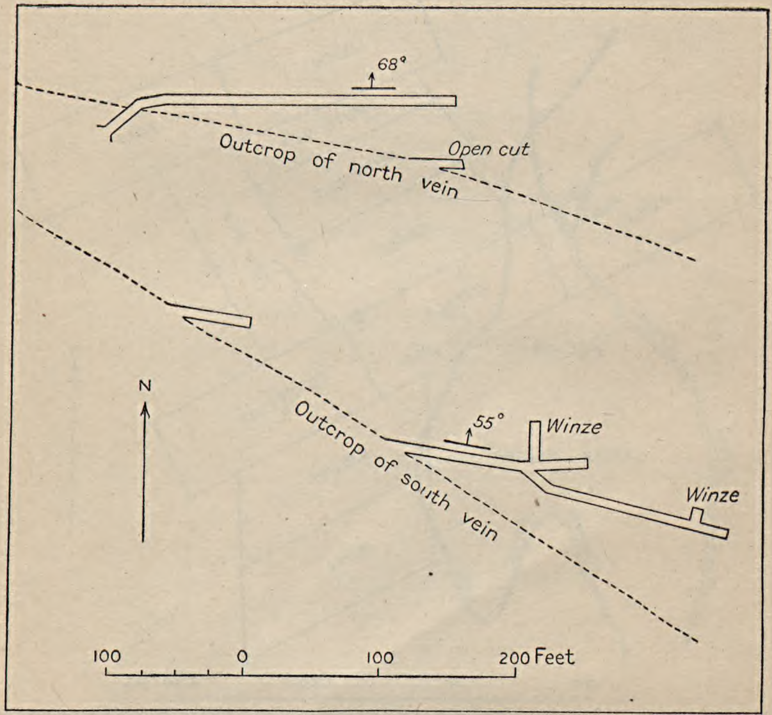


FIGURE 12.—Plan of workings on north and south veins, Stella claim, Barnes property, Crow Creek (1911).

and chalcopyrite in a gangue of vitreous-looking quartz. Pyrrhotite and chalcopyrite also occur in narrow seams in the banded argillite near the igneous rocks.

The ores are free milling. Tests on some of the more highly mineralized ore are reported to have saved 80 per cent of the gold by amalgamation and 16.4 per cent in the concentrate. The gold is found free in the quartz and occurs also in close association with the sulphides. It is also in places included in the grains of galena and arsenopyrite. Along some of the joint planes where the auriferous iron sulphides have been oxidized the gold is especially noticeable. Nuggets worth up to 63 cents have been found in the veins.

The ore from the larger veins on the Stella claim is reported by the owners to average $35 to $40 a ton for the southern vein and $12 a ton for the northern vein. Much higher assays have been obtained, however, in single samples. The limits of the ore shoots are not yet defined. About midway of the upper tunnel on the southern vein a stringer runs out into the hanging wall, and at this point sulphides are said to have been much more abundant and assays much higher than in other parts of the vein. Exceedingly high assays are reported from the crosscut vein on the Stella claim and from the vein on the Ruth claim. The wall rocks of none of the veins are said to carry gold.

TREASURE BOX CLAIM.

The Treasure Box quartz claim, in Crow Creek Pass, was located September 7, 1910, by James Patchell. The ore body consists of a quartz vein a foot wide, striking N. 11° E. and dipping 70° E. The vein is traceable for about 50 feet. No development work had been done at the time the lode was seen, and no data are available as to the gold content of the vein.

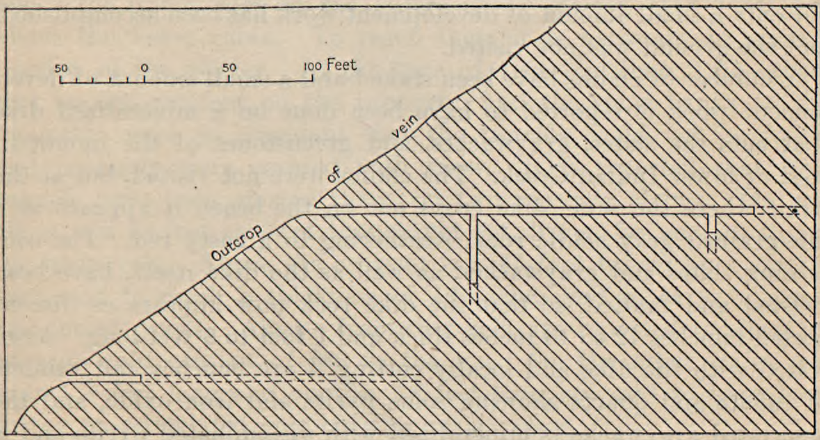


FIGURE 13.—Longitudinal section along plane of south vein, Stella claim, Barnes property, Crow Creek, looking north (August, 1911).

It is reported that in 1915 one man was engaged at Crow Creek Pass in driving a tunnel on a promising gold quartz vein, but the property was not visited.

BIRD POINT.

Two gold quartz claims were located along the Turnagain Arm beach just west of Bird Point in 1911. The vein outcrop was below extreme high-tide level, and in order to protect the mouth of the shaft from the tides a log cribbing, filled with clay, was erected around it. The shaft is reported to have been sunk to a depth of 22 feet, but after that depth had been reached an exceptionally high tide shifted the cribbing and flooded the workings, so they could not be examined at the time of the writer's visit. The quartz vein is said to range from 2 to 16 inches in thickness and to cut slate country rock. Both the vein and the slates strike about magnetic north. The quartz carries pyrite, chalcopyrite, galena, and copper carbonates in addition to the gold. A mill test of 4,200 pounds of ore, made in 1912, is said to have yielded gold at the rate of $52.75 a ton. Acidic dikes cut the slates and graywackes of the mountain north of Bird Point, and there may well be a genetic connection between the gold quartz veins and these intrusives. The dikes themselves and the neighboring portions of the quartz-veined sediments are said to carry gold in encouraging amounts.

OTHER PROSPECTS.

It is reported that assessment work has been done on some gold quartz claims about 4 miles above the mouth of Twentymile River, and also on claims in the upper part of the Peterson Creek basin, but only a small amount of development work has been accomplished, and the ground was not visited.

A number of claims have been staked and a small amount of development work is reported to have been done on a mineralized dike that cuts the slates, graywackes, and greenstones of the mountain west of lower Indian Creek. The claims were not visited, but at the point where the same dike crops out on the beach it appears as a fine-grained gray acidic rock, weathering to a rusty red. The containing slates and graywackes, as well as the dike itself, have been twisted and faulted, so that the dike rock now appears as disconnected bunches 12 to 18 inches thick and 1 foot to 6 feet long. Associated with the dike and locally cutting it are bunches and veinlets of calcite and quartz showing some pyrite and iron oxide, and the associated graywacke is mineralized with disseminated pyrite and is somewhat rusty.

KNIK ARM.

PETERS CREEK BASIN.

Active prospecting has been done for several years on a group of claims near the head of Peters Creek. The country rock in this vicinity consists of a massive series of greenstone and greenstone tuff, with small amounts of interbedded shale. A characteristic phase of the greenstone is a dense, fine-grained green rock inclosing abundant small angular fragments of slate. Two cabins have been built near these claims, which are several miles from the nearest available timber. One cabin is in the main valley of Peters Creek, near the point at which it emerges from beneath the glacier, and the other is high on the edge of the glacier some 2,000 feet above the lower cabin. On the mountain side northeast of the lower cabin and at an altitude about 1,100 feet above it a tunnel 37 feet long was driven on a fracture zone containing a quartz vein 2 inches or less in thickness. This vein strikes N. 60° W. and dips 75° SW. At a point 30 feet from the portal the tunnel cuts an intersecting quartz vein striking N. 77° W. and dipping 60° N., and showing a maximum of 2 inches of quartz. At the breast of the tunnel a second intersecting vein, parallel with the first, was encountered. It lies in a fracture zone that shows about 1 foot of gouge, broken greenstone, and quartz, in which the quartz reaches a greatest thickness of 8 inches. The quartz is sugary and somewhat banded and shows vugs lined with tiny, needle-like quartz prisms. It is cut in places by thin veinlets of calcite. Little mineralization other than some rusty stains was seen, but the ore is said to carry pyrite and lesser amounts of galena and chalcopyrite. The only assay made from this tunnel is said to have yielded $12.60 a ton in gold.

The other tunnels on this property lie on the steep mountain wall above the upper edge of the Peters Creek glacier, over 2,500 feet above the lower cabin. To reach them it is necessary to cross a portion of the glacier. At the time of visit—in June, 1915—there was no one resident on the property, and the snow banks on the mountain were so abundant that the tunnels could not be found and probably were covered with snow. It is reported that four tunnels have been started there, on two separate claims. On one claim is a 12-foot crosscut tunnel, not yet driven far enough to cut the main vein. Above the crosscut is a 45-foot tunnel on a quartz vein said to reach a thickness of 10 inches and to carry a small amount of pyrite. Assays from this vein are reported to show an average gold content of $38 to the ton. On the other claim one tunnel 8 feet long and another 18 feet long are said to have been driven on reticulated gold-bearing quartz veins.

EAGLE RIVER BASIN.

The only lode deposit so far discovered in this region whose chief value lies in some metal other than gold is at the head of Eagle River, near the foot of the glacier in which that stream has its source. This lode is known as the Mayflower lode. The claim was visited by B. L. Johnson,[1] in 1911, and, as no considerable amount of development work has been done on this property since that year, Johnson's description is here quoted in full:

> The Mayflower lode, on the south side of Eagle River, at the foot of the Eagle River glacier, was discovered June 1, 1911, by J. P. Frisbie, William Murray, and M. S. McMelan. The outcrop of the ore body is well exposed on the recently glaciated surface of the massive graywacke country. The ore body consists of mineralized sheeted zones in the massive graywacke. These zones have a north-south strike, dip vertically, and have been traced about 400 feet on the south side of the river. Their continuation on the north bank

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[1] Johnson, B. L., The central and northern parts of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, p. 178, 1915.

is reported. They have a rusty appearance, resulting from the decomposition of the iron sulphides. Two of the zones, 50 feet apart, carry a few mineralized quartz stringers of variable width. The easternmost and widest of these sheeted zones has a width of about 50 feet, only part of which is much fractured. The largest quartz stringer observed lies near the eastern edge of this zone. It has a width of 1 to 6 inches, but in places it widens to 10 or 12 inches. The gangue of the veins is quartz with a little calcite. Small calcite veins also occur along joint planes in the graywacke. The metallic minerals of the ore deposit are galena, pyrite, sphalerite, arsenopyrite, chalcopyrite, and a little malachite. The mineral association is similar to that of the gold quartz veins of Kenai Peninsula. Galena is more abundant than in most of the gold quartz prospects, and an assay from this ledge reporting 0.05 ounce gold and 24.80 ounces silver to the ton was probably made on a specimen consisting principally of galena. No free gold was seen in any of the specimens examined.

GOLD MINING IN THE WILLOW CREEK DISTRICT.

By Stephen R. Capps.

INTRODUCTION.

Mining in the Willow Creek district was continued in 1915 on about the same scale as in the preceding year. The output was derived mainly from the three mines that have been in active operation for several years, although a small single stamp mill was erected on one claim that has heretofore not been among the producers. As a result of the beginning of construction on the new Government railroad, which will pass along the edge of this district, prospecting was active, and plans are under way for active mining on several properties. A report on the Willow Creek district, describing the developments up to the fall of 1913, has recently been published.[1] In September, 1915, the writer spent about a week in the Willow Creek district, and visited all the working mines and many of the more promising prospects. The following notes on the various properties are not intended to be complete in themselves, but to supplement the more complete report by carrying the account of mining developments up to the fall of 1915.

In the following table the figures for 1914 show a larger apparent than actual increase in the production of the mines over 1913, for in 1914 a considerable proportion of the output was obtained by cyanidation of tailings that had been accumulated during milling in earlier years. The output in 1915 came in large part from ores mined during that year.

Gold and silver produced at lode mines in Willow Creek district, 1908–1915.

Year.	Gold.		Silver.[a]	
	Quantity (ounces).	Value.	Quantity (ounces).	Commercial value.
1908	87.08	$1,800	6.88	$3.64
1909	1,015.87	21,000	80.25	41.73
1910	1,320.15	27,290	104.29	56.31
1911	2,505.82	51,800	197.95	109.91
1912	4,673.02	96,600	369.07	226.97
1913	4,883.94	100,960	385.83	233.42
1914	14,376.28	297,184	1,330.00	735.00
1915	11,961.55	247,267	811.00	421.00
	40,823.71	843,901	3,285.27	1,827.98

[a] The silver content recovered from the gold bullion is estimated.

[1] Capps, S. R., The Willow Creek district, Alaska: U. S. Geol. Survey Bull. 607, 1915. See also abstract in U. S. Geol. Survey Bull. 592, pp. 255–272, 1914.

ALASKA FREE GOLD MINING CO.

The Alaska Free Gold Mining Co. operated throughout the open season and employed on an average about 50 men. The mill was run in three shifts of eight hours each, as was also a part of the mine. In other parts of the mine two shifts only were worked. The capacity of the mill has been greatly increased by the installation, in 1914, of an additional Lane mill of 40 tons capacity and a 40-ton cyanide plant and by the elevation of the flume to give a head of 54 feet at the Pelton wheel, instead of the 35-foot head formerly used. During the season of 1915 both mills were in operation only a part of the time, there being either not enough water available to operate both or not enough ore mined to keep both working to their capacity. All the tailings from the mill are now treated by cyanidation. It is reported that even with the greater depth below the surface from which the ore is now taken the tenor of the tailings after amalgamation remains fairly constant and is much the same for tailings from rich and poor ores alike. This fact indicates that even at considerable depth the gold in the veins is likely to be present predominantly in the form of free gold, and the ore from even deeper levels will probably be free milling. Three aerial tramways are in operation—two extending to openings on the Smuggler-Union vein and one to the Eldorado vein.

Since this mine was last visited, in 1913, much underground work has been done on the upper of the two main veins on the property. On this vein, referred to previously as the Skyscraper vein but now known as the Smuggler-Union vein, the main tunnel has been driven along the vein to its outcrop on the southeast side of the mountain, a total distance of 380 feet, and from it stopes and winzes have been made. Two additional tunnels on the same vein have been driven. The upper one, about 100 feet below the main tunnel, is over 250 feet long, and the lower one, 175 feet below the main tunnel, is 175 feet long. Both the vein and the ore shoots have been shown to be continuous between the several levels. The vein, so called, in reality consists of two nearly parallel veins, of which the upper is locally referred to as the hanging-wall vein and the lower as the footwall vein. These veins are in most places separated from each other by several feet of diorite, though they are connected by numerous quartz stringers. Locally they diverge somewhat or approach rather closely, but in general each of the two maintains its own individuality.

On the Eldorado vein, which is apparently the southward continuation of the Smuggler-Union vein, an incline now 40 feet long has been driven, and from it an aerial tram leads to the mill. It is expected that considerable ore will be supplied to the mill from this claim.

It is proposed to install a tramway from the mill to the Rosenthal property, on the high ridge that borders the Fishhook Creek basin on the northeast, in the spring of 1916, in order to provide an additional supply of ore to the mill.

GOLD BULLION MINING CO.

The Gold Bullion mine was operated in 1915 throughout the open season, beginning June 3. During that period the stamps were dropping for 24 hours a day, and two shifts were worked at the mines. About 60 men were employed. No increases were made in the mill capacity, but a 45-ton cyanide plant, installed in 1914, was operated, all the tailings from the mill and a quantity of stored tailings being treated by cyanidation. As the length of the milling season is controlled mainly by the period of adequate run-off in Craigie Creek, from which water for power is taken, a dam 13 feet high was built across the basin of that stream, thus forming a storage reservoir of 13½ acres. Two smaller dams above give additional storage capacity, and the water thus impounded was expected to be sufficient to keep the mill in operation for a season several weeks longer than heretofore.

A large amount of underground work has been done since the property was last visited in 1913. In the fall of 1915 the No. 2 tunnel had over 930 linear feet of underground workings, not including considerable stopes. From this tunnel about half the ore mined in 1915 was taken.

The new Gold Dust tunnel was 360 feet long in 1915, and the near-by No. 1 Gold Dust tunnel 200 feet long, and a large area of the vein between them was stoped out, furnishing about half the season's supply of ore. The No. 3 Gold Dust tunnel had been driven to a length of 139 feet, the No. 4 Gold Dust tunnel about 45 feet, and the No. 2 Gold Dust, which contains a large stope, 65 feet.

The result of this underground development has been to keep the mill supplied to capacity with ore during the 1915 season, and to block out considerable ore bodies for future mining. The Gold Dust No. 3 tunnel follows a thick, strong vein said to be exceptionally high in gold.

INDEPENDENCE GOLD MINES CO.

The property of the Alaska Gold Quartz Mining Co. was taken over by the Independence Gold Mines Co. in 1914. Since the transfer no important changes have been made in the surface equipment, although plans have been made for the installation of a new crushing mill. In 1915 the mill was put into operation on May 19 and, except for some short stops for repairs, was run continuously until the cold weather cut off the water supply. About 18 men were employed in two shifts. Although sufficient ore to keep the mill running was mined, the developments of the year were directed primarily to blocking out ore, in order to determine whether or not the installation of a new mill would be justified. The main tunnel, on the Granite Mountain vein, was driven to a total length of 540 feet along the vein, and at a point 400 feet from the portal a winze follows the vein down the dip for 70 feet. These additional developments show little change in character or gold tenor of the vein with increase in depth, although the breast of the main tunnel is now estimated to be 300 feet below the surface. The veins show the same tendency to pinch and swell that they display nearer the surface; the ore shoots continue, and the ore is apparently as free milling as that taken from shallower parts of the vein. The driving of a long tunnel, to tap the vein at a lower level, is among the plans now being considered.

The upper or Independence vein was opened in 1914 and 1915 by one tunnel 105 feet long and another 15 feet long, and 240 feet of stripping was done on the vein outcrop. The vein is in places 3 feet thick, but in general has not been found to contain as much gold as the Granite Mountain vein.

MABEL MINE.

At the Mabel mine development work has been continued. The adit tunnel, begun in 1913, was driven about 75 feet to the vein, and short drifts were run along the vein in both directions. In these workings the vein pinches and swells within short distances, and the quartz ranges from a mere stringer to a band 1 foot wide. On the surface the vein has been exposed by stripping and open cuts almost continuously for a distance of about 2,000 feet and shows a persistent quartz vein from a few inches to about 2 feet in thickness. The assay values are said to be encouraging. An aerial tramway to extend from the vein croppings to the mill site is on the ground, and it was said that a 20-ton mill was to be installed during the winter of 1915–16, to be run by water taken from Reed Creek.

ROSENTHAL CLAIMS.

The Rosenthal claims, on the ridge between the basins of Fishhook Creek and Little Susitna River, promise to become productive soon. Some additional underground work has been done since 1913, and the extent of the ore body is now fairly well known, as the flat-lying vein crops out around the mountain top and tunnels pierce almost through the center. The ore broken in driving the tunnels has been banked at the portal and in the drifts, and a considerable amount is ready to be trammed to the mill. Control of the property has recently been acquired by the Alaska Free Gold Mining Co., and it is planned to erect an aerial tramway from this ground to the mill in the valley of Fishhook Creek.

SHOUGH CLAIMS.

Prospecting has been vigorously carried on during 1914–15 on the claims of the Oregon group. A winding tunnel with a total length of 150 feet has now been driven along an irregular quartz vein. The quartz is said to contain only moderate quantities of gold, but the main objective of the tunnel is to crosscut a fault zone that may be traced along the surface for some distance. It is estimated by the owner that a distance of 50 to 70 feet still remains between the breast of the tunnel and this fault zone. It is said that at a point about three-eighths of a mile southwest of the tunnel the fault zone was ground-sluiced off to a depth at which the clayey gouge began to give place to solid pieces of quartz. The whole zone, to a width of 60 feet, is said to carry several dollars a ton in gold.

JAP CLAIMS.

Prospecting has been done for some years on ground locally known as the Jap claims, lying on the northwest side of upper Willow Creek, opposite the Gold Bullion mine. No one was resident on this property at the time the district was visited, in September, 1915, but it is reported that a small 1-stamp mill, with a daily capacity of 200 to 300 pounds of ore, was installed and in operation part of the 1915 season, milling ore of encouraging gold tenor.

MAMMOTH CLAIMS.

Some additional underground development work has been done on the Mammoth claims, in the upper Willow Creek basin, since that property was visited in 1913. It is reported that a crosscut 100 feet from the portal of the main tunnel has been driven an additional distance of 30 feet, and from it a 40-foot raise has been made. About 30 feet of miscellaneous raises and drifts were also opened.

McCOY CLAIMS.

The McCoy claims, on the east slope of the mountain west of lower Reed Creek, were further prospected in 1914 and 1915. The work done was confined for the most part to stripping the surface croppings of the vein. It is said that the thickest part of this vein, as now uncovered, shows 9 to 10 feet of quartz, some of which contains much gold. Very little underground work has yet been done on this property.

OTHER PROSPECTS.

Brief reports on the developments during 1914–15 at a number of properties not visited in 1915 were obtained from a number of sources and are given below.

On the ground of the Matanuska Gold Mining Co. only assessment work was done.

The Gold Quartz claims, on the Archangel Creek side of the point lying between that stream and Reed Creek, have been prospected by two tunnels 20 and 30 feet long. The vein is said to reach a maximum thickness of 2 feet and to contain considerable gold.

A short tunnel is said to have been driven on the Hatcher claims, in the Archangel Creek basin.

Some further underground work is reported on the claims known as the Arch prospect, between lower Sidney and Archangel creeks. Four claims called the Archangel group, lying on the mountain east of lower Reed Creek, have been prospected by two tunnels, each about 35 feet long, one on the Reed Creek side and one on the opposite side of the same ridge. It is said that the vein shows a maximum thickness of 38 inches of gold-bearing quartz.

GOLD PLACERS.

The only placer-mining operations of note within this district in 1915 were those on lower Grubstake Creek and on adjoining portions of Willow Creek. These operations were directed to prospecting the gravel benches, and hydraulic methods were available, as the hydraulic plant formerly used for mining on this creek is still in working condition. Work was carried on for only a part of the season.

PRELIMINARY REPORT ON THE TOLOVANA DISTRICT.

By Alfred H. Brooks.

INTRODUCTION.

The Tolovana district[1] lies in the headwater region of Tolovana River, which flows southward into the Tanana, and in the upper basin of Hess Creek, which flows westward into the Yukon. (See map, Pl. IX.) In this region, notably within the Tolovana basin, gold placers have been found and are being developed. Production has thus far been confined chiefly to the placers of Livengood Creek, but some gold has been found on other tributaries of the Tolovana, as well as in adjacent creeks which flow into Hess Creek. Placer gold was found in the Hess Creek basin as early as 1892 by Mike Hess, after whom the creek was named, and this may have been near the scene of the recent discovery. The present importance of the region is due, however, to the discovery of placers on Livengood Creek by Jay Livengood and N. R. Hudson on July 24, 1914. Much excitement was aroused at Fairbanks and other Yukon camps by their discovery, and during 1914 and 1915 hundreds of people went to the district.

Systematic mining began in the summer of 1915. While there was a large amount of prospecting, only about 10 mines were commercially productive, but these made a gold output to the value of $80,000. Considering the isolation of this new camp and the fact that much of the placer ground is deep, requiring boilers and hoists for proper development, the results of the first season's work are very encouraging.

The entire area within which gold placers and prospects are known was mapped topographically by Witherspoon and Oliver[2] in 1907 and 1908, and the geology of a part of the region has been studied by Prindle, Hess, and Katz,[3] but these investigations did ont

[1] Descriptions of boundaries of Tolovana recording precinct are not available at this writing.

[2] Witherspoon, D. C., and Oliver, R. B., Reconnaissance map of Fairbanks quadrangle: U. S. Geol. Survey Alaska map No. 642. Price, 50 cents.

[3] Prindle, L. M., The Fairbanks and Rampart quadrangles, Alaska, with a section on the Rampart placers, by F. L. Hess: U. S. Geol. Survey Bull. 337, 1908.

Prindle, L. M., and Katz, F. J., A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U. S. Geol. Survey Bull. 525, 1913.

cover the scene of the actual mining on Livengood Creek and its tributaries. A large amount of information is, however, available from the operators and prospectors, and it was the writer's good fortune to meet a number of these men. Therefore, while the following statements are not based on the actual observation of the geologists, they are believed to be accurate. The writer was the better able to interpret these statements because of his personal familiarity with the region lying immediately to the south of the scene of the discovery.[1]

The information contained in the reports above referred to has been supplemented by more detailed notes furnished by Jay Livengood, N. R. Hudson, Harry Patterson, W. Allmark, J. P. Norich, Allister McMillan, Falcon Joslin, C. W. Joynt, and C. P. Keen.

TOPOGRAPHY.

The Tolovana district belongs topographically to the Yukon-Tanana upland, having the characteristic flat-topped ridges and interstream areas of that province. The general summit level stands at about 2,000 feet, and many flat-topped spurs, some of lesser altitude, radiate from the summits. Several rounded domes and ridges stand above the general summit level, with elevations of 2,100 to 2,600 feet. Of similar character, but of far greater relief, are the White Mountains, which lie about 20 miles east of the center of the district. This range, one of the most rugged features of the whole Yukon-Tanana region, being from 3,000 to nearly 5,000 feet in altitude, has a sharp crest line trending N. 20° E. In the Tolovana district proper there are no definite trends to the ridges, for these are irregular interstream areas blocked out by a complex drainage system.

The streams draining the area form an intricate system. The master streams, such as the Tolovana, occupy broad alluvium-filled valleys through which they flow in tortuous courses. The lower reaches of the Tolovana meander through a lowland which near the mouth of the river is over 25 miles in width, but which gradually narrows upstream, so that at the mouth of Livengood Creek the valley floor is less than 4 miles wide, and farther up it becomes still narrower. The tributary valley slopes rise gently from the Tolovana floor to the upland surface above. They are broken here and there by terraces, in part well defined, in part masked by talus.

Hess Creek, the second important watercourse of the region, flows in a westerly course to the Yukon through a valley whose floor is some 5 miles in width. It receives numerous tributaries that also

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

have broad valley floors. Prindle has mapped terraces along the slopes of Hess Creek and its tributaries, and others are reported by prospectors as occurring in the unmapped areas.

The upper basin of the South Fork of Hess Creek, called Goldstream by the miners (Pl. IX), lies directly east of the headwaters of Livengood Creek, and is a wide, flat-bottomed valley through which the stream meanders. Its valley slopes are gentle, but are said to be broken by benches. This part of the valley of Goldstream is a mile or more in width. About 2 miles above the mouth of Willow Creek the valley floor narrows to 600 or 800 feet, the walls are steep and lack benches, and the stream maintains a rather straight course. At the mouth of Willow Creek the valley widens again into a broad basin and the stream again takes a tortuous course. Here the valley slopes are broken by broad gravel benches. There is a very low, apparently gravel-filled divide, between the head of Pedro Creek, tributary to South Fork below Willow Creek, and the head of the west fork of Myrtle Creek, tributary to Livengood Creek. In fact, these streams head in the same flat with Excelsior and Lost creeks. Livengood Creek heads in a low, gravel-filled divide which separates it from Goldstream. Its valley, like many of the other stream valleys of this region, is unsymmetrical in cross section, having a gentle talus-covered slope on the northwest and an abrupt slope on the southeast. Below Myrtle Creek, a northerly tributary, the valley broadens. From this point to its junction with Tolovana River the stream meanders over a flat valley floor 2 miles or more in width.

There is a very low divide between the head of Pedro Creek, which flows into the South Fork of Hess Creek, and the head of the West Fork of Myrtle Creek. The facts in hand indicate that there have been extensive changes of drainage in this region. Alabam Creek may have been the former head of Livengood Creek, and a single creek may have occupied the valleys of what are now Myrtle and Pedro creeks. It appears probable that the Lost Creek basin formerly drained northeastward to the South Fork of Hess Creek. Whether the South Fork was then tributary to Hess Creek or found a more direct route northeastward to the Yukon Flats it is not possible to determine from the facts now known, but the latter interpretation of the old drainage lines seems the most likely. An alternate hypothesis is that at this time the West Fork of the Tolovana found an outlet through the Livengood Valley, across the low divide at its head, and into Goldstream. It is also suggested that a former watercourse connected the upper Tolovana and the Beaver Creek valley and probably discharged into the Tolovana Flats. This former drainage system, however, has not yet been sufficiently investigated to permit a definite statement. The direction of even the master streams of the old drainage system is indeed by no means certain. If such differences of drainage were in existence at the times of the deposition of the deep placers, as they may have been, the former courses of the waterways become a matter of economic importance.

GEOLOGY.

Bedrock.—The oldest rocks of the Yukon-Tanana region are those of the Birch Creek schist, which occupies extensive areas in the Fairbanks, Birch Creek, and other placer districts. This formation is not represented in the Tolovana district. The Birch Creek schist is overlain by a great thickness of sediments, including feldspathic sandstones, conglomerates, and graywackes, with slates and some limestones and cherts. Interbedded with these sediments are some ancient lavas and deposits of volcanic ash which have been more or less altered and can now be collectively termed greenstones. This whole series, which on detailed surveys will undoubtedly be separated into several formations, has been placed together under the name Tatalina group and provisionally assigned to the Ordovician period. In the White Mountains there is a great series of heavy limestones that, so far as known, succeed the Tatalina group and range in age from Ordovician to Silurian. Some of these rocks are very siliceous, and they are in part highly crystalline. These limestones are believed to be separated by an unconformity from the older Tatalina group. They are in turn succeeded by a series of red, green, and black slates, sandstone, and conglomerates called by Prindle the Tonzona group. Middle Devonian blue limestones, with some slate, make up the next higher series, and these are succeeded by greenstones with some interbedded cherts and limestones, which are provisionally assigned to the Devonian. These rocks are overlain by Carboniferous gray and black shales and siliceous slates with some cherts. The whole Paleozoic sequence is cut by granitic and related igneous rocks, probably of Mesozoic age.

The formations of the Tolovana district are believed to belong to the several series above named. It appears that the bedrock of the gold-bearing area consists chiefly of cherty crystalline limestone and black and red slates, with some chert beds. The greenstone is reported to be in part altered to serpentine. Quartz veins occur in the greenstones and are believed by many to be the source of the gold. Dikes of granitic rocks are common in the sediments, and there are some large stocks, as in the dome at the head of Amy Creek. The formations south of the Tolovana, including the Wilbur Creek basin, are said to consist of black shales, sandstone, and limestone.

The limestone disintegrates after being mined. It appears that the gold-bearing gravels are largely greenstone and chert, as well as quartz. The cherts are reported to be black and reddish. These rocks appear to have puzzled some of the miners, who have misnamed them "argillites."

Alluvium.—The information at hand indicates that the alluvial deposits of the district belong to four different classes—deep gravels, bench gravels, creek gravels, and talus or slide material. The deep gravels are usually covered by a considerable thickness of muck or talus. Some layers of clay have been found with the deep gravels. The alluvium will be discussed in greater detail under the description of the placers.

GOLD PLACERS.

Auriferous gravels are widely distributed in the Tolovana district. The area in which gold prospects have thus far been found is about 10 miles square and includes Livengood Creek and its tributaries, some streams flowing into the Tolovana above the mouth of Livengood Creek, and the upper basin of the South Fork of Hess Creek.

The auriferous gravels occur in the beds of the present streams, in buried channels, and in bench gravels. Up to the present time most of the gold has been won from the deep channels of Livengood Creek, which have proved to be far richer than either the stream or the bench placers. Some shallow placers have also yielded gold, notably on Olive Creek, but only prospects have been found in the benches.

The only deep channel which has been opened is on Livengood Creek, where it lies underneath the talus slope on the north side of the valley. This channel is in general parallel to the axis of the valley. It appears to have been pretty definitely traced for at least 2 miles, and some evidence of it has been found along a distance of 4 miles or more. As in other districts claims are staked under two or more names. First there are the creek claims staked along the present watercourse. Parallel to them are the bench claims, which may be on the valley floor or on the talus slope. Where the valley is wide there may be one or two or even three or four tiers of bench claims. These so-called bench claims on Livengood Creek are not on stream terraces, as the name would imply, but on the talus slope of the valley, underneath which, it is suspected, lies a buried channel. The claims are numbered from Discovery claim up and down stream and are designated "No. 1 below," "No. 1 above," etc.

A shaft was sunk at "No. 9 below" to a depth of more than 200 feet without reaching bedrock. So far as known to the writer the farthest point downstream that gold has been found in the deep channel is at bench claim No. 4 below Discovery, where a shaft 125 feet deep was sunk to bedrock and was in gravel for the entire distance. At "No. 2 below" a shaft was sunk 230 feet, which did not reach bedrock. This shaft also was chiefly in gravel but pierced three layers of sticky clay, or "gumbo," as the miners describe it. One of the layers was 17 feet, one 70 feet, and one 120 feet below the surface. Prospects of gold were found on these clay strata, the highest value being about 1 grain to the pan. At Discovery claim on Livengood Creek the valley is broken by a central ridge of hard rock which stands about 12 feet above the slope on the north and 40 feet above the present stream on the south. This ridge separates the deep channel from the present stream valley. It is traceable downstream for 1,000 to 1,500 feet and upstream for about 3,000 feet. At "No. 2 above" the ridge merges into the north slope of the valley, or, in other words, it is covered by talus above this point. Upstream from the upper end of this ridge the north slope of Livengood Creek is rather gentle, but there is some evidence near the creek that a rock scarp is buried under the talus. At Discovery claim Livengood Valley is about a mile wide. At "No. 5 above" it narrows to about half a mile, and farther upstream it broadens out again.

There has been much prospecting near Discovery claim, and holes have been sunk on the creek claims as well as on the first and second tiers of bench claims. It is said that by this work and by the discoveries in creek gravels some gold has been found over a width of 3,400 feet. At Discovery bench the deep channel is from 100 to 110 feet below the surface. Of this about 50 to 60 feet is silt or muck. The shafts sunk on the first and second tiers of bench claims near Discovery show the bedrock to be from 40 to 90 feet deep. Here the overburden consists of muck, which contains fragments of wood and some vertebrate remains. At "No. 5 above, fourth tier bench," there has been considerable mining. Here the ground is 90 feet deep. Productive mining has also been done on "No. 5 above, first tier"; on "No. 4 above, third tier"; on "No. 3 above, third tier"; and on "No. 19 above."

Halfway between Wonder and Franklin creeks a hole 78 feet deep was sunk to bedrock, and 300 feet away, higher on the slope, another shaft 28 feet to bedrock; still higher it is only 7 feet to bedrock. The deep hole contained no "slide" material; the shallow holes considerable. On "No. 19 above" on Livengood Creek some deep ground has been found, but the writer did not learn the depth to bedrock.

On the "fourth tier bench No. 5 above," the bedrock on the north is said to rise by a series of benches with 2 to 3 foot scarps. A shaft was sunk on the "third tier bench No. 3 above," where the alluvium is 40 to 50 feet deep. On the Red claim, a short distance above Wonder Creek, a hole has been sunk 60 feet to bedrock. This is the farthest up Livengood Creek that holes had been put down to bedrock in September, 1915.

Not enough work has been done on other tributaries of Tolovana River to indicate the presence of deep channels. On the South Fork of Hess Creek, however, two localities of deep ground have been found. Just across the divide from Livengood Creek, about half a mile below Alabam Creek, a hole has been sunk 100 feet to bedrock. This is on the upper part of South Fork of Hess Creek, here called Goldstream, on claim "No. 7 above." It is probable that 40 or 50 feet of this 100 feet was gravel. About $1\frac{1}{2}$ miles below this point three holes have been sunk. In one no gravel was found, only talus; in the other two about 25 feet of gravel with no gold. Below this locality the gravels do not seem to exceed 25 feet in depth except at the mouth of Pedro Creek, where the depth to bedrock is 90 feet. Of this, 80 feet is gravel, all carrying colors of gold, and the top 10 feet is muck. At this locality there seems to be no concentration of gold on bedrock. Above this deep ground is the narrow part of the valley, and here the alluvium is only 20 to 25 feet deep. A hole has been sunk on Alabam Creek, on No. 1 below Discovery, about 1 mile above the mouth, where it is 52 feet to bedrock. Half a mile above, on the slope, a hole was sunk 125 feet. It was said to be chiefly in gravel, but bedrock was not reached.

Information about the bench gravels is not very definite, except that they occur at several localities. Thick beds of gravel have been found on the east side of Hess Creek below Willow Creek, as high as 200 feet above the stream, and are said to carry gold. It is reported that there are at least four well-marked benches on the south side of Livengood Creek, but no gravels have yet been found on them.

The present stream gravels include those of the main stream and the tributary gulches. On Livengood Creek the creek gravels are separated from the deep gravels by the bedrock rim already described. At Discovery claim the creek gravels are 18 to 20 feet deep. The section includes 6 to 10 feet of green silt or clay and 10 to 12 feet of gravel. The gravels in the creek seem to be of the same character as those on the bench, but the gold is brighter. Many of the tributaries of Livengood Creek carry workable placers, and so do some of the streams flowing directly into the Tolovana from the divide between Livengood Creek and Tolovana River. In the opinion of the miners the streams flowing over the bench ground north of Livengood may have derived a part of their gold from deep placers. As a matter of fact, however, this can be true only where the workings have actually reached the depth of the old channel, in which case they are not properly creek placers, but deep placers.

The creek placers of Livengood Creek proper have been opened at Discovery claim, but have not been mined on a commercial scale. Their gold content seems to be too low to warrant exploitation under the conditions existing in 1915. As a result the creek has been but little prospected. Several of the tributaries, however, have yielded workable placers in ground that was shallow enough to work by open cuts.

At " No. 4 above " the creek has been crosscut and the pay streak is reported to be 60 feet wide. Shallow placers have been mined on Lillian, Gertrude, and Franklin creeks, tributary to Livengood Creek.

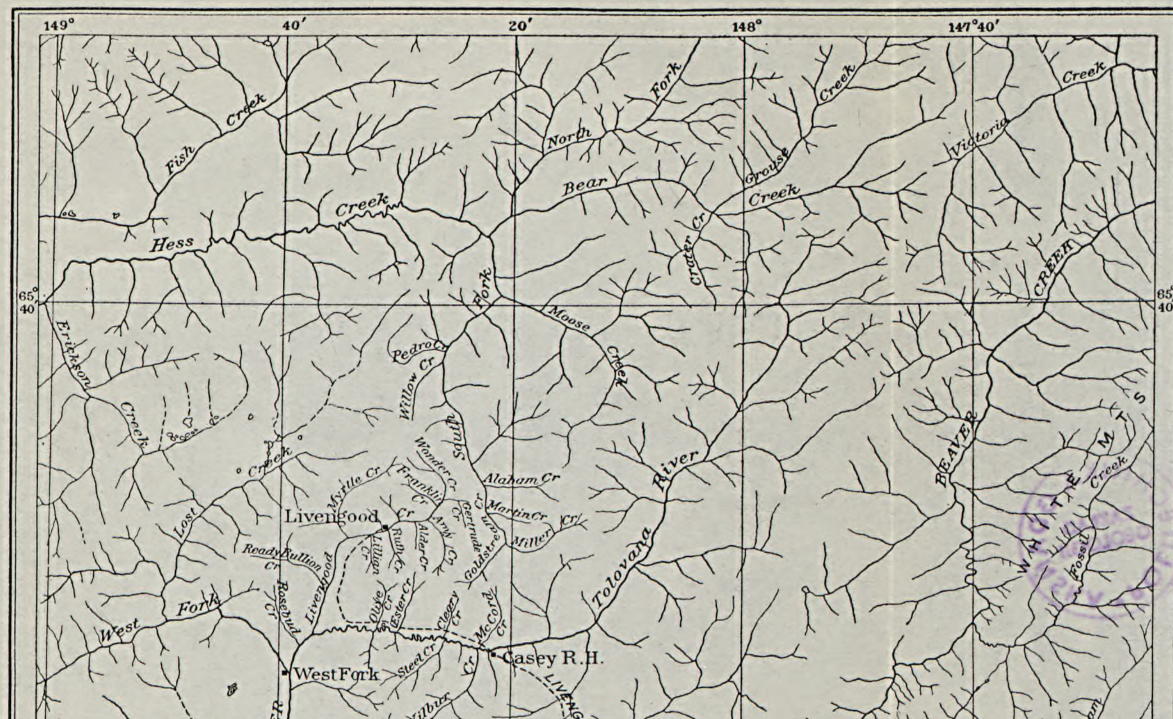
The gravels on the streams flowing directly into Tolovana River above Livengood Creek are shallow. In 1915 productive mining was done on Olive Creek, and prospects were found on Ester, Cleary, and Wilbur creeks.

Most of the data relating to the distribution of gold in the other creeks are contained in the account of the alluvial deposits already presented. Auriferous gravels seem to be widely distributed in the Hess Creek basin, but in 1915 no definitely workable placers had been located. Good prospects of fine gold are reported on Alabam Creek, and gold has been found in the bars of Hess Creek 40 miles below its forks. On "No. 7 above," on the South Fork of Hess Creek, "pay streak" gold with 7 to 8 cent nuggets is reported.

The gold of the deep channel on Livengood Creek is dark colored. Although nuggets worth as much as $20 have been found, the average of the gold thus far mined is not coarse. It has the appearance of what the miners call "pay-streak" gold and includes both rounded and flat nuggets. The finer gold from this source is flat, but not flaky. Its fineness ranges from 0.907 to 0.914, and its value is therefore from $18.75 to $18.90 an ounce. The gold from the present stream channels is brighter colored and appears to be not so coarse. Nuggets worth $4 and $5 have been found. But little gold has been mined from the present creek channel, and therefore it is not possible to give the fineness, which appears to be less than that of the gold from deep placers.

COMMERCIAL CONDITIONS.

The town of Livengood, near Discovery claim on Livengood Creek, is the commercial center of the district. It has a post office, a wireless station, the recording office of the district, and a United States commissioner's office. A settlement at the mouth of the West Fork of Tolovana River contains two sawmills. The region is well timbered, but the water for sluicing is not abundant. Livengood Creek is said to carry three sluice heads of water. Plans have been made for bringing water in from adjacent drainage basins to mine the placers on Livengood Creek. Water is more abundant in the Hess Creek basin.



Scale $\frac{1}{500,000}$

5 0 5 10 15 Miles

MAP OF THE TOLOVANA DISTRICT.

A winter sled and summer horse trail has been built from Olness, a station on the Tanana Valley Railroad, to Livengood, a distance of about 55 miles. Road houses have been built along this trail. Another route of approach is by launch or small steamer up Tolovana River, a deep, winding, sluggish stream. It is reported that small steamers can be taken within 10 or 15 miles of the new camp. Livengood is about 40 miles due east of the Yukon at the mouth of Hess Creek, which can be ascended in small boats to points within about 15 miles of the camp.

Though the district is not very difficult of access, it will be rather expensive to reach with heavy machinery. In the summer of 1915 the freight rate from Fairbanks to Livengood by launch up the Tolovana was about $110 to $140 a ton. It is probable that the winter freight rate by way of Olness will be lower.

SUMMARY.

The deep channel on Livengood Creek seems to constitute the most continuous placer deposit which has been developed in this district. It has by no means been traced continuously, but what seem to be parts of the same channel have been opened at several places for 3 to 4 miles. The richest gravels thus far developed lie in this deep channel and in the streams cutting across it. The present channel of Livengood Creek also carries placers which will be mined when the conditions become a little more settled. Outside of Livengood Creek and its tributaries there has been no productive mining except on Olive Creek, but prospects have been found on several other tributaries of the Tolovana. Interest of the prospectors is at present centered in what they call the "Promised Land," including the basin of upper Hess Creek. On the South Fork of Hess Creek some excellent prospects have been found but not much coarse gold. Only a few holes have been sunk to bedrock. It is fair to say that this region was practically unprospected in the fall of 1915, except for surface pannings. Prospects are also reported on Moose and Grouse creeks, which lie northeast of the Livengood region.

EXPLORATION IN THE COSNA-NOWITNA REGION.

By Henry M. Eakin.

INTRODUCTION.

The area here called the Cosna-Nowitna region extends southward from Yukon and Tanana rivers to Lake Minchumina and the North Fork of Kuskokwim River. It reaches from the longitude of Cosna on the east to Nowitna River on the west. (See index map, fig. 14.)

Prior to 1915 the topography and geology of this region were practically unknown except its eastern margin, which had been

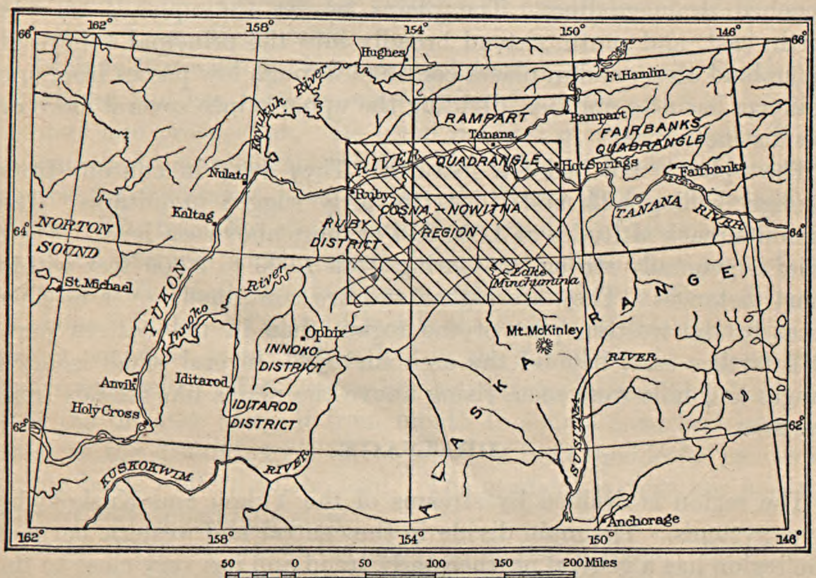


Figure 14.—Index map showing location of Cosna-Nowitna region.

traversed by Herron.[1] Few prospectors had visited it, and so far as known the region had no particular economic importance. In the summer of 1915 a small Geological Survey party in charge of the writer made a rapid exploratory trip from the Tanana at Cosna to the headwaters of Nowitna River, following in a general way the

[1] Herron, J. S., Explorations in Alaska, 1899: War Dept., Adjt. General's Office, No. 31, pp. 1-77, maps, 1901.

Yukon-Kuskokwim divide. A pack train of seven horses was used on this trip, which took from June 12 to August 26. The horses were abandoned on the upper Nowitna and the party proceeded down the river on a raft, arriving at Ruby September 3.

Topographic work was carried on by plane-table method, and most of the uplands between the plains of the Yukon and Kuskokwim were mapped. Geologic mapping was extended over practically the same area. The resulting maps will be published in connection with a more complete report on the region now in preparation.

RELIEF.

The topography of the region shows two contrasting types—the plains and the uplands occupying about equal areas.

The plains are developed on unconsolidated deposits at various altitudes up to about 1,200 feet above sea level. Their relief is generally low, as they have only minor surface irregularities such as dunes and hollows, terraces and canyon-like valleys of locally intrenched drainage lines. The plains border the uplands on the north, east, and south, extend broadly into the principal valleys of the upland areas, and in places continue through low passes from one drainage basin to another, dividing the uplands into several more or less distinct areas.

The uplands are bedrock features. They vary in contour from strongly rolling hills and ridges to fairly rugged mountains. The summits reach altitudes of 3,000 feet or more above sea level. Their relief is generally strong, measuring from 1,000 to 2,000 feet within short distances. They are higher and are continuous over broader areas in the western part of the region than in the eastern part. Still farther east, beyond the area surveyed, several small isolated ranges and hills were seen, rising above the plains like islands from the seas.

DRAINAGE.

The region is drained by streams of the Yukon and Kuskokwim river systems. The main divide in the central and western parts of the region has a general northeasterly trend and lies very close to the course of the North Fork of Kuskokwim River. The northeasterly trend continues to a point about 40 miles north by northeast of Lake Minchumina. Here the divide turns abruptly around the head of North Fork and runs south by southwest past the west end of the lake and then in a general southerly direction to the Alaska Range.

The drainage of the upland area northeast of Lake Minchumina is divided among an extraordinarily large number of distinct streams. The south, east, and north slopes drain into the Kantishna, Zitziana, Cosna, and Chitanana rivers, tributaries of the Tanana; the west slopes into a branch of Titna River, tributary to the Nowitna, and into the North Fork of Kuskokwim River. Thus there are six streams, all of considerable size, that head within a few miles of the same point.

The upland of the western part of the region for the most part drains northward into the Nowitna through Titna and Sulukna rivers. The North Fork of Kuskokwim River receives only short northerly tributaries in this part of the region.

The Kantishna River basin includes only a small area in the southeastern part of the region. Several small streams that drain southward from the upland flow out upon the alluvial plains and empty either into Lake Minchumina or into the Kantishna a short distance below the outlet. The Kantishna flows northeastward from Lake Minchumina to Tanana River, a direct distance of about 80 miles. The distance along the course of the stream is probably more than twice as great. The Kantishna receives most of its water from a number of large southerly tributaries that head in the Alaska Range. It is said to be navigable for launches or small steamboats from its mouth to Lake Minchumina.

Zitziana River has not been shown hitherto on the maps of this part of Alaska and has been known only to the natives and a very few hunters and prospectors. Its basin lies east of that of Cosna River and north of the area drained by the Kantishna. A few southwesterly headwater tributaries head against the North Fork of Kuskokwim River. The basin lies almost entirely in the area of alluvial plains, as only the extreme southwesterly headwaters drain any part of the uplands. The main stream flows northeastward for a direct distance of about 40 miles to Tanana River in the vicinity of Hot Springs. Its valley, which is deeply intrenched in the silt plains, is a quarter to half a mile wide. The stream has an extreme meandering habit, so that the distance along it from mouth to source is several times as great as the distance by a direct line. It is navigable for canoes or poling boats well up to its head. The gradient is very low and the current correspondingly slow.

Cosna River is of about the same size as the Zitziana. Its tributaries head against those of the Zitziana on the east, the North Fork of Kuskokwim River on the south, and the Chitanana on the west. The westerly and southerly tributaries head in the uplands and flow out upon the silt plains, which have a broad extent in the basin. In its lower course the stream has a low grade and is sluggish and meandering. Toward the uplands the grade steepens and the courses of the tributaries are more direct. The Cosna is navigable only for canoes or poling boats.

Chitanana (Redlands) River drains an area lying west of the Cosna River basin and about twice as large. Its southerly tributaries head against those of the Titna, and its westerly tributaries against those of Nowitna River below the Titna. The greater part of the drainage basin is in the area of the silt plains. Uplands partly border the basin on the east and south only. The extreme distance in a direct line from the mouth of the Chitanana to the rim of its basin is probably less than 50 miles. Yet, owing to its very devious general course and meandering habit the distance along the stream is probably at least three times as great. The main stream is deeply intrenched in the silt plains, exposing in places sheer bluffs of silt 400 to 500 feet high. The stream is said to be excellent for canoes or poling boats far up its course.

Nowitna River drains considerably more than half of the central and western parts of the region, through Sulukna, Titna, and Big Mud rivers, its chief easterly tributaries, named in order going downstream. The Sulukna has its source in the highest uplands of the region, the limestone mountain range about 50 miles southwest of Lake Minchumina and near the North Fork of Kuskokwim River. It flows in a general northerly direction for an air-line distance of about 45 miles to its junction with the main river, 10 miles above the head of the canyon. Its easterly tributaries head against two large southerly tributaries of the Titna; its westerly tributaries against those of the upper Nowitna. All its tributaries head in prominent uplands, but the lower course of the main stream is through a broad silt-filled basin which marks the western limit of the present survey. Poling boats have been taken up the Sulukna to points well back in the mountains, 30 to 35 miles in a direct line from its mouth. To do this, however, required numerous portages around beaver dams.

Titna River drains a broad area bounded on the west by the Sulukna basin, on the south by the North Fork of the Kuskokwim, on the east by the Cosna and Chitanana basins, and on the north by the Big Mud River basin. Its extreme easterly headwaters head against the Cosna and it flows in a general westerly direction a straight distance of about 45 miles to the Nowitna 20 miles below the mouth of Suluka River. In this distance it receives three large and several small southerly tributaries. The upper southerly tributary is called the main head of the Titna, although smaller than the easterly branch or the other two southerly branches, all of which have headwaters farther from the mouth of the Titna. The next southerly tributary below this stream is the Sethkokna, a large clear-water stream that heads against the North Fork of the Kuskokwim and Sulukna River 40 miles southwest of its mouth. The other southerly tributary, the Telsitna, joins the Titna 15 miles downstream from the Sethkokna and heads 25 miles to the southwest, against an easterly tributary of Sulukna River. Thus the Titna has four large branches that are navigable for poling boats well toward their heads. All flow through rather broad valleys with a strongly meandering course. The Sethkokna and Telsitna have relatively steep grades and swift water on numerous riffles. There are said to be rapids on the Telsitna near its mouth and also on the Titna below the Telsitna. The Titna rapids are reported to be rather difficult at low stages, but easily traversed by skillful boatmen at medium or high stages.

Big Mud River is an easterly tributary of the Nowitna and joins it about 8½ miles below the Titna. Its easterly tributaries head against the Chitanana and its southerly tributaries against the Titna. It is somewhat smaller than the Titna, but can be traversed by poling boats for a considerable distance. The Big Mud drains a large area of silt plains and derives its name from the great amount of silt which it carries during high stages.

The main upper branches of Nowitna River head against Nixon Fork of Kuskokwim River. The mouth of the Nowitna is about 14 miles above Kokrines village, on the Yukon. The direct distance between its mouth and the divide at its extreme head is about 125 miles, but the actual course of the stream between these points is about 360 miles long. Below the Sulukna the river flows for 166 miles to cover an air-line distance of 57 miles. In its lower course the grade is very low and the current is correspondingly slow, from half a mile to 2 miles an hour at ordinary stages. For a long distance above its mouth the depth of water at mean stages is from 20 to 40 feet. It is navigable for launches, scows, and shallow-draft steamboats for at least 100 miles.

The North Fork of Kuskokwim River heads against Cosna, Zitziana, and Kantishna rivers in the uplands of the eastern part of the region. It flows in a general southwesterly direction beyond the area of the present survey without receiving any large tributaries. The northern limit of its drainage basin is near the south margin of the principal upland area, which is drained mainly by the tributaries of the Nowitna, already described. The southerly tributaries of the North Fork head against streams that belong to the Kantishna system. It is favorable for the use of canoes or poling boats to a point within a few miles of its head.

FORESTS AND VEGETATION.

The Cosna-Nowitna region is almost entirely forested, owing to its generally low altitude. Only a few small areas lie above timber line. which is about 2,000 feet above sea level. Below timber line there are small untimbered areas in places where soil conditions are apparently unfavorable. However, such areas are of only negligible extent, so that the entire region, so far as ordinary users are concerned, may be regarded as forested.

Spruce and birch are generally the dominant species, but in some places cottonwood and tamarack are the more abundant. The largest specimens of spruce grow along streams and at the heads of valleys, where trees 2 feet or more in diameter may be found within any considerable area. Along the main rivers there are large areas of heavy spruce timber. Stunted spruce trees grow generally over poorly drained areas and are the chief form of forest growth in the swampy areas of the alluvial plains. Birch, on the other hand, does better on well-drained slopes and finds a favorable habitat on the scarp faces and dunelike hillocks of the alluvial plains, where it vies with the cottonwood. The tamarack grows sparingly in all parts of the region, but appears in perfection only in the areas underlain by limestone, especially on northerly slopes. In some such areas tamarack trees form the forest growth exclusively, and the largest specimens are a foot or more in diameter.

Willow and alder are the most useful of the smaller species growing in the region. They thrive along water courses and at timber line. The alder is valuable for fuel for high camps and is to be had in all parts of the region. The willow is less valuable for fuel, but supplies agreeable forage for horses and browsing animals. In some places the pack horses subsisted on willow for days at a time and showed a preference for this food even when grass was available. The willow growth along some of the low-lying streams is remarkably heavy, attaining heights of 30 to 40 feet. Some very old trees, 18 inches in diameter, were seen on a branch of the Sethkokna.

The vegetation of the region, besides trees, consists of mosses, grasses, shrubs, and a great variety of herbaceous plants. The sphagnum varieties of moss are prevailingly abundant and, growing in company with bunch grass, blueberry bushes, and trailing birch, give a soft, laborious footing over the whole region except in the limestone areas. Grass is not plentiful in the region, but outside of the areas underlain by limestone it can be found in quantities sufficient for the needs of pack animals, provided camp is held only a day or two at any one place. The scarcity of grass in parts of the region was of considerable inconvenience to the Survey party, and had it not been for the willow used as forage in the limestone belts the horses would have fared still worse than they did.

Blueberries, currants, raspberries, and cranberries are found in the region. The blueberries and cranberries are to be had in unlimited amount, but the others are rather scarce.

FISH AND GAME.

Food fishes are fairly abundant in the streams and some of the lakes of the region. Salmon were seen on the North Fork of Kuskokwim River near its head and on the Sethkokna near the middle of its course. Grayling are plentiful in both large and small streams. Trout were taken only in the clear-water streams that drain the limestone mountains. Pickerel and other species are said to be found in the larger lakes that have outlets.

Large game is very abundant in parts of the region. Moose and bear were seen almost daily in the area between Lake Minchumina and Sulukna River, and bright game trails indicate this to be an unusually favorable game country. No brown bear were seen, but the black bear is so numerous in most of the region as to be more or less of a nuisance. Caribou were not so plentiful, a single specimen shot on a tributary of North Fork being the only one seen. However, well-worn caribou trails in the eastern part of the region and old Indian fences, now in disrepair, show that this animal frequents the region, at least during its migrations.

Waterfowl, including ducks, geese, cranes, and swans, were seen on the lakes and streams. Land fowl were almost entirely lacking, but this is probably a temporary condition, as these species are said to disappear and grow numerous again more or less periodically. They were formerly plentiful and undoubtedly will be so again in a few years.

Fur animals, including fox, lynx, martin, mink, and beaver, were seen in different parts of the region, and trappers report good catches during the last few years. Beaver are very numerous on the tributaries of North Fork and of Nowitna River. Their dams so obstruct some of the valleys that it is difficult to travel through them with a pack train.

INHABITANTS.

The region is practically uninhabited during the summer, but in winter half a dozen white prospectors and trappers and a few natives sojourn for a longer or shorter period within its boundaries. The nearest native settlement is Cosna, on Tanana River, which consists of but a few families. Formerly there was a considerable native population in the region of North Fork and Lake Minchumina, but they have been so depleted by measles and other diseases that there are now said to remain scarcely 50 individuals—mostly adults. Parts of the region serve as hunting grounds for natives of both Tanana and Kuskokwim tribes, but there are large areas that apparently are seldom if ever visited by either natives or whites.

ROUTES OF TRAVEL.

The most available routes of travel in summer are those furnished by the principal streams of the region. Winter travel across the region from the vicinity of Lake Minchumina to Yukon and Tanana River settlements mainly follows two principal routes, which are marked by more or less definite trails. These trails are apparently very old, and at present where seen they are somewhat overgrown and in disrepair.

The route from Cosna to Lake Minchumina leads up Cosna River for about 25 miles, thence eastward across a low divide to the headwaters of the Zitziana, and thence around the east margin of the uplands through another low pass into the valley of a stream flowing southwestward into the lake. The other winter route from the lake to the Yukon leads northwestward across the upper basin of North Fork across a low divide to the Titna, down this stream to a point below the mouth of the Sethkokna, and thence northward across the low country to the Yukon above Ruby.

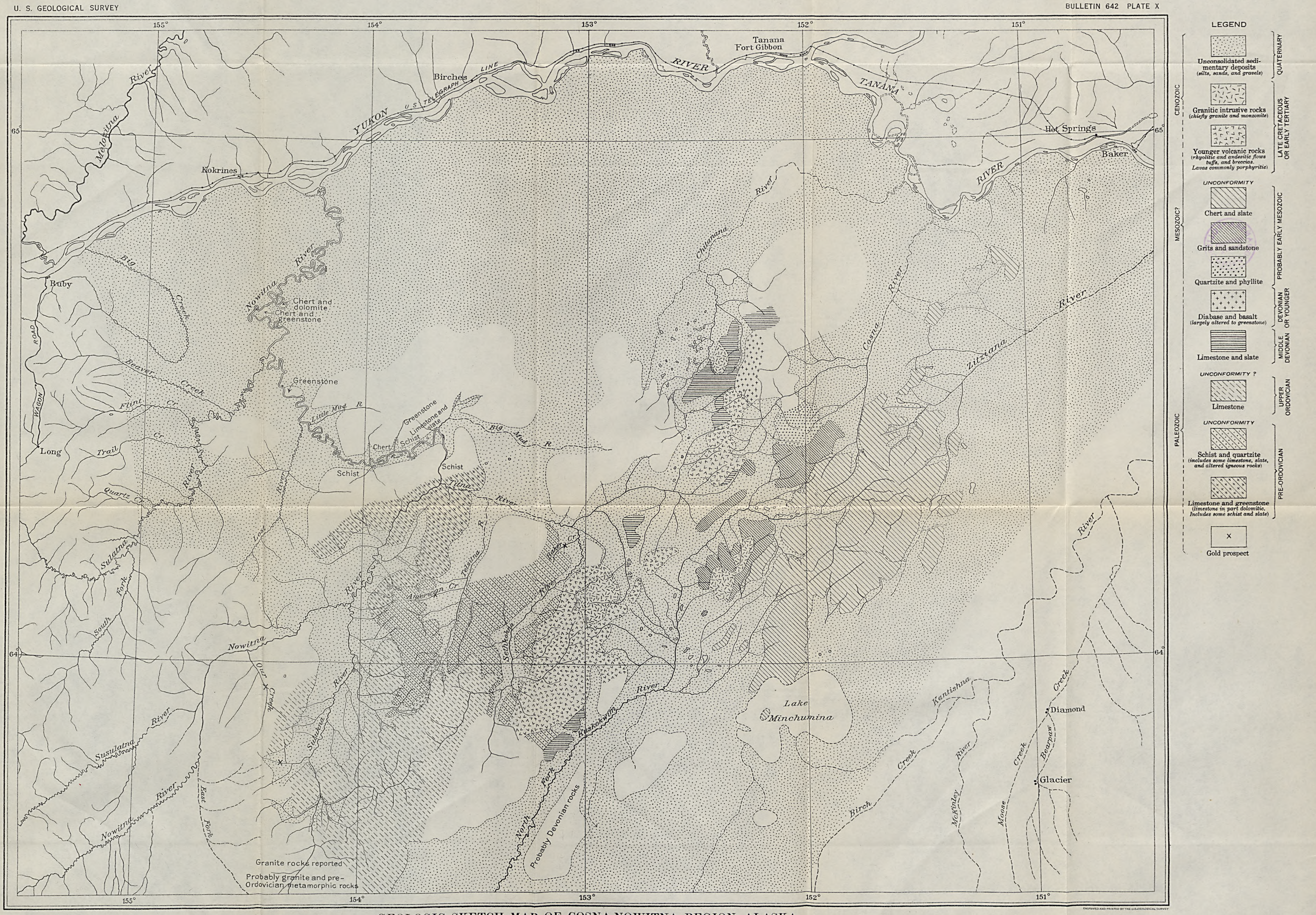
A number of other trails were seen, chiefly those made by trappers for short distances along their trap lines. These follow the crests of many of the timbered ridges in the eastern part of the region. Farther west, where the upland ridges and divides are more uneven and lack timber, the trails are located chiefly along the streams in the valley bottoms.

The trappers and prospectors who frequent the region generally outfit at Tanana or Ruby and get their supplies to their base camps during the open season by poling boat, going up Nowitna River. They bring out their furs in the spring by the same means, following the break-up of the ice on the navigable streams.

GENERAL GEOLOGY.

The geology of the region is rather complex. The rocks are of many different kinds and ages, as is indicated on the accompanying geologic sketch map (Pl. X). They are here separated into 11 different groups, according to their lithologic and structural affinities. The ages of some of these groups are definitely known from the fossils which they furnish; the relative ages of other groups may be inferred from their structural relations; and still other of the groups can not, from the data at hand, be assigned with any great assurance to even a general position in the geologic column.

Fossils were collected from limestone beds at three different localities. Two of the collections represent a Middle Devonian and one an Ordovician horizon. The Ordovician fossils were taken from a single bed in a thick limestone series that occupies a large area in the southwestern part of the region. One of the Devonian collections was made on the headwaters of Chitanana River, and the other near the North Fork due west of Lake Minchumina. The Devonian rocks include, besides the fossiliferous limestones, calcareous and carbonaceous slates. These rocks crop out at intervals along a zone lying between the two fossil localities.



GEOLOGIC SKETCH MAP OF COSNA-NOWITNA REGION, ALASKA

Scale $\frac{1}{500,000}$

10 5 0 10 20 30 Miles

1916

The Ordovician limestones are underlain unconformably by a metamorphic series, which is separated into two groups—an upper group composed chiefly of schists and quartzites and a lower group composed chiefly of limestones and greenstones. These metamorphic rocks extend northward from the Ordovician limestone area to the margin of the silt plains.

The eastern part of the region is occupied mainly by a thick series of sedimentary rocks that are separable into three different groups. The lower group is composed dominantly of banded quartzites and phyllites; the middle group of grits, sheared sandstones, and slates, and the upper group of cherts and slates.

Two groups of volcanic rocks are distinguished on the map. The older group consists of more or less altered diabase and basalt flows which form the highest part of the Cosna-Chitanana divide, east of the Devonian fossil locality. The younger group includes an assemblage of lavas, tuffs, and breccias that are extensively developed along the same general belt with the Devonian rocks. There are two other small areas of volcanic rocks near the head of Telsitna River, covering part of the fault contact between the Ordovician limestones and the schist and quartzite group.

Intrusive igneous rocks occur in large masses at several localities indicated on the map and also in the form of dikes that are too small to be shown on a map of this scale. The larger masses are batholithic in form and typically have the composition of monzonite. The dike rocks are mainly rhyolite or rhyolite porphyry, although more basic rocks that are probably in the form of dikes were found.

The rocks noted in the foregoing descriptions constitute ten separate groups and include all the igneous and consolidated sedimentary rocks noted in this region. Their masses form the upland features that cover about half the area of the region. The other half is occupied by unconsolidated sedimentary deposits, chiefly of silt, which form broad terraces and plains at different altitudes up to about 1,200 feet above sea level. These deposits extend broadly up the principal valleys and spread over large areas to the north, east, and south of the immediate region under discussion.

ECONOMIC GEOLOGY.

VEINS AND MINERALIZATION.

Quartz veins or other signs of mineralization are not generally abundant in the region. Veins were noted only locally about the granitic intrusives, in the area of the quartzite-phyllite group of rocks between the forks of Cosna River and in the pre-Ordovician metamorphic rocks. At none of these places, however, were they very abundant or highly mineralized, so far as could be noted in the field examination.

Sulphide mineralization has affected the rocks of the quartzite and phyllite group to some extent, but not in a manner that suggests any economic possibilities. These rocks in places carry finely disseminated granules of pyrite, and they are cut by rhyolite dikes that are similarly mineralized. Weathered surfaces of these rocks in places show iron and copper stains.

Auriferous mineralization is nowhere evident from the study of rocks in place. However, placer gold is known to occur at two localities within the region—on Baker Creek, a westerly tributary of Sethkokna River near its mouth, and on American Creek, a westerly tributary of the Telsitna about the middle of its course. Placer gold has been reported also from the head of Our Creek, a tributary of the Nowitna next above the Sulukna, and from a tributary of the Sulukna that heads against Our Creek.

PROSPECTING.

A great deal of time has been spent by a few prospectors in the search for placer gold on the tributaries of Nowitna River, and the occurrences enumerated above have been known for a long time. Exaggerated reports of gold placers in the region have been circulated among the river settlements at different times, and several so-called stampedes have occurred, when large numbers of people hurried away to this or that locality. So far the occurrence of commercial placers in the region has not been demonstrated, and during the summer of 1915 the creeks were entirely deserted. However, it should be noted that new discoveries on the tributary of the Sulukna heading against Our Creek were reported during the summer, and a number of prospectors were on their way to that locality.

Except in the Our Creek locality, where the alluvial deposits are comparatively shallow, the region holds out great difficulties and little promise to the prospector, owing to the great depth and breadth of the alluvial filling of the larger valleys. This condition has limited prospecting to the smaller streams, which lie relatively high in the uplands. Such streams naturally have narrow valleys and steep grades and, as they have performed only a small amount of erosion, large concentrations of placer gold in their gravels are not to be expected. The concentrations that might have been made by the larger streams can be looked for only in the broad depressions that are now floored with deep alluvial deposits. The distribution of the alluvial deposits is shown on the map. They extend up all the larger valleys well toward their heads. Wherever these valleys were occupied, prior to their alluviation, by streams of considerable size, such as might have formed large placer concentrations, these deposits probably measure scores if not hundreds of feet in thickness. Furthermore, the present streams generally do not follow the exact courses of the original streams, and there is no definite indication as to the position of the earlier deposits. Under these conditions it seems that erratic prospecting in the broad, deeply filled valleys is not justified.

As gold is known to occur on some of the small and relatively shallow streams of the region, it is likely that prospectors will continue, in some measure, the search for profitable placers. The most intelligent plan to follow would appear to be that of tracing the known auriferous deposits down the smaller streams and out in the broader valleys by means of successive crosscuts. Once the trend of the auriferous gravels is established the hazard of succeeding operations will be reduced to a minimum. Whether a systematic plan of prospecting, such as this, is justified will depend on the showings in the smaller streams where work might be begun. Upon this point the writer was unable to obtain any data. The occurrence of any large concentrations in the major valleys is, of course, an open question.

In this connection mention should be made of the relation of auriferous mineralization to intrusive igneous rocks that is evident in the Innoko and Iditarod districts, to the southwest of this region. It seems clearly proved that the introduction of gold into the rocks of those districts was a phase of the same igneous activities that produced the granitic intrusives, and areas in the vicinity of such intrusives have proved to contain the most valuable placers. The monzonites and granites of the Cosna-Nowitna region are probably closely related to the intrusives of the Innoko and Iditarod districts in age and character, and it would not be surprising if auriferous mineralization were to be found associated with them also. However, it is equally possible that such mineralization may not have occurred, for there are granites and monzonites in many places in interior Alaska that apparently have no such association. Still, on the whole, the vicinity of igneous intrusive rocks would seem to be a more logical place for prospecting than the areas more distant from them.

MINERAL RESOURCES OF THE RUBY-KUSKOKWIM REGION.

By J. B. MERTIE, Jr., and G. L. HARRINGTON.

INTRODUCTION.

The region here described is an irregular area lying between Yukon, Nowitna, Tuentna (Nixon Fork of the Kuskokwim), Kuskokwim, Takotna, Iditarod, Innoko, and Yuko rivers, or between meridians 153° 40′ and 158° 20′ west longitude and parallels 65° and 61° 40′ north latitude. The index map on Plate XI shows the location of the region with respect to the surrounding territory.

Portions of the area discussed in this paper have been visited previously by a number of Survey geologists. Spurr,[1] in his trip down the Yukon in 1896, passed the present site of Ruby and made some geologic observations on the crystalline limestones that crop out along the south bank of the river, near the mouth of Melozi River. In 1898 also Spurr,[2] in the course of his exploration of Kuskokwim River, skirted the southern edge of this region. His notes on the geology along that part of Kuskokwim River shown on Plate XI remain still the only geologic data bearing upon that stretch of the river. The Survey has also in its possession some unpublished notes on the Ruby Bluff made by Collier in 1902, incidental to his study of the coal resources of the Yukon.[3] In 1907 Gilmore[4] ascended Nowitna and Yuko rivers for considerable distances from the Yukon and made some geologic notes. In 1908 a portion of the field season was spent by Maddren in an investigation of the region about the headwaters of Innoko River, and in 1910 he visited the Innoko and Iditarod districts.[5] In 1910 C. G. Anderson carried a topographic reconnaissance from the present town of Ruby to the Innoko and Iditarod districts. H. G. Birkner, who was attached to the Anderson party, collected geologic data along the route, and these data were used in

[1] Spurr, J. E., Geology of the Yukon gold district, Alaska: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, p. 173, 1898.

[2] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept. pt. 7, pp. 31-264, 1900.

[3] Collier, A. J., The coal resources of the Yukon, Alaska: U. S. Geol. Survey Bull. 218, 1903.

[4] Gilmore, C. W., Smithsonian Misc. Coll., vol. 51, No. 1807, 1908.

[5] Maddren, A. G., The Innoko gold-placer district, Alaska: U. S. Geol. Survey Bull. 410, 1910; Gold placer mining developments in the Innoko-Iditarod region: U. S. Geol. Survey Bull. 480, pp. 236-270, 1911; The Ruby placer district: U. S. Geol. Survey Bull. 520, pp. 287-296, 1912.

the reports prepared by Maddren. In 1912 Eakin [1] spent about eight weeks in a geologic reconnaissance of the Iditarod-Ruby region and an examination of the placer-mining operations in the Ruby, Innoko, and Iditarod districts, and in 1913 he visited the Ruby district again and reported on the mining developments there. The region between Georgetown, on the Kuskokwim, and Iditarod was mapped topographically and geologically on a reconnaissance scale in 1914 by Sargent and Smith.[2]

During the summer of 1915 a strip of country extending from Ruby to Iditarod by way of McGrath and adjoining on the east the area examined by the Anderson party in 1910 was surveyed topographically and geologically on a reconnaissance scale. In all, about 8,000 square miles of territory was covered, of which, however, about 2,100 square miles was resurveyed, having been covered by the work done in 1910.

Two Geological Survey parties were engaged in this work. The northern party was in charge of C. E. Giffin, with G. L. Harrington attached as geologist. Mr. Harrington devoted his attention to the geology and mining operations in the vicinity of Ruby, Long, and Poorman. A topographic map was prepared, which supersedes the older map of this district and covers an area extending eastward to Nowitna River and adjoining there an area mapped by H. M. Eakin.[3] On the south connection was made with the work of the southern party. All the producing creeks were visited by Mr. Harrington and the geology and mineral resources were studied in such detail as the time and character of the country permitted.

The southern party, in charge of R. H. Sargent, began work at Poorman and carried the survey through to Iditarod, passing through the mining districts at Candle Creek and Moore Creek. To this party J. B. Mertie, jr., was attached as geologist. The mining properties on these two creeks, together with most of those in the Iditarod district, were visited and examined by Mr. Mertie. A. H. Brooks also spent 10 days in the Iditarod district, and the results of his observations and study are incorporated in the present paper.

This paper aims chiefly to sketch the progress of mining in 1915, and to present a brief discussion of the mineral resources of the Ruby-Kuskokwim region. It will be followed by a more complete report, dealing in greater detail with the geology of the region. The writers, however, have visited only a portion of the area included on the map that accompanies this report (Pl. XI). Hence, with the

[1] Eakin, H. M., Gold placers of the Ruby district and the Innoko-Iditarod region: U. S. Geol. Survey Bull. 542, pp. 279–303, 1913. The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, 1914; Gold placers of the Ruby district: U. S. Geol. Bull. 592, pp. 363–369, 1914.

[2] Smith, P. S., Mineral resources of the Lake Clark-Iditarod region: U. S. Geol. Survey Bull. 622, pp. 247–271, 1915; The Lake Clark and central Kuskokwim region: U. S. Geol. Survey Bull. (in preparation).

[3] Eakin, H. M., The Cosna-Nowitna region: U. S. Geol. Survey Bull. (in preparation).

view of presenting all the available information about the area, the observations of the earlier workers have been freely used.

Special acknowledgments are due to Messrs. Sargent and Giffin, in charge of the field parties, for their ready assistance and cooperation in furthering the geologic work; and to the other members of the field parties, who showed at all times a willingness to help that was very gratifying.

Without exception the operators and prospectors in the region displayed an unfailing hospitality and evinced a desire to assist the writers so far as lay within their power. Information sought of them was given freely. To Mr. Vance McDonald, of Long, and Mr. David Strandberg, of Flat, the writers are particularly indebted for courtesies extended in this and other ways.

GENERAL CHARACTER OF THE REGION.

GEOGRAPHIC FEATURES.

The underlying conception of the Ruby-Kuskokwim topography should be that of a rolling country of low ridges, from which long, flat-topped spurs extend laterally into broad stream valleys. The monotony of this topography is broken at a number of localities by higher mountain groups, which, however, are not connected but stand out in isolated relief from the surrounding country. This region is a part of the great central plateau region of interior Alaska and is in reality the southwestward continuation of the Yukon-Tanana belt, at a lower level.

Yukon and Kuskokwim rivers, the trunk streams of central Alaska, drain this region, but the watershed between the two streams is near the southeastern limit of the region, so that most of the surface water finds its way to the Yukon. Nowitna, Sulatna, and Yuko rivers, the Innoko and its various headwaters, and Iditarod River drain into the Yukon; Nixon Fork, Takotna River, and Tatalina River are the main tributaries of the Kuskokwim.

The region comprises two rather distinct physiographic provinces. The northern province lies between Poorman and Ruby, extending east and west to the limits of the area mapped. It is drained mainly by Sulatna and Nowitna rivers. The southern province begins at the hills south of Poorman and continues south and west to Ophir and Iditarod and south to the Kuskokwim. The northern province is distinguished from the southern by its generally lower elevation and relief, by the extreme width and flatness of its stream divides, by the tortuous courses of the streams, and by the abnormally wide spacing of the headwater tributaries.

The character of the drainage is worthy of note. The larger streams meander in broad, open valleys, over much aggraded flood plains, which contain many swamps and oxbow lakes. In their upper reaches the streams characteristically flow in deep, narrow channels, between cut banks, with a general absence or marked scarcity of gravel bars. This is particularly true of Sulatna and Nowitna rivers, which drain the northern part of the region. To the south, where mountain groups tend to steepen the headwater grades, this characteristic is not so marked.

In two areas within the region local glaciation has been pronounced enough to leave a record of its existence in the present topography. About 15 miles east of Ophir there is a high mountain group, the highest peak of which has an altitude of 4,600 feet. The area about the headwaters of one of the tributaries of Folger Creek which heads in this group shows a well-developed glacial topography. Several glacial cirques, one of which forms a hanging valley, drain into a U-shaped valley, in the lower part of which are undoubted glacial deposits. The other locality in which glaciation played an important part is in the Beaver Mountains. This locality was visited by Maddren and later by Eakin, both of whom report the presence of cirques, U-shaped valleys, and glacial deposits.

TIMBER AND FORAGE.

Timber grows in the valleys and on the upland slopes over much of this region. Nowhere is the growth very thick or the trees very large, but in most places the supply is sufficient for the local demand. Along the valley floors may be seen trees as much as 24 inches in diameter, which are available for lumber and for use in mining. The smaller trees serve a useful purpose as fuel.

Spruce is the most common variety and occurs from the valley bottoms up to timber line. With it are associated birch, tamarack, and cottonwood. Along the creek banks and near timber line, especially along small drains, alder and willow brush grows very thickly.

The upper limit of timber is a variable line in the country between Ruby and Iditarod, which is a transition zone between the wooded portion of the interior and the treeless tundra of southwestern Alaska. In the vicinity of Ruby and Long little timber grows above an altitude of 1,800 feet, and in the country around Iditarod and Flat there is little above the 1,500-foot line. Untimbered spurs extending well down into the valleys are common everywhere, yet in some especially favored gulches timber is found at altitudes above 2,000 feet. In general, timber becomes scarcer toward the southwest, as indicated by the figures given above.

Forage for stock is plentiful along the valley floors of some of the larger streams, such as the Sulatna, the Nowitna, and the Takotna, but on the upland slopes grass is scarce. Where the country has been burned over and the moss destroyed, however, good grass may usually be found.

GAME AND FISH.

Game is by no means plentiful, especially near the settlements. In the mountain areas, back from the mining camps, caribou may be seen occasionally, but nothing comparable to the immense herds of the Yukon-Tanana region is known in this region. A few bears are present. Moose are seldom seen.

Small game, such as rabbits, ptarmigan, and grouse appears to vary in abundance from year to year. Occasionally a porcupine is encountered. During the summer of 1915 very little small game was in the country, but earlier travelers record an abundance of it.

Salmon, pike, and other large fish are taken in Yukon and Kuskokwim rivers. In the uplands between these rivers grayling are caught in many streams, and in the mountain areas trout inhabit the creeks.

SETTLEMENTS AND POPULATION.

The principal settlements in this region are Ruby and Long in the northern part, Ophir in the central part, and Iditarod and Flat in the Iditarod district. There are smaller settlements at Poorman, Cripple, Takotna, McGrath, and Discovery (Iditarod district).

In all, the white population probably does not exceed 1,900, of whom about 500 are at Ruby, about 100 at Ophir and on the creeks in the Innoko district, about 700 in the Iditarod district, including Iditarod, Flat, Discovery, and the near-by creeks, and the rest in the smaller settlements and on the producing creeks, including a small number of men who are prospecting in the region. According to Eakin,[1] there are also several small Indian settlements along Innoko River, the largest of which is Dishkakat, about 20 miles below the mouth of Dishna River. Another small Indian settlement is at the base of Joaquin Mountain on Takotna River.

In 1912 the population was estimated by Eakin at 3,100, which is 1,200 more than the present estimate, showing a decrease of nearly 40 per cent. Elimination of the floating population that accompanies the opening of a new mining district and the concentration of producing ground in the hands of larger companies, accompanied by the inevitable introduction of modern mining machinery and labor-saving methods, have brought about this decrease in population.

TRANSPORTATION.

River steamboats ply on Yukon, Kuskokwim, Innoko, and Iditarod rivers during the summer. A regular passenger and freight service is maintained on the Yukon from Whitehorse and from St. Michael. On the Kuskokwim one river boat made three round trips

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[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 18, 1914.

from Bethel to McGrath during the summer of 1915. From McGrath freight is carried by gasoline launches up Takotna River to Takotna. The Innoko is navigated by small river steamboats up to the mouth of the North Fork, whence supplies are brought up to Ophir by horse scows and poling boats. At ordinary stages of water the Yukon River boats ascend Iditarod River to Dikeman, and gasoline boats relay the passengers and freight up to Iditarod. Small launches go on up the Iditarod as far as the mouth of Otter Creek.

A wagon road and a winter trail connect Ruby with Long and Poorman. Small launches, however, navigate Sulatna River up to the mouth of Tamarack Creek, where the wagon road crosses. Most of the supplies intended for summer delivery at Poorman are therefore brought up to this point by boat and freighted the rest of the way.

In the Innoko district there is a wagon road between Ophir and Gaines Creek, and summer and winter trails connect Ophir with the other creeks near by and with Takotna.

A tram road equipped with wooden rails and with an automobile rebuilt on a railroad truck transports passengers between Iditarod and Flat. In addition, wagon roads connect Iditarod with Flat and Discovery. The wagon road to Flat continues up to the head of Flat Creek, serving the mining properties on the creek and at the summit. The Government winter trail between Iditarod and Seward passes through the mining camp on Moore Creek, and through Takotna and McGrath. Moore Creek also has communication with Discovery over a summer trail.

SUPPLIES.

Ruby is the distributing point of supplies for Long, Poorman, and the creeks in the neighborhood. The average freight rate from Seattle to Ruby is about $45 a ton. The winter freighting charge from Ruby to Long is from 1½ to 2 cents a pound, and to Poorman from 4 to 5 cents (1915). In summer it costs from 6 to 7 cents a pound to bring supplies from Ruby to Long, and about 9 cents to Poorman by way of Sulatna River (1915).

Candle Creek receives its supplies from McGrath. The winter rate is 1½ cents a pound. In summer supplies are brought down the Kuskokwim from McGrath, landed at a point about 4 miles from the creek, and brought over the hill by a pack train, at a total cost of 6 cents a pound. The freight rate from Seattle to McGrath is probably not greatly different from that to Ruby.

Ophir, the central point for the Innoko district, obtains supplies by way of both the Yukon and the Kuskokwim routes. The latter in time will probably be the more used, because of the relative cheapness of supplies at Takotna, compared with the cost of boating up Innoko River from Holy Cross.

Iditarod is the supply point for Discovery, Flat, and the surrounding creeks. According to Eakin[1] freight from Seattle may be laid down at the mines along Flat and Discovery creeks at a total cost of 4 to 6 cents a pound (1912). Supplies are taken to Moore Creek on the main Seward trail in winter at a cost of 6 cents a pound from Iditarod. During the summer the rate by way of Discovery is 24 cents a pound.

OTHER MINING FACTORS.

The general wages paid for labor in 1915 were $5 a day and board, but men performing work that requires experience or special knowledge, such as winchmen or engineers, received as much as $7. In 1915 labor was plentiful.

Wood has been so far the only fuel used. Around Long and Poorman it is fairly plentiful and sells at $7.50 to $9 a cord, and 16-foot tree trunks about 1 foot in diameter cost $1.25 laid down at Long. In the Iditarod district the supply is smaller and the cost higher, and much of the neighboring country has been deforested to supply the demand. In another year or two it will be necessary to bring wood from the head of the Ditna or from the Iditarod River valley above Otter Creek. It is possible that some small coal seams between Flat and Iditarod may be developed and prove useful as fuel.

The problem of obtaining an adequate supply of water for mining purposes is serious at some localities, especially where the producing ground lies in the upper basin of a creek. The owners of the properties that surround the monzonitic mass at the head of Flat Creek have dug many ditches along the upper slopes to catch the surface water, and this supply is augmented by the construction of snow fences, which cause the snow to pile up in huge drifts in the winter and last late in the summer. At Candle Creek, where the workings are also close to the head of the creek, a bedrock basin has been excavated to collect the surface and underground water. Along creeks where many operators are at work, as at Long, the water supply is sometimes insufficient, especially during a dry spell of weather. Where the pay streak is several miles down the creek, however, and too many are not tapping the supply, it is usually adequate, because the heavy carpet of moss over the country acts as a sponge, preventing the rapid run-off of surface water after hard rains.

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 579, p. 19, 1914.

GENERAL GEOLOGY.

SUBDIVISIONS.

Between Ruby and Iditarod occur a number of geologic formations, including rocks of many varieties. These formations are of widely differing ages, ranging from the ancient rocks of the Ruby district down to the recent fillings in the present stream valleys. Lava flows and intrusive rocks of several kinds add further diversity to the geologic sequence. On the geologic map (Pl. XI) six mappable units of sedimentary rocks and five varieties of igneous rocks are recognized. These divisions may be modified or further subdivided in the final report on this region.

The sedimentary sequence consists of Paleozoic and older rocks, a chert formation of uncertain age, the Cretaceous rocks, and the unconsolidated deposits. The Paleozoic and older rocks are treated under three subdivisions—the undifferentiated metamorphic rocks, the crystalline limestone, and the Devonian limestone and slate. The igneous rocks include greenstone, presumably of Paleozoic age, and intrusive and extrusive rocks of later date.

PALEOZOIC AND OLDER ROCKS.

UNDIFFERENTIATED METAMORPHIC ROCKS.

The rocks grouped under the head of undifferentiated metamorphic rocks predominate in three general localities—the area extending from Ruby south to the Sulatna-Innoko divide, the area encircling Mount Hurst, and the Iditarod Valley near Iditarod.

This group includes schist, phyllite, slate, quartzite, chert, and Paleozoic limestone. In the present report certain areas of greenstone and of crystalline limestone, which really form a part of this complex, have been mapped separately, so far as possible, but much of the bedrock is concealed by a mantle of unconsolidated deposits and vegetation, so that the series as grouped doubtless includes unknown areas of greenstone and crystalline limestone. The scale of the map forbids the delineation of certain small areas of Paleozoic limestone in the Ruby district, but these will be shown on the map accompanying the final report.

The rocks of this series are dominantly recrystallized and represent in large part ancient sediments which have been brought to their present condition through severe and long-continued metamorphism. The complex history of the series is indicated by the intricacy of the folding and faulting, by the secondary structure which has been developed, and by the amount of quartz and calcite veining wherever these rocks occur.

The intensity of the metamorphism and the thoroughness of the recrystallization in some of these older rocks is comparable with that shown by the Birch Creek schist (pre-Ordovician and possibly pre-Cambrian) in the Yukon-Tanana country, and it is quite likely that sediments as old as this are present. Yet the degree of metamorphism is inadequate as an ultimate criterion for correlating geologic formations. It is therefore unsafe, in the absence of fossils, to make any definite correlation of this complex as a whole. The present grouping should be understood to represent a composite treatment of Paleozoic and older rocks, which it has been found impracticable to divide into separate units or true geologic formations.

Little information is available as to the structure of the metamorphic rocks, for exposures showing their attitude are unknown except along the river sections and a few of the creeks. Some indication of trends may be obtained from these sections and from the joining of isolated outcrops of similar rocks. It is thus found that the principal structural direction is about N. 25° E., with variations of from 20° to 30° to the east and west from this direction. The dip is generally to the west at a moderate angle. Folding and faulting along axes parallel to the main trend of the rocks are indicated by the shattered nature of some of the heavier beds and by the deformation and brecciation of quartz veins; and in places the fault planes are distinctly evident. From the general structure, the oldest beds should crop out, the farthest to the east in the vicinity of Ruby, and that this is the case seems to be borne out by the lithology, for the rocks on the east show greater metamorphism, being in fact garnet schists, while the rocks on the west contain less of the metamorphic minerals.

CRYSTALLINE LIMESTONE.

At two localities in the Ruby district crystalline limestone has been found in sufficient quantity to warrant its representation on the accompanying map (Pl. XI). One is along the south bank of the Yukon above Ruby; the other is at Sulatna Bluff, on the east fork of Sulatna River.

This limestone is a dark to light gray granular crystalline, nondolomitic rock and is so distinct in appearance from the Devonian limestone described below as to justify its separation from the metamorphic complex as a distinct unit. Along the Yukon it is associated with garnetiferous mica schists, phyllites, and other recrystallized rocks; and at Sulatna Bluff it is bordered by quartz-mica schist. It should therefore be considered as belonging with the older members of the metamorphic complex. No more exact statement of age is justified by present knowledge.

DEVONIAN LIMESTONE AND SLATE.

Under the designation Tachatna series Spurr[1] describes a series of "gray limestones (generally thin-bedded and fissile) having carbonaceous and chloritic slates and occasional generally fine-grained arkoses, which outcrop along Kuskokwim River from a point 20 miles above the present town of McGrath down to below Vinasale." He says further that these rocks have been considerably folded, contain numerous quartz veins, and are cut by granitic dikes. Middle Devonian fossils were collected by Spurr in this series at one locality.

Certain small areas of Paleozoic limestone, not here separately mapped, exist within the metamorphic complex in the Ruby district. From a limestone bed at one locality Devonian fossils were collected by Eakin in 1912. The limestone in the other areas is similar in appearance and is likewise believed to be of Devonian age. The writers have reasons, however, to be set forth in more detail in the final report, for believing that these limestones and certain other rocks closely associated with them represent sediments infolded with older rocks.

CHERT AND ARGILLITE.

A formation consisting essentially of chert and argillite begins on the hills just south of Poorman and continues southward almost to the Cripple Creek Mountains. It is bounded on the east largely by the rhyolitic and basaltic lavas of the Sulatna basin. Its western limit is unknown. Another band of chert borders the Mount Hurst metamorphic complex on the southeast. Rocks of this nature also occur in association with the greenstones near Yuko Mountain.

The rocks of this formation are distinct from the rocks north of Poorman and do not resemble the Cretaceous beds to the south. Green and white chert and a hard dark-gray argillite constitute the typical exposures. Here and there are bands of thin-bedded sandstone and grit. Banding is very common, and in many places the chert and argillaceous beds finger out laterally into one another. Brecciation is noticeable at certain places, but recrystallization is absent. The general structural trend of these rocks is about N. 55° E., but the dips are markedly inconstant. Both northwest and southeast dips were observed within short distances, and evidently close folding is common.

No definite statement as to the age of this formation can be made, for determinable fossils have not been found in it, and its relation to surrounding rocks is obscure. The rocks, although they are closely folded, differ markedly from the complex of the Ruby district in their lack of recrystallization. They are apparently much younger even

[1] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, p. 158, 1900.

than the infolded areas of Devonian rocks to the north. On the other hand, they are much older than the Cretaceous rocks to the south. It seems best to regard them tentatively as early Mesozoic without making any more definite correlation.

CRETACEOUS ROCKS.

Rocks that are assigned generally to the Cretaceous system form the bedrock over more than half of the area treated in this paper. Beginning at the southern limit of the cherts, argillites, and lavas in the Susulatna Valley, they continue south and west through Ophir to Iditarod and thence south to Kuskokwim River.

The Cretaceous beds consist dominantly of sandstone, with considerable areas of grit and conglomerate in certain localities. Locally, near intrusive masses or along zones of compression, the sandstone has been highly indurated, forming quartzite, and the shale has been altered to argillite and slate. As a rule the sandstone is impure, plagioclase feldspar and fine-grained igneous material being the constituents other than quartz. The conglomerate pebbles are usually chert, vein quartz, and a dark slaty rock. Bowlders as much as 3 feet in diameter were noted by Eakin [1] in the conglomerate in the vicinity of the Cripple Creek Mountains, but at the head of Folger Creek and near Iditarod 6 inches is the maximum size.

The sandstone and conglomerate of this series are associated with a variety of igneous rocks, of effusive and intrusive character. These will be considered in detail in the final report. They include acidic and basic coarse and fine grained intrusives, largely of Tertiary age, and basic lava flows.

Fossils of Upper Cretaceous age have been found at the headwaters of Folger Creek. It is not certain that all the rocks of this series are Upper Cretaceous, but it is rather unlikely that any beds older or younger than Cretaceous are included in the area mapped.

IGNEOUS ROCKS.

GREENSTONE.

Greenstones are present in a number of areas. The largest area is in the Kaiyuh Mountains, where much of the country rock is believed to be greenstone. The actual extent of the greenstone in this range is not known, but its northeastern limit has been mapped southwest of Ruby. In going up Innoko River in 1910 Maddren noted what is probably its southeastern limit along the northwest bank of the Innoko River at several places. Twin Butte, at the headwaters of the North Fork of Innoko River, is probably the next

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Bull. 578, p. 23, 1914.

largest occurrence of greenstone. A number of smaller areas in the upper Sulatna basin are also mapped, and numerous other small unmapped bodies are included with the undifferentiated metamorphic rocks.

Under the single term greenstone have been grouped altered intrusive and extrusive rocks, mainly of basic character, together with some tuffaceous and cherty beds. It may be found possible later to subdivide the group into several rock units, for it shows a great diversity in petrologic character. The rocks range in texture from aphanitic and vesicular to medium granular, and in composition from basic basalts and diabases to more acidic rocks. Monzonite may be present. Some of the cherts are mapped with the greenstones on account of their small extent and intimate relations with the other members of the group. An equally wide variation appears in the degree of metamorphism exhibited by different members of the group, though they are a unit in displaying a greenish color, due, in part at least, to surficial weathering. Some of the rocks show little or no effect of shearing; others have been converted into schists.

But little can be said regarding the age of these rocks. Part of them have some of the characteristics of intercalated flows and so are contemporaneous with the undifferentiated metamorphic rocks in which they occur. Others are more clearly intrusive and therefore younger than a part of the metamorphic rocks.

MONZONITE.

Monzonite, the granular igneous rock intermediate between granite and diorite, is present as intrusive bodies at a number of localities. The principal ones, named from north to south, are the Cripple Creek Mountains, Twin Mountain (east of Ophir), the mountain southeast of Takotna, Joaquin Mountain, the head of Candle Creek, the head of Willow Creek (a tributary of Moore Creek), Discovery (on Otter Creek), and the head of Flat Creek in the Iditarod district). In the high mountain group a few miles east of Twin Mountain many dikes and smaller bodies occur. In the Ophir district dikes of such material cut the Cretaceous rocks; and this fact, together with the evidence of mineralization in that area, suggests strongly the presence of a larger underlying body of intrusive rock. Smaller bodies and dikes are present elsewhere.

The monzonite is a light to dark gray granular rock, consisting essentially of quartz, potash, feldspar, and soda feldspar in approximately equal amounts and black minerals, usually hornblende or mica or both. Microscopic examination will probably show that variations from this average type exist, grading in composition toward granite on the one hand and toward diorite on the other. These acidic intrusive rocks are of the highest economic importance, because they have been found to be intimately associated with and genetically related to the gold deposits.

The intrusive monzonite invades rocks of Upper Cretaceous age, and its granularity indicates that it was intruded at considerable depth. This conception involves the deposition and burial of the Upper Cretaceous beds prior to the intrusion and leads to the conclusion that the monzonite is of Tertiary age.

Certain altered granular rocks in the Ruby district, which are suspected to be of monzonitic or dioritic character, are in this paper, grouped with the Paleozoic greenstone. Subsequent microscopic work may justify the differentiation of these rocks as representing a Paleozoic or Mesozoic period of intrusion.

DIORITE, GABBRO, ANDESITE, AND BASALT.

A striking feature in this region is the constant association of gabbro, diabase, and basalt with the monzonitic intrusive bodies. Such basic rocks usually surround or nearly surround the monzonitic areas, as at Twin Mountain, at the mountain southeast of Takotna, at Candle Creek, on the headwaters of Moore Creek, and at Flat and Discovery. At other localities, where the basic intrusive is the dominant intrusive rock, as in a mountain group at the headwaters of Folger Creek and in the high mountains east of Twin Mountain, monzonitic and dioritic dikes are found in great abundance.

The basic material seems to have come to the surface in most places, being outpoured as surface lava. The intrusive and extrusive types grade into each other, and separation of the flows from the intrusives is difficult. The presence of tuffaceous beds in certain localities is a helpful criterion in recognizing the flows.

In composition, these rocks range from basic diorite and basic andesite to gabbro and basalt; and differences in granularity, arrangement of the minerals, and the presence or absence of phenocrysts lends variety to their appearance. They are composed essentially of plagioclase feldspar, pyroxene, and magnetite. The pyroxene diorite and gabbro are coarse grained, and the pyroxene andesite and basalt are their fine-grained equivalents.

The basic intrusives, like the monzonitic rocks, invade the Upper Cretaceous sediments, and are therefore younger than that part of the Upper Cretaceous which they intrude. They are invaded, however, by the monzonite, which is considered to be of Tertiary age. It is possible, then, for the intrusion of the basic rocks to have taken place either in late Upper Cretaceous time or in the Tertiary. The common association of the basic intrusive rocks with the basic extrusives, which are assigned to the Tertiary, is interpreted as evidence that the intrusion of basic lava occurred in Tertiary time.

RHYOLITE.

Rhyolite occurs in two general localities in this region, covering considerable areas about the headwaters of the South Fork of Sulatna River, and occurring in small bodies far to the south, on the headwater tributaries of Takotna River, near the Moore Creek mining camp.

Little microscopic work has yet been done on these rocks. In a general way, however, they are known to be fine grained and composed largely of quartz and alkali feldspar. The rhyolites in the northern area seem to be badly altered, but those to the south appear fresher and better preserved.

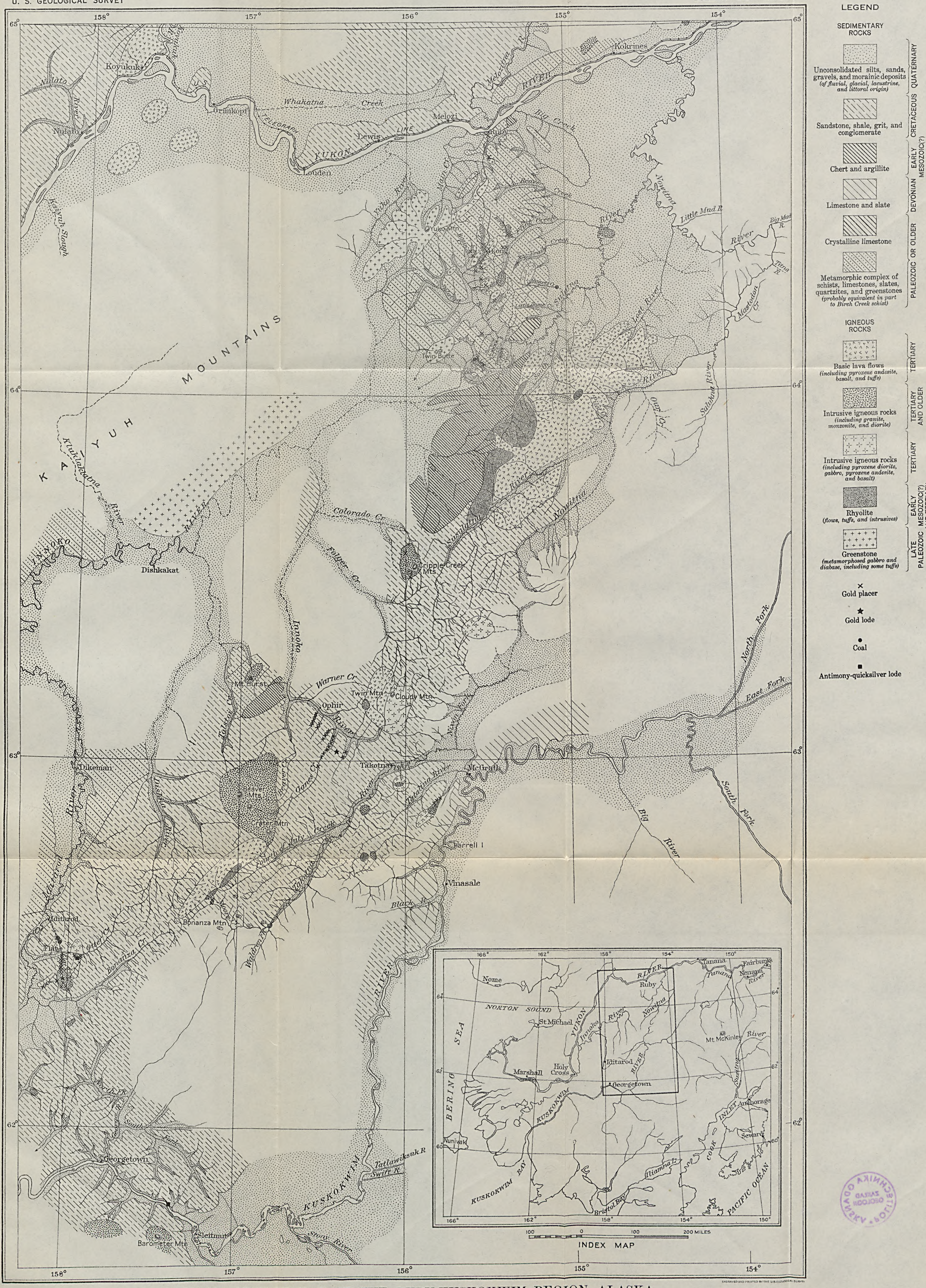
The northern rhyolites appear to represent surface flows, which are intimately associated and apparently interbedded with the chert and argillite formation and which were therefore probably erupted in early Mesozoic time. On the other hand, the southern rhyolites are intrusive in nature, for they clearly cut the Cretaceous rocks. It is highly probable that these rocks are contemporaneous in a general way with the Tertiary granitic intrusives, of which indeed they may be fine-grained representatives. On the accompanying map both rhyolites have been grouped together as a single unit, but they will be separated in the final report.

ANDESITE AND BASALT.

Surface flows of intermediate and basic composition occur at a number of localities. They are usually associated with the Cretaceous rocks and with the basic intrusives previously described. It is believed that the extrusion of the basic lavas and the invasion of the Cretaceous sediments by basic intrusives are contemporaneous features of the geologic history of this region. No Tertiary sediments are present, so far as known, so that direct stratigraphic evidence of the age of the basic lavas is lacking. But certain structural features of the lavas and the surrounding Cretaceous rock, which will be presented in detail in a later report, favor the view that the outpouring of this lava occurred chiefly in Tertiary time.

QUATERNARY DEPOSITS.

Quaternary deposits cover practically the entire surface of the region north of Poorman and much of the country south of Poorman. In the Ruby, Long, and Poorman districts unconsolidated deposits extend well up toward the headwaters of the creeks, and residual débris mantles the slopes, in most places clear to the tops of the ridges. Farther south the stream valleys are likewise filled with alluvium and gravel, but the relief is greater and the quantity of residual material



GEOLOGIC SKETCH MAP OF THE RUBY-KUSKOKWIM REGION, ALASKA

By J. B. Mertie, jr., and G. L. Harrington

Scale $\frac{1}{750,000}$

10 0 10 20 30 40 50 Miles

1916

less. High-lying gravels were noted by Eakin [1] at several localities in the Innoko district. Among the higher mountain groups glacial and glaciofluviatile deposits are present in a few places.

The valley fillings consist of silt, sand, and gravel, in various relations. The silt and finer deposits commonly lie at higher levels, and the gravels and coarser material near bedrock. On the headwaters of the creeks little silt is present, the deposits consisting mainly of gravel. The deposits farther downstream become very deep in the broad valleys of such rivers as the Sulatna, Nowitna, Takotna, Iditarod, and Innoko.

The residual material consists of unconsolidated rock breccia and clay, derived from the disintegration of the country rock. It is widespread and of considerable depth, especially in the area between Poorman and the Yukon. At the head of Flat Creek, in the Iditarod district, placer gold is associated with residual deposits.

MINERAL RESOURCES.

GENERAL FEATURES.

Placer gold is the only mineral deposit in the Ruby-Kuskokwim region that has been exploited on a commercial scale. There are several general areas where placer mining is now being carried on. These areas are considered and discussed separately below.

Where so much placer gold is found it is reasonable to expect the development of gold lode mining some time in the future. As yet, however, little lode mining has been done. Eakin [2] reports the development of a gold lode in a small way in the Innoko district. At the head of Flat Creek, in the Iditarod district, there are numerous small quartz stringers which look promising as potential gold lodes. On the hills north of Moore Creek vein quartz carrying gold was picked up by the senior writer. It is probable, however, that the placer gold areas in this region will be more or less depleted before the advent of lode mining, for in much of the region rock exposures are not plentiful, and prospecting for gold lodes means much development work.

During the summer of 1915 considerable stibnite (the sulphide of antimony) was shipped from the Fairbanks district, showing the possibility of the exploitation of antimony deposits in Alaska under the present demand for that metal. Stibnite ore has been uncovered at several localities in the Innoko and Iditarod districts. Such deposits may be exploited at some later date.

Cinnabar (the sulphide of mercury) is found in the concentrates on a number of creeks in the region. The economic importance of cinnabar as a mineral product for export from this region is questionable,

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 26, 1914.
[2] Idem, pp. 28-29.

but probably in time it will be used as a local source of mercury for use on the copper plates which are utilized in catching the fine gold. The cinnabar in the concentrates at Candle Creek is already being treated in retorts and used for this purpose. The abundance of cinnabar in the concentrates at certain localities lends encouragement to the belief that future prospecting may uncover cinnabar lodes of economic importance.

Cassiterite (the oxide of tin) occurs on several creeks in the Ruby district, in the concentrates from the gold-bearing gravels. The amount is too small, however, for this to be considered as a possible important source of tin.

Scheelite (the tungstate of calcium) occurs in the concentrates taken from Otter Creek, in the Iditarod district. It is therefore present in the basin of that creek, and probably the bedrock source will sometime be discovered. The possible value of such a discovery depends on the character and extent of the deposit. Scheelite-bearing pegmatites in the Fairbanks district are now being prospected as a possible source of tungsten. The present high value of tungsten would justify the recovery of the scheelite from some of the concentrates of placer mining.

Coal has been found in several places in the Ruby and in the Innoko-Iditarod districts. In the Ruby district it has been found on Poorman Creek and has been reported from Quartz Creek. There is also some evidence of coal on one of the tributaries of Basin Creek, and Maddren[1] states that coal is reported from Homestake Creek, a tributary of the upper Nowitna.

In the Iditarod district two seams are known to exist at the crest of the ridge between Flat and Iditarod. These seams have not been prospected to a depth sufficient to learn the true character of the coal; but if there is any place in the Ruby-Kuskokwim region where native coal would prove valuable, it is in this locality, where wood is so scarce and costly.

GOLD PLACERS.

RUBY DISTRICT.

GENERAL CHARACTER.

The placers of the Ruby district are in general of uniform character. Most of them are deeply covered, irregularly distributed, discontinuous bodies lying in the bottoms of the broad silt-buried valleys, and though numerous producing placers are on so-called bench claims, they are generally little if any higher than the bedrock bottom of the filled valleys in which they lie. Colors of gold may be found in the bottom of almost any valley throughout the slate and schist area, but the gold is not concentrated sufficiently to make its recovery commercially

[1] Maddren, A. G., oral communication.

practicable, and it is only where there has been considerable primary concentration or a local reconcentration that the deposits are being worked. On none of the creeks throughout the district is there an extensive continuous pay streak. An increase in richness may be noted at the mouths of some small lateral draws, and this result might be obtained by concentration of the placer gold from the breaking down of gold-bearing quartz ledges within the drainage basins of these small tributaries. Even where the basins of lateral feeders are very small, there is at the mouths of some of them a marked enrichment of the gravels of the main stream.

RUBY CREEK.

The gold deposits on Ruby Creek are of greater interest historically than economically, as it was on this creek that the first mining was done in the Ruby district. The creek is less than 2 miles in length, and the placer ground lies near its mouth on a small bench on the east bank. The gravels and overlying muck average a little more than 12 feet in thickness. At the bottom is a layer of finer wash filling the interstitial spaces in a blocky limestone bedrock, overlain by and interbedded with other thin layers of gravel. Above this is the muck, which contains larger, well-rounded bowlders of intermediate igneous rocks, together with cobbles of vein quartz. The fine gold is associated with the sediments in and on bedrock. The total production from Ruby Creek is probably little over $2,000. During the summer of 1915 work was done intermittently on the creek, but the small catchment basin makes it possible to work only while the seepage from rains affords water for sluicing.

LONG CREEK AND TRIBUTARIES.

Regarding the deposits in the Long Creek basin Eakin [1] says:

> The valleys of Long Creek and its tributaries contain remnants of older alluvial deposits that stand considerably above the present flood plains of the streams. The bedrock floors of the valleys are practically level in cross section, so that the depth to bedrock often increases away from the streams toward the valley wall. There is also a general increase in depth to bedrock downstream.

Above Long all the mining has been done on the left side of the stream at distances of 100 to 600 feet from it. Just above the mouth of Bear Pup the ground is only 20 to 30 feet deep, but farther up it ranges from 30 to 50 feet, of which the bottom 6 to 8 feet is gravel. In places the pay streak is on bedrock; in others it is above a false clayey bedrock, which may be 2 or 3 feet above the true bedrock. The muck contains numerous fragments of unworn, brecciated vein quartz. Over half the gold on "No. 3 above" is in nuggets, and although many of these show some rounding, a very considerable

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[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, pp. 40-41, 1914.

number have a spongy appearance, and their edges are but slightly rounded, indicating that the gold has traveled only a short distance from its bedrock source.

Gold has been mined on lower Long Creek from Long to a point below Snow Gulch, and most of the workings are farther from the stream than those above Bear Pup. It is about 75 feet to bedrock on the Mascot bench, at Long, but this depth is due to the distance from the creek up the hill slope. The workings are at about the creek level. Farther downstream the gravels are covered by less overburden. At the lower end of the Novikaket Association's ground, a mile below Fourth of July Creek, the depth to bedrock ranges from 20 to 40 feet, depending on the distance from the main stream. A little below Snow Gulch Long Creek flows over a bedrock riffle, and from this point downstream the bedrock slope is greater than the present stream gradient. Eakin [1] estimates that the depth to bedrock increases at least 10 feet to the mile below the last workings on Long Creek.

The section encountered varies somewhat in the different localities. The uppermost 15 to 30 feet consists of muck; below this is 5 to 30 feet of mixed gravel and muck, commonly termed "slide," in places represented by a layer of rather fine gravel called "chicken feed," and below this is the auriferous gravel, or "sediment," which may be 8 feet thick. The nature of the pay streak varies greatly. In some places it lies within the top 1 or 2 feet of bedrock or in gravel on the bedrock; in others it is above a false bedrock or clay seam which lies 2 or 3 feet above true bedrock and below which there is usually no gold.

The gold is almost everywhere associated so closely with a gravel containing rather large pebbles embedded in a clayey matrix that it is necessary to break up the material before it passes through the sluice boxes, for it would not only pass out without releasing its gold but would perhaps pick up gold from the boxes as it rolled through them. To avoid this result the gravels are washed into the dump box by a jet of water from a nozzle, the pressure for which is obtained by pumping; thus the clay lumps are disintegrated before reaching the sluice boxes.

In general the gravels are frozen, and little timbering is necessary. On the Mascot bench, however, thawed ground was encountered, and it was found necessary to advance the drifts by forepoling, thus increasing the cost of mining very appreciably. Under average conditions ground can be profitably worked by underground methods when it carries from 85 cents to $1.25 to the square foot of bedrock. There is much ground which just affords wages, but one place is said to have averaged over $15 a square foot of bedrock surface over a considerable area, and most of the operations are conducted on ground averaging $1.50 to $3 to the square foot of bedrock.

[1] Op. cit., p. 41.

On upper Long Creek two men worked during the winter on the fraction just below No. 2 above Discovery, and a mine on "No. 1 above" employing about 10 men was operated during the early part of the summer. Two other mines in the vicinity, employing about 28 men, were worked until August 1. In June two men were prospecting the bench claim above "No. 1 above." During the winter prospecting was done on the Mascot bench with a Keystone drill, and nine other outfits, employing a total of about 70 men, were prospecting or mining on lower Long Creek. During the summer some prospecting was done on the hillside and the crest of the ridge above Long. There were also eight or nine outfits mining or sluicing their winter dumps, employing about 65 men, but this number was decreased at the end of the summer to four or five, employing 25 to 30 men.

The tailings on the Mascot bench were reworked early in the summer, cable-drawn scrapers being used. Some $25 nuggets were obtained, and it seems noteworthy that nuggets so large should be found during operations of this nature. An explanation may be afforded by the possibility that they had been transported through the sluice boxes the first time in clay-cemented lumps of gravel. Another explanation may be sought in the fact that the water used for the first sluicing was impounded, pumped back into the sluice boxes, and used over and over again. The fineness of the suspended silts and the small area of the settling pond prevented anything near complete clarification, consequently the water for sluicing was exceptionally dirty. The amount of silt present increased the viscosity and specific gravity of the liquid and decreased the relative weight of the gold, so that it was more easily carried or rolled. The following principles, discussed by Gilbert,[1] may serve to explain why the coarse particles of gold should be more easily transported in a silt-laden stream:

> The law found for stream traction is that the load of the initially transported grade is increased by the moderate addition of other débris, provided the added débris is relatively fine. * * * In stream traction the pathway for larger particles is smoothed by the presence of smaller particles and rolling is promoted.

The gravels of Bear Pup are so shallow that they can be mined by open-cut methods. The section consists of 6 to 8 feet of gravel, overlain by about 15 feet of muck. The muck is sluiced or scraped off, and the gravels are then hoisted in order to get elevation for the line of sluice boxes. The stream has been practically worked out in the channel for about a mile and a half above its mouth. In the season of 1915 operations were confined to the southeast side of the stream, where one small outfit worked in the spring and two outfits, employing about 30 men, operated late in the summer.

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[1] Gilbert, G. K., The transportation of débris by running water: U. S. Geol. Survey Prof. Paper 86, p. 213, 1914.

Some of the stream gravels were fairly rich, and several nuggets worth $50 or over were found. This gold shows some wear but is far from being completely rounded. The largest nugget in the Ruby district, valued at $1,900, was found on the Mascot bench at the mouth of Bear Pup. A $200 nugget is reported from the bench claim below, and the gold apparently gets finer down Long Creek, that from the claim below the Novikaket group being very fine. It is said to assay from $17 to $17.65 an ounce. No consistent difference is to be noted in the value of the gold from the upper and lower workings.

Three miles below Long, in a small depression between Snow Gulch and Fifth of July Creek, about a third of a mile from Long Creek, some mining was done during the winter and spring of 1915 by a small plant. The working shaft, 75 feet deep, passes through 40 feet of muck and 35 feet of gravel and slide rock. Most of the gold lies close to the white clay bedrock, but some of it is scattered through 4 feet of the clay. The ground is extremely spotted. The gold is fine and the nuggets found are few and small, the largest being worth about $5.

Short Creek valley is less deeply filled with alluvium than the valleys farther up the main stream. The covering of muck amounts to but 6 or 8 feet and lies above 4 to 6 feet of well-worn gravel and sands containing numerous iron-stained bowlders of quartz and cobbles of greenstone. These deposits are being worked by open-cut methods about half a mile above the winter trail and are said to contain a little gold for half a mile farther up the creek. The gold content is low but generally runs in a somewhat irregular and poorly defined channel. The pay streak usually lies within a foot of bedrock. Open-cut operations have been carried on for the last two years but were seriously hindered in 1915 by the frequent lack of water in Flat Creek, from which water for sluicing was obtained. Besides the gold, some cassiterite is obtained in the concentrates from the boxes. It is rather finer grained than that found on other creeks in the district. No attempt has been made to save it.

The gravels on Midnight Creek are worked by underground methods. The only property being worked in 1915 lies about a mile above the winter trail to Sulatna River. Operations were carried on at a relatively shallow depth, the muck being only about 14 feet thick, and the 4 feet of gravel immediately beneath was being mined. Apparently the mining was done on a false bedrock or clay-cemented band, as true bedrock was not seen nor was angular blocky gravel found on the dump, which contained many large quartz and greenstone bowlders. The depth to bedrock increases considerably downstream, as a hole sunk near the winter trail is said to have been 80 feet deep. If the depth at the locality where mining was being done is 20 feet, a continuation of this grade would give a depth of over 125 feet to bedrock at the mouth of the creek. The gold found has all been very fine, with a few 25-cent nuggets. Associated with the gold is a considerable amount of cassiterite, which it might prove advantageous to save, although the annual production from gold placer operations would amount to only a few hundred pounds.

Greenstone Creek is like Midnight Creek in many respects, and its valley includes extensive deposits of auriferous gravels, though their tenor is said to be low. The placer ground is said to be over 100 feet wide in the bottom of the valley, which is considerably wider, and to extend for over 2 miles along the valley. Considerable development work has been done in preparation for working on a large scale. On the lower part of the creek a large amount of stripping has been done, and a dam has been put in for storage of water for sluicing. During the winter of 1914–15 about 40 prospect holes were sunk on the upper part of the creek, and in the following summer about 65 more were put down from 5 to 17 feet deep to test the ground for dredging. Favorable results were obtained, and a dredge is being installed. Tin is also found on this creek and may prove a valuable accessory mineral in dredging operations.

Last Chance, Basin, and Ptarmigan creeks are tributaries of Long Creek from the west. They have been prospected, but Basin Creek is the only one upon which mining has been done. Two of its tributaries, Willow and Swift creeks, received attention in 1915. Some prospecting was done on the headward tributaries of Willow Creek in an effort to locate shallow ground for open cutting, but the results were unfavorable. A few holes were also sunk about a mile from the mouth of the stream. The upper holes are 35 feet deep, and a quarter of a mile farther down bedrock was not reached at 70 feet. Mining was being done on a false bedrock of clayey gravel. Owing to lack of water, only a small amount of gravel was taken out. The gold is fine, bright, and but slightly rounded. Little or no sulphide is associated with it, but there is a considerable amount of magnetite.

The upper part of Swift Creek has been worked by open cutting, and two men are now working on a single claim farther down. On this claim there is 6 to 8 feet of gravel overlain by 10 to 12 feet of muck. The muck is removed by sluicing, and the gravel is hoisted by a windlass. A considerable amount of the gold is in nuggets; one valued at $50 was the largest seen. One layer of the gravel is very carbonaceous. The source of this material is doubtful, but it may be decomposed débris from a buried coal seam farther upstream, as coal fragments are said to have been found near by.

UPPER SULATNA RIVER AND TRIBUTARIES.

Long Creek joins Sulatna River about 3 miles below the mouth of Greenstone Creek. The next tributary on the east is Monument Creek, on which prospecting has been done for several years and some mining operations were conducted in 1913. Since then there has been further prospecting, and two small outfits were on the creek in 1915. Ophir Creek has been prospected, but there were never any extensive mining operations on it, and nothing was being done in 1915. Late in the summer a small prospecting outfit was working on Star Creek, but this was not visited.

On the south side of the Sulatna there are several creeks which have received attention. Gold Run, Banner, and Spangle creeks were early staked, and good prospects are said to have been found on Gold Run and Banner creeks, but no mining was undertaken. Spangle Creek was prospected and then the claims were allowed to lapse. It was restaked in 1915, and one party of three men did some prospecting in August, but without results. Fourth of July Creek is being held, but little or no work has been done to ascertain the value of the ground.

Spruce Creek was among the creeks early staked and then left idle after a nominal amount of prospecting. A part of it was still held in the winter of 1914–15, but the lower part was open to location. Active prospecting on this ground showed workable deposits and led to the restaking of the creek below the mouth of Schist Creek. During the summer six outfits, comprising about 15 men, were on the creek for a part of the summer engaged in prospecting or mining, and obtained considerable gold. The stream flows in a rather broad valley with a gentle gradient, apparently about the same as that of the bedrock channel, which lies at depths of 55 to 70 feet. Mining operations have been conducted for about 3 miles along the valley. The ground is generally frozen to bedrock, but thawed ground and water were encountered at one place, and the hole was abandoned for summer work. The gravel is from 2 to 5 feet thick and is made up of several varieties of igneous rocks and dark siliceous slates, usually with considerable clayey material. The gold is found in the gravel close to bedrock. Most of it is well rounded and rather fine, though several \$2 to \$3 nuggets have been found. Some of these nuggets contain vein quartz. The workable gravels range from some yielding 75 cents a square foot of bedrock to rich spots from which \$12 pans are reported.

Tamarack Creek, staked in 1912, was actively prospected in 1913, and mining has been carried on since. During the summer of 1915 four plants, employing about a dozen men, were at work; three were using steam hoists and the other a hand windlass. A number of holes were sunk about 1½ miles from the Sulatna, but the first plant is located about half a mile farther upstream, and work is being done for about 1½ miles along the creek above this. The holes average 60 feet in depth throughout that part of the creek which is being worked. The bottom layer consists of 1 to 5 feet of "soft" bedrock above the true bedrock. Above this is 3 to 8 feet of gravel, and the rest is muck. The gold lies in the upper foot of soft bedrock and in the lower 3 feet of gravel, on what appears to be the rim of an old channel.

The gold is rounded and shotty, not flaky, running mostly in pieces worth 10 cents to $2. One $50 nugget has been found. Assay returns show that the gold ranges from $16.50 to $17 an ounce. Mining costs are reported to range from 40 cents to $1 to the square foot of bedrock, and the gravels worked yield 75 cents to $2.50 to the square foot of bedrock.

TRAIL CREEK.

Workable ground extends for over 2 miles along Trail Creek, and colors are said to have been obtained down the valley for 17 miles. During the winter of 1914–15 four plants were working on the creek and three of these continued operations during the summer. There is a small difference in the thickness of the valley filling within the area where mining is being done. The upper workings show a thickness of 30 to 35 feet of frozen muck and gravel, in which the gravel amounts to 2 to 5 feet. At the lower workings the thickness increases to about 40 feet, with about the same amount of gravel. It is said that 7 miles downstream the depth to bedrock is 70 feet. The upper course of the creek presents conditions similar to those on Long Creek, the depth to bedrock increasing away from the creek, owing to the difference in bedrock and surface profiles.

The gold lies close to bedrock, in the little-rounded, coarse gravels. It is irregularly distributed, but the gravel is reported to be richer at the mouths of small tributary gulches. The average value is said to be between $1 and $2 to the square foot of bedrock surface. On the upper part of the creek about 10 per cent of the gold is in nuggets worth over $5, the largest having a value of about $300. Some of the gold is spongy in appearance and shows little rounding, but some is well rounded. Assay returns give the value of gold in this vicinity at about $16.85 an ounce. The gold and silver occur in the ratio of 5.5 to 1.

FLINT CREEK AND TRIBUTARIES.

During the winter considerable prospecting was done with a churn drill near Root Gulch, on upper Flint Creek, but without result, and no mining is being done. In former years there has been considerable prospecting of the creeks between Root and Glen gulches, but no extensive mining. Most of the dumps from the prospect holes show angular granitic débris, associated with the gravels of metamorphic rock, both near the creek and on some of the ill-defined terraces that are considerably above it.

Two mines on Glen Gulch took out small winter dumps in 1915 at a locality about a mile and a half above the mouth of the creek, and two other plants did some winter prospecting, but nothing was attempted during the summer. At the locality where the work was done, on the south side of the creek, it is 25 to 30 feet to bedrock, of which from 1 to 7 feet consist of gravel. Farther upstream the ground is shallower, and some open-cut mining was done. Considerable good ground was found about a mile up from Flint Creek, but it has been mined out. Prospecting at the mouth of Glen Gulch in the deeper gravels has thus far proved fruitless. The ground is frozen, and thawing is necessary. Here the gold is usually found in the first foot of gravel or in the shattered bedrock. The gold is somewhat rough, and some of it is coarse, nuggets worth as much as $150 being reported.

When the mining operations were begun on Glen Gulch ground was staked on Lucky Gulch, and there was some prospecting, but the results obtained were not promising and no mining has been done.

In 1914 Birch Creek was staked and considerable prospecting was done on it. During the winter of 1914–15 three mines were being worked and some other claims were being prospected. Bedrock on this creek is deeper than on any of the others worked, as it lies 70 to 90 feet or more below the surface. On the south side of Crooked Creek to its mouth there is an ill-defined silt terrace several feet above the creek level but below that on the south side of Birch Creek. As the bedrock slope is less than that of the surface of the terrace, holes sunk on the terrace are considerably deeper than those put down in the present stream valley. Normally they show 40 to 50 feet of silts and sands, and the rest of the depth to bedrock is made up of gravel with clayey layers. Some of the silt layers are reported to contain leaf impressions. It is said that near the mouth of the creek there are layers of iron-cemented gravel near the bottom. The iron is probably derived from the oxidation of the pyrite in the sands or from the leaching of the pyritiferous slates, which, with numerous large bowlders of vein quartz, make up the gravels on lower Birch Creek. On the upper part of this stream igneous rocks constitute a larger proportion of the gravels.

Gold is found for 2 miles or more along the lower course of Birch Creek and between Straight and Crooked creeks. It occurs on or near bedrock, which is said to be granite on the upper workings and black pyritiferous slate farther downstream. The gold from the granite is fairly coarse, much of it is badly tarnished, and the concentrates contain tin and a little pyrite. The concentrates from the lower workings are composed mainly of pyrite, and the tailings dumps emit a distinct odor of SO_2, produced by its oxidation.

Mining and prospecting are rendered difficult by thawed ground and live water, which may be encountered below 80 feet. The amount of water and the depth make it almost impossible to prospect without a rather large plant having sufficient boiler capacity to do the necessary pumping.

POORMAN CREEK AND VICINITY.

Poorman Creek lies in the Innoko River basin, being separated from the Sulatna drainage basin by a broad ridge whose altitude is between 1,050 and 1,100 feet. Duncan and Tenderfoot creeks, tributaries of Poorman Creek, rise in this ridge opposite the heads of Tamarack and Spruce creeks, which flow into the Sulatna.

Poorman Creek was staked early in 1913, and in the same year some prospecting was done and a small amount of gold produced. In the last two years mining has been actively carried on. In 1915 eight mines employing about 40 men were operated during most of the summer, and three or four other outfits of two or three men each worked for short periods or were engaged in prospecting during a part of the season. The work was confined to a distance of about 3 miles along the north bank of the creek, except for one outfit working on Little Pup, a tributary from the south. In general the work is being done on bench claims, and the old channel in places lies on the second-tier bench.

The north bank is the gentler, and, as in the vicinity of Long Creek, the bedrock floor of the old valley is wider than the present stream, and depths to bedrock increase with distance from the creek. There seems also to be a slight increase in depth downstream. The thickness of the valley filling ranges from 45 to 80 feet, as determined by mining operations; the deepest shaft was on one of the bench claims.

The section consists of coarse gravel, 2 to 12 feet; fine, sharp, clean gravel or "chicken feed," 6 inches to 12 feet; and muck to the surface. The material is frozen down to bedrock. The coarse gravels consist largely of bowlders of vein quartz and rusty quartz breccia or conglomerate, with varying amounts of igneous rocks, quartzite, slate, and chert. In the concentrates pyrite is the most common mineral, but it decreases in amount downstream. Rounded and polished pebbles of cassiterite showing concentric structure are common, as is also barite, and there is a small amount of magnetite.

Most of the gold lies close to the bedrock surface, but it may extend up into 2 or 3 feet of gravel. Its assays average about $17.30 per ounce. Nuggets worth $25 have been found, but as a rule the gold is rather fine. It is mostly somewhat rough, and small pieces of vein quartz are attached to many of the larger pieces. Though usually bright, the gold from at least one prospect was dull and nearly black. The minimum cost of mining is about 60 cents to the square foot of bedrock, but some ground running a little less has been worked. The richest ground is said to run about $5 to the square foot.

Flat Creek was staked during the winter of 1913–14 and yielded considerable gold in the following summer. The production was materially increased in 1915, when there were 18 men working on seven claims. The creek is a small tributary of Timber Creek, which heads against Little Pup. The gradient is gentle, but there is an abrupt headward steepening. The uppermost workings lie less than a quarter of a mile from the head, and others extend down the creek for about 1½ miles. Near the head the depth to bedrock is 50 feet, 2 feet of which is gravel. Farther downstream the depth increases to 55 feet, including 5 feet of coarse material. In the workings of the two outfits farthest downstream the depth increases to 65 feet, including over 20 feet of gravel. Of this 20 feet the lower 15 feet is somewhat rusty and oxidized, differing from the upper layer of unoxidized gravels characteristic of the rest of the creek, and probably represents an old channel of Timber Creek. These gravels carry some gold on bedrock. On the upper part of the stream most of the gold is found in or near bedrock in the subangular gravels, but some of it occurs above a clay seam constituting a false bedrock a short distance above the base of the gravels. Associated with the gold are pyrite, rounded grains of cassiterite, magnetite, and a small amount of arsenopyrite. It is peculiar in its fineness and extreme roughness and in the amount of quartz attached to even the smallest particles. Such nuggets as have been found are small. It is stated that assays show the gold to have a value of about $15.75 an ounce. Mining costs are in the vicinity of 75 cents to the square foot of bedrock and the ground carries from 50 cents to $4 a square foot.

OTHER CREEKS.

There are numerous other creeks in the district that contain some auriferous gravels, and many of the tributaries of the Sulatna have been prospected in the endeavor to locate workable deposits. Easy Money and Tip creeks were prospected in 1913. At their junction it was 80 feet to bedrock. On White Channel, a tributary of Trail Creek, holes were sunk more than 150 feet without reaching bedrock, but disclosed the presence of an unknown depth of white quartz gravels. Some prospecting was done here during the winter of 1914–15. Quartz Creek has also received some attention, and holes sunk on the main stream and on Rabbit Creek early in 1915 represent the last work done. Fine colors were obtained, but no workable placer ground was located.

More or less prospecting has been done along Big Creek, a tributary of the Yukon, ever since the first discoveries were made in the district. No mines have yet been developed. During the summer of 1915 a churn drill was working near the head of the stream and holes were also being sunk on small tributaries southeast of Ruby.

Late in the summer of 1915 there was a stampede from Ruby to take ground a few miles upstream and across the Yukon on one of the lower terraces. The auriferous gravels lie below 20 feet or more of clean white quartz bowlders, which are covered with several feet of fine sediment or muck. Sufficient work had not been done in the fall to determine the value of the deposits.

At various times prospectors have sunk holes on the creeks between Tamarack Creek and Nowitna River, but the so-called "hard formation" has never yielded even a fair prospect, and their endeavors were shifted to creeks lying within the metamorphic area, which gave greater promise.

CRIPPLE CREEK MOUNTAINS.

The gold-bearing creeks in the Cripple Creek Mountains were not visited by the Survey party in 1915. It was reported to the senior writer, in Iditarod, that this locality is still in the prospecting stage, although some mining is being carried on both by drifting and open-cut methods. The status of operations there in 1912, when the creeks were visited by Eakin,[1] was as follows:

> The work that has been done in the vicinity of the Cripple Creek Mountains on Cripple Creek, Fox Gulch, Colorado, and Butte creeks has been all prospecting. Workable deposits of placer gold apparently exist on some of these streams, but the existence of large placers has not yet been demonstrated. The gravels on the streams range in depth from 10 to 20 feet. Values vary and probably range in places up to $2 a square foot of bedrock surface. The future of placer-mine development in this locality will depend upon the extent of such deposits, which will be known only when much additional work has been done.

INNOKO DISTRICT.

The Innoko district was west of the line of travel of the Survey party in 1915 and therefore was not visited. For the sake of completeness, however, the latest information on this district, obtained by Eakin [2] in 1912, is included:

> Prior to the summer of 1912 the only workable placer-gold deposits known to exist in the Innoko district were those on Ophir, Spruce, Little, Ganes, and Yankee creeks. These streams are practically parallel and are tributary to Innoko River from the southwest—except Little Creek, which is tributary to Ganes near its mouth— in the order given, progressing upstream. The placers on all are within a few miles of the Innoko. Gold prospects are said to occur on several other streams in the same neighborhood. * * *

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 38, 1914.
[2] Idem, pp. 35-36.

All placers of the Innoko district are of medium or shallow depth. The bedrock throughout the placer areas consists of members of the Cretaceous sedimentary series and of igneous intrusives. The latter are mainly acidic dikes and sills. * * *

PLACER MINES.

Ophir Creek.—The mines of Ophir Creek have been among the chief producers of the Innoko district, but the available placer ground is now nearly exhausted.

Auriferous gravels formerly extended almost continuously along Ophir Creek valley for about 2 miles. They ranged up to 70 feet in width. The alluvium is 30 feet deep at the lower end of the valley. Its depth gradually becomes less upstream, and in the upper mines it is less than 20 feet.

Bench gravels have been exploited at a single point at claim No. 6 above Discovery. The bedrock floor of the bench is 7 feet above the flood-plain level and is overlain by a 10-foot thickness of gravels.

The alluvium of Ophir Creek is largely composed of slightly worn materials of the local bedrock. Well-worn gravels are rare. Silt and muck are also included in the upper part of the deposits. Practically all the alluvium is permanently frozen.

Spruce Creek.—The developed placers on Spruce Creek are on a low bench on the east side of the valley about 3 miles above the mouth of the stream. Two claims have proved rich enough to support mining by economical open-cut methods. A ditch delivers water from a point farther upstream, at the upper margin of the bench deposits. The overburden is groundsluiced off, and the gold-bearing material is then shoveled by hand into lines of sluice boxes.

The gold occurs in the shattered surface of bedrock and in an overlying stratum of gravels 2 to 6 feet thick. The gravels are overlain by 10 to 15 feet of very wet frozen muck or silt. The width across valley of the deposit available for mining differs from place to place, but is at some places more than 100 feet. The gold tenor of different parts of the deposit depends largely upon the roughness of the bedrock surface beneath and is extremely variable from place to place. Little is known of the gold tenor of the gravels farther downstream, where the bench continues for the length of several claims.

Little Creek.—Auriferous deposits occur for about 2 miles along the valley of Little Creek. They have proved to be rich enough to support mining through much of this extent. They are in part the gravels of the present flood plain and in part bench deposits. The flood-plain deposits are relatively narrow and those of the benches relatively broad.

The lower creek claims and the bench claims contain shallow placers worked by open-cut methods. The stream gravels are 18 to 30 feet deep farther upstream, where underground methods of mining are employed.

The alluvium in the lower creek placers is made up almost entirely of gravels. It includes a few large bowlders, but they offer no special hindrance to mining by the methods in use. There is usually a slight overburden of muck. The greater depth of the creek placers farther upstream is due chiefly to the greater thickness of muck above the gravels.

The benches are best developed along the middle reaches of the stream's course, and where widest they extend 500 feet from the creek. About 300 feet of this width is said to carry values sufficient for profitable mining. The gold occurs throughout a considerable thickness of gravel that is overlain by a thin deposit of muck. In mining a method is employed that is similar to that used on Spruce Creek—that is, the overburden is removed and the gravels are concentrated as much as possible by groundsluicing, after which the gold-bearing materials are shoveled by hand into lines of sluice boxes.

Ganes Creek.—Ganes Creek has a pronounced development of gravel-covered benches along the right side of the valley and below the canyon a rather broad gravel-covered flood plain. Gold occurs in the gravels of both types of deposits, but thus far only the bench gravels have proved available for mining. It seems likely that the flood-plain gravels may contain fairly high values in places, but the work of prospecting them is difficult because they are thawed.

The original concentration of gold in the Ganes Creek valley occurred in preglacial time, when the stream was much shorter and had less volume. Apparently a continuous pay streak was formed at that time extending for miles along the stream. When the stream cut down to its present level part of the old pay streak was carried down and reconcentrated in the present stream gravel and should be found in the reaches between the gold-bearing benches. Parts of the original concentration remain in the bench gravels. Where lateral streams cross the course of the old pay streak they have concentrated its values from the width of the tops of their recently cut valleys to the narrow gravel deposits in their bottoms. This form of reconcentration has probably produced some of the richest spots of the Ganes Creek valley.

The Ganes Creek placers have been worked almost entirely by open-cut methods. Water for sluicing is taken from the small tributaries of Ganes Creek, and in many places work has progressed slowly on account of the small supply. The bench gravels have now been nearly worked out, and the future of Ganes Creek as a producer will depend largely upon the gold tenor of the flood-plain gravels. If systematic prospecting should prove their worth, these gravels would be admirably adapted for dredging.

Yankee Creek.—The Yankee Creek placers are between 6 and 7 miles above the mouth of the stream and are all included apparently in two association groups of claims, each comprising 160 acres. Yankee Creek has an exceptionally broad, flat valley, and the auriferous deposits have a correspondingly wide cross-valley extent. The alluvium consists of a stratum of gravel 5 to 7 feet thick, which is overlain by a thin bed of muck. The ground is mostly thawed in summer and is worked exclusively by open-cut methods.

A placer gold strike is reported to have been made on Tolstoi and Boob creeks during the winter of 1915–16. Tolstoi Creek is about 40 miles in length and is tributary to Dishna River (known locally as Ditna), which is part of the Innoko system. It heads in the Beaver Mountains, but has also a number of tributaries which head around Mount Hurst.

The Beaver Mountains contain much monzonite, a rock which, as elsewhere pointed out, is an important source of the gold in the Ruby-Kuskokwim region. In the Mount Hurst area, however, the country rock consists mainly of phyllite, slate, quartzite, chert, and crystalline limestone. Prospecting has been carried on intermittently in this area since 1908, and gold has been found in small quantities on a number of creeks. If the productive ground is in this general vicinity, it is most likely that the gold is derived from quartz veins, which are plentiful here, as in the Ruby district. If so the gold is likely to be less localized than where the bedrock source is a body of granitic or monzonitic rock.

CANDLE CREEK.

On the upper part of Candle Creek, a tributary of Tatalina River about 12 miles long, active mining was begun on a four-claim association by the owners in 1914 and continued by laymen in 1915.

The laymen had been working only two weeks at the time when this creek was visited (July 31), and no clean-ups had yet been made. This outfit, consisting of two laymen and nine others, represents all the mining activity in this vicinity at present.

A ham-shaped body of monzonite, with the shank pointed downstream, forms the bedrock in the upper part of Candle Creek. It extends downstream about 3 miles, ending about three or four claims above Discovery claim. The divide at the head of Candle Creek is made up of a hard, dense basalt, but the spurs on both sides of the valley are composed largely of sandstone and shale, presumably of Cretaceous age. The stream gravels are from 9 to 15 feet thick in the upper part of the creek, where they are being worked, and increase gradually downstream. Bowlders 4 feet in diameter occur in the gravel, and smaller ones are numerous. Basalt and monzonite are the chief materials of the gravel.

Open-cut methods were being used at the time this creek was visited, but a hydraulicking outfit was nearing completion. On account of the scarcity of water in the headwaters of the creek, a bedrock basin has been excavated above the workings to catch surface and ground water, and a head of 100 feet will be developed.

The gold is irregularly distributed through the gravel in grains averaging about 1 per cent. Very little flour gold is reported. The heavy sand recovered with the gold is reported to be largely cinnabar, with some magnetite.

There can be no doubt that the gold at this locality is connected genetically with the monzonite. Quartz veins cut the monzonitic bedrock, and it is entirely probable that these veins, with perhaps mineralized zones in or adjacent to the monzonite, constitute the source of the gold. Furthermore, it appears that the richest ground is on the upper part of the creek, where the bedrock is monzonite. Below the monzonite prospect the tenor of the gravel is lower. From 250 to 350 drill holes have been sunk with a No. 8 Keystone drill in the monzonite area, on the four-claim association which is being worked, and on claims Nos. 8, 9, and 10 above Discovery, which adjoin the association on the downstream side. The values reported for these prospects are exceedingly high and if this is true point to the future development of Candle Creek as a small but very rich placer-mining district.

MOORE CREEK.

The workings on Moore Creek, the south fork of Takotna River, are on the upper part of the creek, about 10 miles below its source. The gold-bearing gravels at this locality were discovered and staked about 1910, and mining has since been carried on in a small way. During the season of 1915 two outfits were engaged in mining, one on claim No. 5 above Discovery and the other on a bench association and an adjoining fraction. Two men were at work on the creek claim and four on the bench claims.

The bedrock here is sandstone and shale, standing vertical or dipping steeply to the north and striking in general to the northeast. On the creek claim the gravel is about 10 feet thick and is composed of cobbles ranging from 6 inches to 3 feet in size, mainly sandstone, shale, granitic material, and basic igneous rock. On the bench claims the gravel is only 3 feet thick and is covered by 2 feet of clay and vegetation.

On the bench diggings mining is carried on by pick and shovel methods. Hydraulicking is used only for stripping off the overburden. The water is brought in a ditch from Willow Creek, a tributary of Moore Creek. On the creek claim hydraulicking is utilized in moving the gravel. The water coming from the bench diggings is impounded and delivered to the nozzle under a head of about 20 feet.

The gold is little worn and contains much quartz. Cinnabar is the chief heavy sand found in the concentrates, but this is much more plentiful on the creek claim than on the bench claims. Zircon and a little magnetite are also present.

As on Candle Creek, the gold is connected genetically with the mineralizing effect of monzonite. A body of monzonite occurs in the hills to the north, at the head of Willow Creek, and it is not unlikely that similar bodies may be present farther up Moore Creek, for a considerable amount of granitic rock has been noted at Camelback Mountain (known locally as Bonanza Mountain), at the head of Moore Creek.

IDITAROD DISTRICT.

GENERAL FEATURES.

Placer gold was discovered in the Iditarod district in 1908, on Otter Creek. Mining operations began in 1909 and have continued to the present time. This district is now a well-established mining community and a constant producer of placer gold. Two towns, Iditarod, on Iditarod River, and Flat, on Otter Creek, at the mouth of Flat Creek, have post offices and, together with Discovery, farther up Otter Creek, handle the business of the district. Flat and Discovery are the supply points for the adjoining mining operations.

All of the mining is of the placer type, no gold or other lodes having yet been developed into producing mines. Placer ground is being worked on Otter, Flat, Black, Slate, and Willow creeks, and Glen Gulch, and on the slopes of the granitic dome at the heads of Flat, Chicken, and Happy creeks.

CHARACTER OF DEPOSITS.

Eakin,[1] in discussing the placer deposits of this district, has divided them into two types—the alluvial deposits of gravel in the present stream valleys and the residual deposits, or those in the development of which water has played a minor part. Some of the stream deposits, such as those in Glen Gulch and on Otter Creek, at Discovery, partake of the nature of residual deposits, in that they lie in an area of monzonitic bedrock, which is the source of the gold. The residual deposits proper, however, are those in the formation of which stream action has had no place; and the deposits on the slopes of the granitic mass at the heads of Flat, Chicken, and Happy creeks exemplify this type particularly well.

STREAM PLACERS.

Otter Creek.—Mining is being done both on creek and bench claims on Otter Creek, in the vicinity of Discovery. There are six creek claims, running from claim No. 2 above Discovery claim to claim "No. 3 below." These are joined upstream and downstream by association claims. A tier of bench claims on the north bank and two tiers of bench claims on the south bank lie alongside the creek claims. About six single and association claims were being worked during the season of 1915.

The bedrock at Discovery is a body of monzonite, which extends upstream to the mouth of Slate Creek and ends downstream about three claim lengths below Discovery claim. The valley wall north of Discovery is a basaltic rock, so that the monzonite on that side of the creek is confined to the present valley floor. To the south the monzonite reaches well up into the head of Glen Gulch, where it attains its maximum width. Above and below the monzonite on Otter Creek the bedrock is sandstone and shale, supposedly of Cretaceous age, with a general strike of about N. 70° E. and a steep dip to the northwest. The gravel is composed of granitic and basaltic material, together with considerable sandstone and shaly material. The maximum depth to bedrock is about 15 feet in the creek bottom, but becomes gradually less on the bench claims.

Mining on the bench claims near Discovery is being done by means of mechanical scrapers. These remove all the loose gravel and convey it to cars, which are hauled up an inclined track and dumped into the dump box, at the head of a chain of sluice boxes. The upper part of the bedrock, which also carries some gold, is picked by hand and wheeled in barrows to the cars.

A dredge of the bucket-elevator flume type, using distillate for fuel, is at work mining the gravels of the creek. The gravels are frozen and are prepared for the dredge by thawing with steam points.

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Bull. 578, p. 31, 1914.

According to Brooks,[1] there are two kinds of gold on Otter Creek, a coarse and a finer variety. These two are of different appearance. The coarse gold is darker than the fine and much waterworn. The fine gold is angular and bright. The concentrates contain cinnabar, arsenopyrite, and scheelite.

The monzonite that lies in the bed of the stream is undoubtedly the source, directly or indirectly, of the gold on Otter Creek. The fine, bright, unworn gold comes directly from quartz veinlets and mineralized zones within the monzonite. Brooks is inclined to believe that the coarser and darker gold has its source in antimony or cinnabar lodes that closely adjoin the monzonite.

Glen Gulch.—An association claim on Glen Gulch was worked during the season of 1915. Mining operations were suspended before this locality was visited, but it is said that manual methods were employed. The bedrock is monzonite, as on Otter Creek, and the gold occurs at the base of the gravel and in the disintegrated bedrock.

Black Creek.—Two plants were at work on Black Creek in 1915. The following, written by Eakin,[2] is an adequate description of conditions there.

The placers of Black Creek are not well defined as to extent. It seems likely that continuous placer deposits do not extend for any great distance in the valley. However, workable deposits have been discovered locally at several places. The bedrock in general consists of members of the sedimentary series and of local bodies of intrusive monzonite. As on the other creeks, the depth of the Black Creek placers is not great, the usual range being 12 to 16 feet.

Slate Creek.—Small placer-mining operations were carried on at the lower end of Slate Creek in 1915. It is reported that the bedrock is much the same as on Black Creek and that the gravels are unfrozen.

Flat Creek.—On Flat Creek a dredge, two plants operating on bench claims, and a bucket hoist operating in the upper part of the creek were at work in 1915. The company working the dredge owns all the creek claims in the lower 3 or 4 miles of Flat Creek, down to Otter Creek, and its operations are the most extensive.

The bedrock at the extreme head of Flat Creek is monzonite. Below, down to Otter Creek, sandstone and shale, rather more indurated than other Cretaceous rocks near by, form the rock floor of the valley. Locally beds of quartzite and slate were recognized. Dikes of igneous rock cut the sedimentary rocks. Along the wagon road, about halfway up Flat Creek, the rocks strike N. 60° E. and dip 50° NW. This general northeasterly direction is believed to be the regional strike in this vicinity. The creek gravels at the point where the dredge is at work are about 10 feet deep and carry little or no overburden.

[1] Brooks, A. H., unpublished notes on Iditarod district, 1915.

[2] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 32, 1914.

The bedrock configuration of Flat Creek, according to Brooks,[1] differs markedly from that of Otter Creek. On Otter Creek the bench and creek deposits merge gradually into one another, there being no sharp break or bedrock rim between the two. On the east side of Flat Creek, in its upper part, there is a bedrock reef which sharply separates the bench deposits from the creek deposits. Moreover, the gravel deposits are of different thickness and character at several localities. The bench deposits, however, merge into the creek deposits farther downstream.

The creek mining is of two kinds. The bench claims are worked by mechanical scrapers, much as at Discovery, on Otter Creek. The dredge operates in the creek gravels, which are frozen and have to be thawed ahead of the dredge by steam points.

The gold is of two grades.[1] That taken from the bench gravels is coarser and of higher grade than that taken from the creek gravels (known as the "formation gold"). There is, however, more or less intermingling of these two types, especially farther downstream, where the bench and creek deposits coalesce.

The gold of Flat Creek is undoubtedly derived from the monzonitic mass at the head of the creek. Unlike the gold around Discovery, on Otter Creek, it can not be considered to have any of the characters of a residual gold deposit, for nearly all of the Flat Creek valley has a sedimentary bedrock. The Flat Creek gold, therefore, is a typical creek placer deposit.

Willow Creek.—Willow Creek was visited in 1915 by A. H. Brooks, who states that two plants were operating there. One of these employed a drag-line excavator, and the other was operating underground, raising the gravel with a bucket hoist.

Bench and creek claims are staked, as on Otter Creek. Like that of Otter Creek, the valley is unsymmetrical, the valley wall on the west being abrupt. The bedrock is slate, and the gravels are made up largely of sedimentary rock, with lesser amounts of granitic and basaltic material. There is about 10 feet of muck overlying from 3 to 4 feet of gravel on the bench ground, but the muck thins rapidly toward the creek. The gold lies in the lower 1 or 2 feet of gravel and in the decomposed bedrock.

The source of gold is not established. It apparently is not a continuation of the Happy Creek pay streak, for Happy Creek does not carry gold to its mouth. Moreover, the gold is coarser and of somewhat higher grade. Brooks is inclined to believe that outlying lodes from the main monzonite mass have been the source of the gold.

[1] Brooks, A. H., unpublished notes on Iditarod district, 1915.

RESIDUAL PLACERS.

The residual placers have been described by Eakin. Ten claims and associations may be described as belonging to this type. Five of these are at the head of Flat Creek, two at the head of Chicken Creek, and three at the head of Happy Creek.

The monzonitic bedrock which is the source of these placer deposits is much sheared and mineralized. The mineralization appears to have been accomplished in two or more ways. Numerous quartz veinlets, from an eighth of an inch to 2 inches in width, cut the monzonite. These carry free gold, and are therefore a known source of some of the gold. Many of them have a general east or north of east direction. There are also numerous iron-stained joint planes which are probably also sources of gold. Most of them strike in accordance with the quartz veinlets, but some have a northwesterly strike. Brooks [1] has observed that on several claims there is little evidence of quartz veining or of extensive sheeting. The monzonite is iron-stained and massive, and the inference is that the rock may have been completely saturated with the mineralizing solutions.

The monzonite is deeply weathered, commonly to a depth of 5 to 10 feet and in some places deeper still. It weathers out into great rounded bowlders, which very much resemble water-worn material. Some of these have moved down the slope and are found overlying finer gravel, and in such places gravel may appear to underlie bedrock.

Mining on this granitic dome is attended with difficulties. Most of the work is done by open cuts and hydraulicking. The great difficulty, especially in the hydraulicking operations, is the scarcity of water. Ditches have been dug at numerous places along the upper slopes of the dome to catch the surface and ground water. These ditches lead the water to reservoirs, where it is impounded to give the necessary head for hydraulicking or to give a steady flow for open-cut work. Obviously the length of time during which gravel may be washed is limited by the amount of water available. The work begins when the reservoir is full and ends when the water is exhausted, giving the work an intermittent character during the day. The owner of the claims at the head of Flat Creek has built snow fences during the winter to cause the snow to collect in huge drifts, thus augmenting the summer water supply. This method will probably be followed by other operators.

The gold is bright and angular and contains much quartz. Much of the gold is very fine, and one of the operators reported that 10 per cent of his total output was recovered by amalgamating on copper plates, a process that is commonly followed. The richest part of the placer is usually near the bedrock.

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[1] Brooks, A. H., unpublished notes on Iditarod district, 1915.

GOLD LODES.

Little gold-lode mining has been done in this region. Quartz and quartz-calcite veins are very common in the Ruby district, but it remains to be demonstrated how many of these are capable of supporting lode mining. Several good-sized quartz veins near Ruby have been prospected, and although small quantities of gold are reported, none of the veins have yet proved to be of commercial importance. The fact, however, that good-sized nuggets with intergrown quartz are often found favors the belief that richer veins are present and will ultimately be located and mined.

Eakin[1] reports that in the Innoko district quartz veining is common, especially in the vicinity of acidic dikes. One such quartz vein was being worked in 1912. Of this he says:

> The Independence mine is near the head of Carter Creek, an eastern tributary of Ganes Creek. The ore body is a quartz vein, averaging about 2 feet in thickness, that occurs along the hanging wall of a rhyolite dike intrusive in the sedimentary series. The microscope shows that the gold lies in iron-stained crevices and vugs in the quartz and is also embedded in grains of magnetite within the quartz vein. Veinlets of iron carbonate cut the quartz, and iron carbonate is abundantly present in the altered sedimentary rock on the one hand and in the altered dike on the other. The dike is much altered in places, so that the original character of the rock is obscure.
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> The altered sedimentary and igneous rocks both contain more or less gold. The workings show that the vein is continuous to a depth of more than 90 feet, and there are no evident geologic reasons that it may not extend to a much greater depth.

In the Iditarod district quartz veining is not common in the sedimentary rocks except close to the intrusive rocks. The monzonite, however, contains many quartz veins. In the monzonite at the head of Flat Creek much of the quartz is bluish in color and carries free gold in grains that are visible to the naked eye. The presence of arsenopyrite and cinnabar in the concentrates here indicates that these minerals probably occur in the quartz veins. Over 500 pounds of the rich gold quartz material has been gouged out from veins in the monzonite at the head of Flat Creek and shipped to the Selby smelter, in Tacoma, Wash.

ANTIMONY AND QUICKSILVER LODES.

Vein deposits of stibnite and of stibnite and cinnabar are known to exist in the vicinity of the monzonite intrusive bodies. None of these have been worked, but it is quite possible that some of them or other lodes as yet uncovered may become producers in the future.

At the head of Wyoming Creek, in the Cripple Creek Mountains, Eakin[2] reports the presence of a 30-inch vein of stibnite and quartz. A specimen from this locality shows that quartz and cinnabar form

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 28, 1914.
[2] Eakin, H. M., oral communication.

the walls and stibnite the center of the vein. The vein is said to occur in the contact zone between the monzonite and the sedimentary rocks.

In the Innoko district Eakin[1] saw a 12-inch vein of stibnite and quartz at the Kaatz prospect, 1½ miles above the mouth of Copper Gulch, a tributary of Ganes Creek. This vein strikes N. 30° E., dips 75° SE., and is traceable, in association with a rhyolitic dike, for 6,000 feet. Stibnite is disseminated through the vein, but is concentrated along the footwall. An examination of a thin section of this ore shows conclusively that the quartz was injected into the vein and was followed later by the stibnite.

At the border of the monzonite area at the head of Flat, Chicken, and Happy creeks lodes carrying stibnite and cinnabar are present. A sample from one of these, collected by Eakin at the head of Chicken Creek, shows a vein 2 inches thick. It is mentioned, not because of its potential significance as a lode deposit, but because it shows very well the same feature that was noted in the ore from Wyoming Creek—that is, quartz and cinnabar along the edge of the vein and stibnite in the center.

At the head of Glen Gulch a stibnite claim known as the Mohawk lode has been staked. This is a mineralized shear zone about 2 feet wide, at the contact of the monzonite with the country rock. The strike of this zone so far as could be determined is N. 45° E. and the dip 45° S., according to Brooks.

This zone, like most of the others mentioned, carries gold. Some narrow stibnite-bearing veins have also been found on the lower part of both Glen Gulch and Black Creek.[2]

The Parks prospect, on the north bank of Kuskokwim River, about 15 miles above Georgetown, has been described in considerable detail by Smith and Maddren.[3] The ore is cinnabar and stibnite, and the lode is in a shattered or brecciated zone at the contact between the country rock and intrusive igneous rock. The intimate association of granitic and diabasic material, the characteristic feature of the igneous rocks in this region, is also to be seen here. According to the authors cited, the cinnabar and stibnite are intimately intergrown, and the deposition of the two minerals was almost contemporaneous. The gangue is quartz and ferruginous carbonates.

STREAM TIN.

Stream tin in the Ruby-Kuskokwim region is not considered by the writers to be plentiful enough to warrant a discussion of its possible economic significance. Many queries, however, were made by

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[1] Eakin, H. M., oral communication.

[2] Brooks, A. H., The antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, 1916.

[3] Smith, P. S., and Maddren, A. G., Quicksilver deposits of the Kuskokwim region: U. S. Geol. Survey Bull. 622, pp. 274–280, 1915.

miners regarding the nature of certain heavy brown pebbles recovered by them in the concentrates. The following notes are intended as an answer to such queries:

Tin in the form of the oxide, cassiterite, is obtained in the concentrates on Short, Midnight, Greenstone, Monument, and Trail creeks, in the vicinity of Long, and represents a phase of mineralization which is doubtless associated with the coarse-grained granite occupying the crest of the ridge at the head of Flint Creek. A similar granite intrusion and its attendant mineralization accounts for the presence of tin on upper Birch Creek. On Ruby Creek there is no known exposure of granite, but the concentrates likewise contain cassiterite. The cassiterite occurring at these places is in the crystalline form, translucent to opaque, and from yellow-brown to black. It resembles rutile or wolframite in appearance.

On Poorman and Flat creeks, in the vicinity of Poorman, the cassiterite is in the form known as wood tin, showing no crystal form, but having surfaces which are mamillary or reniform and internally showing concentric structure in which bands range from yellow to dark brown. The source of this tin is unknown, but probably it is of vein origin. This form much resembles limonite and is with difficulty distinguished from it.

A simple test for both forms of cassiterite consists in placing fragments of the mineral in a glass or enameled dish with some granulated zinc, and pouring over them sulphuric or hydrochloric acid. After heating a few minutes cassiterite shows a coating of tin, which becomes more evident after rubbing on a piece of cloth to brighten it.

COAL RESOURCES.

Coal-bearing rocks of Cretaceous age occur at numerous places in the lower Yukon basin, and some small mines have been opened in them, but the demand for coal has been slight and consequently the development has not been extensive. In the Ruby-Iditarod region coal has been reported from several places. A prospect hole 9 or 10 miles from the head of Quartz Creek, in the Ruby district, is said to have reached coal at a depth of 100 feet. On Swift Creek, a tributary of Basin Creek, a layer of the gravel shows a high percentage of carbonaceous material, resembling the detritus from a coal seam, and coal fragments are said to have been found near by.

Coal has been found in a prospect hole sunk to a depth of 50 feet on lower Poorman Creek. Water filled the hole at the time of the writer's visit, and the extent of the coal was not observed. A crosscut driven from the foot of the shaft is said to show coal having a 70° dip. This indicates a seam of considerably greater thickness than is found elsewhere in the adjacent regions. There is said to be 15 feet of a yellow gummy gouge between the coal and the overlying gravel, and this gouge also forms partings in the coal. Only a small quantity of the coal has been mined—at most a few tons. It is subbituminous, igniting with difficulty but burning readily after ignition. Some of it has been used as blacksmith coal, but has not proved wholly satisfactory for this purpose. On exposure to the air it slacks badly, although it is probable that the material seen was obtained near the surface of the seam and in consequence would tend to disintegrate more readily than coal taken at greater depths beyond the influence of atmospheric agencies. Owing to the depth and the distance from any considerable market, the present utilization of this coal seems extremely doubtful.

Maddren obtained information in 1910 from a prospector to the effect that coal had been found on Homestake Creek, in the Nowitna basin, at a depth of 46 feet, and that it also occurred at the head of the Nowitna.

The open-cut mining on Moore Creek has exposed the bedrock along the creek, and at one place there is a very carbonaceous layer in the shales. Little is known of this occurrence, but it is probably only a thin carbonaceous seam.

In the Iditarod district coal croppings have been reported from a number of localities. Smith [1] has described these in detail and given an analysis of some coal taken from a prospect on the tramroad between Iditarod and Flat.

During the winter of 1914–15 another coal prospect was opened in the same vicinity, near the juncture of the wagon roads from Flat and Discovery. Additional work was to be done on this property during the winter of 1915-16. The owners stated that the strike of the beds is N. 38° E., and the dip of the coal seam about 80° SE. A shaft 30 feet deep has been sunk, the lower 25 feet of which is in frozen ground. The section of coal, as given by the owners, is as follows: Shale (hanging wall); coaly shale, 10 inches; clean coal, 14 inches; shale (footwall). The coal appears to be subbituminous. A sample was taken from the dump and will be analyzed for a report later.

It is likely that there are a large number of coal beds in the Cretaceous rocks in this general neighborhood, and other beds will therefore probably be discovered in the course of time. The fact, however, that only small beds have so far been uncovered indicates that these are the rule rather than the exception. Nevertheless, in the Iditarod district, where wood is becoming scarce, such beds may prove to be of considerable importance as a source of fuel for local consumption. They certainly merit further prospecting.

[1] Smith, P. S., Mineral resources of the Lake Clark-Iditarod region: U. S. Geol. Survey Bull. 722, pp. 268-270, 1915.

MINERALIZATION.

The rocks collected during the field season of 1915 have not yet been studied in detail, and it may be necessary later to modify some of the conclusions reached in this paper. At the present time, however, the data at hand points to mineralization at two periods in the Ruby-Kuskokwim region. This conclusion is based on evidence regarding the genesis of the placers, on the character and distribution of the quartz veins, and on the character of the concentrates taken with the gold.

In the Ruby district, exclusive of the Cripple Creek Mountains, quartz veins are very common throughout the sedimentary and igneous rocks, and Eakin [1] has assigned these as the source of the gold in this district. Many such veins, however, are apparently barren, and it is rather likely that there may be several series of quartz veins, of which certain ones, related perhaps to a definite period of mineralization, are the sources of the gold. It may be that some of the intrusives grouped in this report under the term greenstone are of original monzonitic or dioritic nature and have a genetic relation to the auriferous quartz veins. It is hoped that later microscopic work will shed some light on this problem. It is certain, however, that in this district placer ground is found overlying sedimentary bedrock at considerable distances from any known bodies of granitic rocks, and it is necessary to postulate auriferous quartz veins to explain the presence of gold.

In the other placer gold areas to the south, including the Cripple Creek Mountains, the Innoko district, Candle Creek, Moore Creek, and the Iditarod district, different conditions prevail. In some places, as at the head of Flat Creek, the gold placers are residual, being weathered out of granitic bedrock. In other places the placer ground is some distance downstream from such rock or from gold lodes, but the gold is always definitely related to acidic intrusive rocks. Moreover, in the districts above named, quartz veining is uncommon, except within intrusive bodies and near their peripheries, a condition which is in sharp contrast to that prevailing in the Ruby district. A further difference exists in regard to the character of the quartz veins. The only accessory sulphides observed in the quartz veins in the vicinity of Ruby, Long, and Poorman are pyrite and arsenopyrite. In the southern areas cinnabar and stibnite, as well as pyrite and arsenopyrite, are found in the quartz veins and lodes.

The concentrates present a most striking illustration of the difference in character of the northern and southern mineralization. The rock-forming iron minerals, magnetite and ilmenite, are found uni-

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[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 43, 1914.

versally. Pyrite and arsenopyrite likewise are not localized. Around Ruby, Long, and Poorman, however, cassiterite is very common in the concentrates, and on Poorman Creek barite also occurs. Neither of these minerals, so far as known, are present south of Poorman. On the other hand, cinnabar is found universally in the southern zone, with stibnite and scheelite in some places. The only known occurrence of any of these minerals in the northern zone is at Spruce Creek, northeast of Poorman, near the south end of the northern zone, where cinnabar occurs in the concentrates. If, as is supposed, the southern zone represents a later period of mineralization, it is quite possible that this period should be represented in the north, especially near the boundary between the two zones. Hence the occurrence of cinnabar on Spruce Creek is not anomalous. On the other hand, the restriction of cassiterite to the northern zone is quite essential to the truth of the hypothesis to be proposed.

From the foregoing considerations the writers are led to believe that there were two distinct periods of mineralization in the Ruby-Kuskokwim region. The mineralization in the vicinity of Ruby, Long, and Poorman is the older, but its age can not be assigned with certainty. It may be either Paleozoic or Mesozoic, but the facts that Mesozoic intrusions elsewhere in Alaska are connected with mineralization and that there is no record of definite Paleozoic mineralization afford presumptive evidence in favor of considering the northern mineralization to be of Mesozoic age. The monzonite of the southern zone, to which the placers are related, has been considered to be of Tertiary age, and the mineralization which accompanied it is of course also Tertiary. It seems necessary, if this hypothesis is correct, to believe that the northern mineralization took place in the old Paleozoic and Mesozoic land mass prior to the deposition of the Cretaceous sediments that cover much of the country south of Poorman.

One other factor bearing on the age of the mineralization in the Ruby-Kuskokwim region remains to be considered. It is probable that the northern and southern types of mineralization do not represent single periods of mineralization in the Mesozoic (?) and Tertiary. Direct evidence on this point is lacking in the northern zone, but the presence of cassiterite in some of the concentrates and its absence in others, as well as the occurrence of barite on a single creek (Poorman Creek), suggest this possibility. Microscopic work has already shown that in the southern zone the stibnite is later than some of the vein quartz; and gold is known to exist both in quartz veins and in the stibnite and cinnabar lodes. Attention has already been called to the two different kinds of gold which are found in the

Iditarod district. Such facts are certainly suggestive of the possibility that the gold mineralization may have taken place in two or more distinct stages, within the same general period of mineralization.

POSSIBLE AREAS FOR PROSPECTING.

The areas in which the two types of mineralization above referred to have occurred coincide in their distribution in a general way with the two physiographic provinces of the region, and both the mineralization and physiography are factors that must be taken into account in giving advice to the prospector.

In the Ruby district, exclusive of the Cripple Creek Mountains, placer gold is not known to be directly dependent for its position on bodies of intrusive rock, though such bodies were probably influential in the formation of the quartz veins. Were it possible to know the character of the country rock in this district, the best advice would probably be to prospect in creeks in whose upper basins the country rock is cut by numerous quartz veins. It happens, however, that in the major part of the Ruby district bedrock is effectually covered by a mantle of unconsolidated deposits. The prospector and geologist are therefore alike in the dark as to what creeks are likely to become producers. The ultimate solution of the problem lies in prospecting.

In the Cripple Creek Mountains and in the Innoko-Iditarod district the conditions are different. Here, too, the valleys are filled with alluvium, but the ridges are higher, and bedrock exposures may usually be found on the interstream divides. Such exposures afford a general idea of the character of bedrock in the valley bottoms. It is now commonly recognized that the gold placers in this part of the region are closely associated with granitic rocks. Streams which head in areas of granitic rocks or which have a granitic bedrock are therefore the logical places to prospect. It does not follow, however, that gold will be found universally around granitic rocks, for such is not the case, but it may be stated negatively that in this region gold is never found very far from granitic bodies.

There is one point which may be of value to the prospector in searching for granitic rocks. It sometimes happens that such rocks are present in the valley bottom covered by alluvium and the interstream divides give no indication of this fact—that is, the granitic body may be small and confined to the valley bottom. This condition actually occurs on Candle Creek and Otter Creek. It has been observed, however, that most of the granitic intrusives in this region are surrounded, adjoined by, or in some way associated with basic intrusive rocks such as gabbro, diabase, and basalt, and it seldom happens that both the basic and acidic intrusives fail to crop out on the divides. Therefore where basic intrusives are found the prospector should look carefully down the valley slopes and in the valley wash for granitic detritus. On Otter Creek and Candle Creek the presence of large masses of basic rock on the adjoining divides would have caused the initiated to search for granitic rock in the neighborhood.

MINING IN 1915.

RUBY DISTRICT.

Mining was done in 1915 in the Ruby district, including the Cripple Creek Mountains, about two principal centers, Long and Poorman, and in addition some gold was taken out from Ruby Creek at Ruby and from Colorado Creek, in the Cripple Creek Mountains. Long Creek and its tributaries, Bear Pup, Short, Midnight, Monument, and Basin creeks, together with Glen Gulch, Birch Creek, tributaries of Flint Creek, and Trail Creek were the sources of placer gold in the vicinity of Long. Spruce and Tamarack creeks, tributaries of the Sulatna, and Flat and Poorman creeks were the producers near Poorman.

In all 61 outfits were at work in the Ruby district, employing 254 men. Six claims were operated by open-cut methods, some of which used steam hoisting machinery as an accessory to convey the gravel to the elevated line of sluice boxes, or in stripping. On 21 properties the hoisting was done by hand, and on 34 it was done by steam hoists. It is estimated that gold to the value of about $700,000 was produced in the Ruby district in 1915.

INNOKO DISTRICT.

In the Innoko district the same creeks were productive in 1915 as in former years, including Ophir, Spruce, Little, Ganes, and Yankee creeks, with some of their tributaries. The returns that have been received indicate that most of the mining was done by open-cut and hydraulicking methods, except on Little Creek, where underground mining was done on two claims. Reports have been received from 12 properties, employing a total of 49 men. The gold produced in 1915 had a value of about $190,000.

CANDLE AND MOORE CREEKS.

Seventeen men were at work on Candle and Moore creeks, on three properties. On two of these the work is being done by hydraulicking and on the other by open-cut and manual methods. Complete dates on the value of the gold produced are not available at this writing.

IDITAROD DISTRICT.

In the Iditarod district mining was done on Flat, Chicken, Happy, and Willow creeks and on the divide at the head of Flat Creek. In the vicinity of Discovery mining was in progress on Otter, Black, and Slate creeks and on Glen Gulch. In all, 24 mines were worked, and from 350 to 400 men employed. Two dredges were active, but most of the plants used mechanical scrapers and hydraulicking operations. Open-cut work, involving shoveling and sluicing, as well as little drift mining, was also done. The total value of the gold produced in 1915 is $2,050,000.

INDEX.

D.

H.

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

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

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

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost. The publications marked with an asterisk (*) in this list are out of stock at the Survey, but can be purchased from the Superintendent of Documents at the prices stated.

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

GENERAL.

REPORTS.

*The geography and geology of Alaska, 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. $1.

Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin 259, 1905, pp. 18–31.

The mining industry in 1905, by A. H. Brooks. In Bulletin 284, 1906, pp. 4–9.

*The mining industry in 1906, by A. H. Brooks. In Bulletin 314, 1907, pp. 19–39. 30 cents.

*The mining industry in 1907, by A. H. Brooks. In Bulletin 345, 1908, pp. 30–53. 45 cents.

*The mining industry in 1908, by A. H. Brooks. In Bulletin 379, 1909, pp. 21–62. 50 cents.

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*Railway routes, by A. H. Brooks. In Bulletin 284, 1906, pp. 10–17.

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

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

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

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

*Tin resources of Alaska, by F. L. Hess. In Bulletin 520, 1912, pp. 89–92. 50 cents.

*The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp. 15 cents.

Alaska coal and its utilization, by A. H. Brooks. Bulletin 442J, reprinted 1914.

*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.

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 362 pp. (Abstract in Bulletin 259, 1905, pp. 32–46.)

*Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin 345, 1908, pp. 54–77. 45 cents.

*Geographic dictionary of Alaska, by Marcus Baker; second edition prepared by James McCormick. Bulletin 299, 1906, 690 pp. 50 cents.

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

In preparation.

The mineral springs of Alaska, by G. A. Waring. Water-Supply Paper 418.

MAPS.

*Map of Alaska showing contours; scale 1:2,500,000; 1906, by R. U. Goode and E. C. Barnard. In *Professional Paper 45. $1. Not issued separately.

Map of Alaska; scale 1:5,000,000; 1912, by A. H. Brooks. 20 cents.

Map of Alaska; scale 1:1,500,000; 1915, by A. H. Brooks and R. H. Sargent. 80 cents.

Map of Alaska showing distribution of mineral deposits; scale, 1:5,000,000; by A. H. Brooks. 20 cents. Also included in *Bulletin 520. 50 cents. (New edition included in Bulletin 642.)

Index map of Alaska, including list of publications; scale 1:5,000,000; by A. H. Brooks. Free.

SOUTHEASTERN ALASKA.

REPORTS.

The Porcupine placer district, Alaska, by C. W. Wright. Bulletin 236, 1904, 35 pp.

Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 259, 1905, pp. 47–68.

*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.

Lode mining in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 284, 1906, pp. 30–53.

Nonmetallic deposits of southeastern Alaska, by C. W. Wright. In Bulletin 284, 1906, pp. 54–60.

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Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. In Bulletin 314, 1907, pp. 73–81.

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

*Lode mining in southeastern Alaska, 1907, by C. W. Wright. In Bulletin 345, 1908, pp. 78–97. 45 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, 186 pp. 50 cents.

*Mining in southeastern Alaska, by C. W. Wright. In Bulletin 379, 1909, pp. 67–86. 50 cents.

Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 442, 1910, pp. 133–143.

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

Report of water-power reconnaissance in southeastern Alaska, by J. C. Hoyt. In Bulletin 442, 1910, pp. 147–157.

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

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

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

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*Marble resources of the Juneau, Skagway, and Sitka districts, by E. F. Burchard. In Bulletin 592, 1914, pp. 95–107. 60 cents.

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

*Lode mining in the Ketchikan district, by P. S. Smith. In Bulletin 592, 1914, pp. 75–94. 60 cents.

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

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Water-power investigations in southeastern Alaska, by G. H. Canfield. Bulletin 642, 1916, pp. 105–127.

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Geology of the Glacier Bay and Lituya region, by F. E. and C. W. Wright.

TOPOGRAPHIC MAPS.

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

Juneau special (No. 581A); scale, 1:62,500; by W. J. Peters. 10 cents each, or $3 for 50.

Berners Bay special (No. 581B); scale, 1:62,500; by R. B. Oliver. 10 cents each, or $3 for 50.

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 each, or $3 for 50.

Copper Mountain and vicinity, Prince of Wales Island (No. 540B); scale, 1:62,500; by R. H. Sargent. 10 cents each, or $3 for 50.

Eagle River region (No. 581C); scale, 1:62,500; by J. W. Bagley, C. E. Giffin, and R. E. Johnson. In Bulletin 502. Not issued separately.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

REPORTS.

*The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp. 15 cents.

*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.

*Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin 345, 1908, pp. 176–178. 45 cents.

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

*Copper mining and prospecting on Prince William Sound, by U. S. Grant and D. F. Higgins, jr. In Bulletin 379, 1909, pp. 87–96. 50 cents.

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*Mining in the Kotsina-Chitina, Chistochina, and Valdez Creek regions, by F. H. Moffit. In Bulletin 379, 1909, pp. 153–160. 50 cents.

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Mining and prospecting on Prince William Sound in 1909, by U. S. Grant. In Bulletin 442, 1910, pp. 164–165.

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

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.

*The Chitina district, by F. H. Moffit. In Bulletin 520, 1912, pp. 105–107. 50 cents.

*Gold deposits near Valdez, by A. H. Brooks. In Bulletin 520, 1912, pp. 108–130. 50 cents.

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

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

Mining in Chitina Valley, by F. H. Moffit. In Bulletin 542, 1913, pp. 81–85.

Mineral deposits of the Ellamar district, by S. R. Capps and B. L. Johnson. In Bulletin 542, 1913, pp. 86–124.

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

Preliminary report on water power of south-central Alaska, by C. E. Ellsworth and Royal W. Davenport. In Bulletin 592, 1914, pp. 155–194.

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

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 592, 1914, pp. 237–244.

Geology of the Hanagita-Bremner region, by F. H. Moffit. Bulletin 576, 1915, 56 pp.

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

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Mining on Prince William Sound (1914), by B. L. Johnson. In Bulletin 622, 1915, pp. 131–139.

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

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Controller Bay region; scale, 1:62,500; by E. G. Hamilton and W. R. Hill. 35 cents. No wholesale rates.

Chitina quadrangle; reconnaissance map; scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. In Bulletin 576.

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Port Valdez district; scale, 1:62,500; by J. W. Bagley. Price 20 cents.

The Bering River coal fields; scale, 1:62,500; by G. C. Martin. Price, 25 cents.

The Ellamar district; scale, 1:62,500; by R. H. Sargent and C. E. Giffin. Published in Bulletin 605. Not issued separately.

The Kotsina-Kuskulana district; scale, 1:62,500; by D. C. Witherspoon.

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*The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp. 15 cents.

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

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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.

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The geology of upper Matanuska basin, by G. C. Martin.

The Nelchina-Susitna region, by Theodore Chapin.

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

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

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

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

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

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

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

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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.

Gold mine on Unalaska Island, by A. J. Collier. In Bulletin 259, 1905, pp. 102–103.

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

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Lake Clark-Central Kuskokwim region, by P. S. Smith.

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

Chignik Bay region, reconnaissance map; scale, 1:250,000; by H. M. Eakin. In Bulletin 467. Not issued separately.

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

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

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

*Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin 345, 1908, pp. 179–186. 45 cents.

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Gold placer mining developments in the Innoko-Iditarod region, by A. G. Maddren. In Bulletin 480, 1911, pp. 236–270.

*Placer mining in the Fortymile and Seventymile river districts, by E. A. Porter. In Bulletin 520, 1912, pp. 211–218. 50 cents.

*Placer mining in the Fairbanks and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 240–245. 50 cents.

*Gold placers between Woodchopper and Fourth of July creeks, upper Yukon River, by L. M. Prindle and J. B. Mertie, jr. In Bulletin 520, 1912, pp. 201–210. 50 cents.

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

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*The Chisana placer district, by A. H. Brooks. In Bulletin 592, 1914, pp. 309–320. 60 cents.

*Placer mining in the Yukon-Tanana region, by Theodore Chapin. In Bulletin 592, 1914, pp. 357–362. 60 cents.

*Lode developments near Fairbanks, by Theodore Chapin. In Bulletin 592, 1914, pp. 321–355. 60 cents.

Mineral resources of the Yukon-Koyukuk region, by H. M. Eakin. In Bulletin 592, 1914, pp. 371–384.

The Iditarod-Ruby region, Alaska, by H. M. Eakin. Bulletin 578, 1914, 45 pp.

Surface water supply of the Yukon-Tanana region, 1907 to 1912, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 342, 1915, 343 pp.

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Mining in the Fairbanks district, by H. M. Eakin. In Bulletin 622, 1915, pp. 229–238.

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

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

Preliminary report on the Tolovana district, by A. H. Brooks. In Bulletin 642, 1916, pp. 201–209.

Exploration in the Cosna-Nowitna region, by H. M. Eakin. In Bulletin 642, 1916, pp. 211–221.

Mineral resources of the Ruby-Kuskokwim region, by J. B. Mertie, jr., and G. L. Harrington. In Bulletin 642, 1916, pp. 223–266.

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The Lake Clark-Central Kuskokwim region, by P. S. Smith.

The Ruby-Kuskokwim region, by J. B. Mertie, jr., and G. L. Harrington.

The Lower Kuskokwim region, by A. G. Maddren.

The Cosna-Nowitna region, by H. M. Eakin.

TOPOGRAPHIC MAPS.

Circle quadrangle (No. 641); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. 50 cents each, or $15 for 50. Also in Bulletin 295.

Fairbanks quadrangle (No. 642); scale, 1 : 250,000; by T. G. Gerdine, D. C. Witherspoon, R. B. Oliver, and J. W. Bagley. 50 cents each, or $15 for 50. Also in Bulletins *337 (25 cents) and 525.

Fortymile quadrangle (No. 640); scale, 1 : 250,000; by E. C. Barnard. 10 cents each, or $3 for 50. Also in Bulletin 375.

Rampart quadrangle (No. 643); scale, 1 : 250,000; by D. C. Witherspoon and R. B. Oliver. 20 cents each, or $6 for 50. Also in Bulletin 337 and part in Bulletin 535.

Fairbanks special (No. 642A); scale, 1 : 62,500; by T. G. Gerdine and R. H. Sargent. 20 cents each, or $6 for 50. Also in Bulletin 525.

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

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

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

In preparation.

Yukon-Koyukuk region; scale, 1 : 500,000; by H. M. Eakin.

Lake Clark-Central Kuskokwim region; scale, 1 : 250,000; by R. H. Sargent.

Lower Kuskokwim region; scale, 1 : 500,000; by A. G. Maddren.

Cosna-Nowitna region; scale, 1 : 250,000; by H. M. Eakin.

Ruby-Kuskokwim region; scale, 1 : 250,000; by R. H. Sargent and C. E. Giffin.

SEWARD PENINSULA.

REPORTS.

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

Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin 284, 1906, pp. 132–141. The Kougarok region, by A. H. Brooks. In Bulletin 314, 1907, pp. 164–181.

*Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin 314, 1907, pp. 157–163. 30 cents.

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

*Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin 345, 1908, pp. 206–250. 45 cents.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 72 pp.

*Recent developments in southern Seward Peninsula, by P. S. Smith. In Bulletin 379, 1909, pp. 267–301. 50 cents.

*The Iron Creek region, by P. S. Smith. In Bulletin 379, 1909, pp. 302–354. 50 cents.

*Mining in the Fairhaven district, by F. F. Henshaw. In Bulletin 379, 1909, pp. 355–369. 50 cents.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, Alaska, by P. S. Smith. Bulletin 433, 1910, 227 pp.

Mining in Seward Peninsula, by F. F. Henshaw. In Bulletin 442, 1910, pp. 353–371.

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

*Notes on mining in Seward Peninsula, by P. S. Smith. In Bulletin 520, 1912, pp. 339–344. 50 cents.

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

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

*Placer mining on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. 385–396. 60 cents.

*Lode developments on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. 397–407. 60 cents.

Iron-ore deposits near Nome, by H. M. Eakin. In Bulletin 622, 1915, pp. 361–365.

Placer mining in Seward Peninsula, by H. M. Eakin. In Bulletin 622, 1915, pp. 366–373.

TOPOGRAPHIC MAPS.

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

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

Seward Peninsula, northwestern portion, reconnaissance map (No. 657); scale, 1 : 250,000; by T. G. Gerdine and D. C. Witherspoon. 50 cents each, or $30 a hundred. Also in Bulletin 328.

Seward Peninsula, southern portion, reconnaissance map (No. 656); scale, 1 : 250,000; by C. E. Barnard, T. G. Gerdine, and others. 50 cents each, or $30 a hundred. Also in Bulletin 328.

Seward Peninsula, southeastern portion, reconnaissance map (Nos. 655–656); scale, 1 : 250,000; by E. C. Barnard, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 449. Not issued separately.

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

Grand Central quadrangle (No. 646A); scale, 1 : 62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents each, or $3 for 50. Also in Bulletin 533.

Nome quadrangle (No. 646B); scale, 1 : 62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents each, or $3 for 50. Also in Bulletin 533.

Casadepaga quadrangle (No. 646C); scale, 1 : 62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents each, or $3 for 50. Also in Bulletin 433.

Solomon quadrangle (No. 646D); scale, 1 : 62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents each, or $3 for 50. Also in Bulletin 433.

NORTHERN ALASKA.

REPORTS.

*A reconnaissance in northern Alaska across the Rocky Mountains, along Koyukuk, John, Anaktuvuk, and Colville rivers and the Arctic coast to Cape Lisburne in 1901, by F. C. Schrader, with notes by W. J. Peters. Professional Paper 20, 1904, 139 pp. 40 cents.

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

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

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

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

In preparation.

The Canning River region of northern Alaska, by E. de K. Leffingwell.

TOPOGRAPHIC MAPS.

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

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

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


MAP OF
ALASKA
SHOWING DISTRIBUTION OF
MINERAL DEPOSITS
Compiled under the direction of
Alfred H. Brooks, Geologist in charge
Division of Alaskan Mineral Resources
Base compiled chiefly from maps of the U. S. Geological Survey. Coast line from U. S. Coast and Geodetic Survey charts.
Scale 1/5,000,000
Approximately 80 miles to 1 inch
50 0 50 100 150 200 Miles
50 0 50 100 150 200 Kilometers
1916
LEGEND
Area known to contain anthracite and high-grade bituminous coal
Area which may contain anthracite and high-grade bituminous coal
Area known to contain low-grade bituminous coal
Area which may contain low-grade bituminous coal
Area known to contain lignite
Area which may contain lignite
Gold and silver lode
Gold placers
Copper lode
Tin deposit
Petroleum seepage
Gypsum mine
Marble quarry
Quicksilver
Antimony
ARCTIC OCEAN
BERING SEA
GULF OF ALASKA
PACIFIC OCEAN
BRISTOL BAY
NORTON SOUND
ALEUTIAN ISLANDS
West of Greenwich

Base from U.S. Coast and Geodetic Survey charts