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MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN

1908

BY

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INVESTIGATION OF MINERAL RESOURCES OF ALASKA IN 1908.

By Alfred H. Brooks and others.

ADMINISTRATIVE REPORT.

By Alfred H. Brooks.

PREFACE.

The present bulletin is the fifth of the annual volumes [a] which both summarize the conditions of the mining industry in Alaska and record the more important economic results attained by the investigations during the year. The more elaborate reports, illustrated with maps, etc., are of necessity slow in preparation and publication, and hence the more important conclusions, so far as possible, are presented briefly in this preliminary form. These reports are intended to serve as handbooks of reference to those who are engaged in the mining industry within the Territory, though it is impossible, with the funds available, to collect complete information each year in regard to every district.

Although it is intended to present here only the conclusions established by the investigations and to leave to the more detailed publications the discussion of the more difficult problems, yet it sometimes happens that a geologist finds on the completion of his office work that he must modify his preliminary statement of results; hence the matter contained in this volume is not offered with the same degree of confidence as if the laboratory and office investigations had been finished. Nevertheless, the importance of making public the economic results of the surveys has appeared to justify the policy of printing these preliminary abstracts of reports not yet completed. Those interested in any particular mining district, however, are

[a] Report on progress of investigations of the mineral resources of Alaska, 1904: Bull. U. S. Geol. Survey No. 259, 1905; idem, 1905: Bull. No. 284, 1906; idem. 1906: Bull. No. 314, 1907; idem, 1907: Bull. No. 345, 1908.

cautioned to depend for detailed information on the more complete reports.

Three groups of subjects have been recognized in the arrangement of this volume, as in those previously issued—(1) summaries of progress of the various phases of the mining industry in different parts of the Territory during the year; (2) preliminary accounts of investigations in progress or completed; (3) statements of results of minor investigations made incidental to other field work and not to be published elsewhere.

In outlining mining conditions in parts of the Territory which could not be visited during the year by the small force of men available for the purpose recourse is had to various sources of information that are believed to be reliable. Such compiled data, however, are as a rule used solely as a basis for statements regarding the conditions of mining development. The discussion of the occurrence and distribution of the various types of mineral deposits is based on the field observations of the members of the Geological Survey, except in the few cases where what appeared to be reliable information could be obtained from other sources, such assistance being credited to the person furnishing it.

It would be impossible to record the advancement of the mining industry throughout the Territory were it not for the many men who have cooperated with the Survey in the collection of this information. These men include not only the large number of operators who have furnished statistics of their own production that have been utilized in making up the summary, but also the many persons who, by conference or correspondence, have furnished valuable information regarding fields which it was impossible to visit. To enumerate the individuals and corporations who have aided the investigations would be to give almost a complete roster of the mining men and corporations who have come into contact with the work of the Geological Survey. The writer feels, however, under special obligation to the following persons and companies, many of whom have been especially helpful in sending him data about the mining industry in isolated districts which were not studied during the past season by members of the Survey: E. T. McNally, of Sunrise; Milin Dempsy, of Chisna; G. M. Esterly, of Nizina; R. Blix, of Copper Center; William Grogg, of Valdez Creek; A. J. Childs, of Deadwood; Samuel Sim, of Circle; W. B. Ballou, of Hot Springs; H. L. Hedger, of Richardson; A. T. Whitehead, of Coldfoot; S. J. Marsh, of Caro; C. W. Thornton, of Nome; Lewis Lloyd and M. F. Moran, of Shungnak; the Alaska Commercial Company, and the Northern Navigation Company, who have furnished information in regard to both mining development and gold output, and C. D. Garfield, of Nome; Maj. J. P. Clum, the First National Bank, the Washington Alaska Bank, and the Fairbanks Banking Company, of Fairbanks; and the Alaska Pacific Express Company, who have contributed statistical data in regard to gold production.

As in previous reports, much of this volume is devoted to a discussion of the gold placers, for these still form much the largest source of the mineral output. In this volume, however, it has been possible to give more space to some of the other phases of the mining industry. The lode mining of southeastern Alaska is treated, as heretofore, but the bulletin also includes accounts of the occurrence of copper in the Copper and White river regions and Prince William Sound, based on examinations made in 1908; a report on the new field of southwestern Alaska, which has some promising mineral deposits; a preliminary statement of the first detailed geologic surveys of the Fairbanks district; and an account of the Iron Creek region of the Seward Peninsula. Of particular interest to prospectors will be the report here presented on the Innoko region which previous to 1908 had not received any study by members of the Geological Survey. It is to be regretted that there are so many other districts where some mining development has taken place, but which it has not been possible to survey. Among the most important of these are the Valdez Creek region, the Iliamna Lake region, the Kuskokwim Valley, and the Chandalar and Koyukuk districts, in all of which a large amount of prospecting has been done.

Like the previous volumes, this one is made up mainly of papers written by the members of the Survey's division of Alaskan mineral resources. It contains nineteen different papers by fifteen authors. A general account of the mining industry forms the introductory paper of the report, and this is followed by a paper on the use of peat, by Charles A. Davis. This paper is presented in the belief that it may serve a useful purpose in drawing attention to the possibility of utilizing Alaska peat as a fuel. The remaining papers are arranged, so far as possible, geographically from south to north and from east to west. The importance of publishing this report without delay makes it necessary to limit the illustrations to a few outline maps. The complete reports, which are in preparation, will contain more elaborate illustrative matter, including both geologic and topographic maps.

PROGRESS OF SURVEYS.

INTRODUCTION.

Thirteen parties were engaged in Alaskan surveys and investigations during the season of 1908 for varying periods of time between March and November. Some of these parties were subdivided in the field, making a total of 17 parties that were engaged in various kinds of investigation. The personnel of these parties included 22 technical men and 20 to 25 camp hands. Of the technical men, 13 were geologists, 5 topographers, and 4 engineers. In addition to these, the geologist in charge spent a part of the summer months in Alaska, carrying on geologic investigations and visiting field parties. Four clerks were employed in the office for the whole or a part of the year.

The area covered by topographic reconnaissance surveys during 1908 aggregated 3,975 square miles; the detailed topographic surveys, 427 square miles. Detailed geologic surveys were made of 604 square miles, and geologic reconnaissance surveys over an area of about 4,850 square miles. In addition to the actual areal mapping most of the geologists spent considerable time in studying special problems connected with the mineral deposits. The investigation of the water supply in placer districts covered an area of 6,700 square miles and included 556 measurements of stream volumes at 53 gaging stations.

To present the matter geographically, two parties were in southeastern Alaska, of which one made detailed geologic surveys of two copper mining districts, while the other, a topographic party, was engaged in preparing a base map of the same region. In the Copper River region there were three parties, two of which were making detailed topographic surveys of one copper district, and the third a general geologic reconnaissance, with some topographic work, in another district. One geologic party was occupied for about three months during the summer in a geologic reconnaissance, with some incidental topographic surveys, in the Prince William Sound copper district. Similar work was carried on in the coal fields of southwestern Alaska. Five parties were at work in the Yukon placer district. Of these, one was making detailed geologic surveys; another, geologic and topographic reconnaissance surveys; a third, topographic reconnaissance surveys; the other two were engaged in stream gaging. In Seward Peninsula one party was engaged in geologic mapping, both detailed and reconnaissance; a second was working on general geologic and stratigraphic problems; and two more were engaged in stream gaging.

The following table shows the allotment (including both field and office expenses) of the total appropriation of $80,000 to the various districts investigated:

Allotments to Alaskan surveys and investigations, 1908.

Surveys and investigations, southeastern Alaska	$9,800
Surveys and investigations, Prince William Sound and southwestern Alaska	9,100
Surveys and investigations, Copper River region	20,000
Surveys and investigations, Yukon basin	27,950
Surveys and investigations, Seward Peninsula	13,150
	80,000

The following table shows approximately the amount of money devoted to each class of investigation. It is not possible to give the exact figures, as in some cases the same party, or even the same man, carried on two different kinds of work; but this statement will help to elucidate the later table, which summarizes the completed areal surveys:

Approximate allotment of Alaskan funds to different classes of surveys and investigations, 1908.

Geologic reconnaissance surveys	$14,100
Detailed geologic surveys	10,000
Special geologic investigations	8,900
Topographic reconnaissance surveys	12,200
Detailed topographic surveys	14,200
Investigation of water resources	9,900
Collection of statistics of mineral production	1,500
Miscellaneous, including clerical salaries, administration, inspection, instruments, and office supplies and equipment	9,200
	80,000

Under geologic reconnaissance surveys in the above table are included all those made for publication on a scale of 4 or 10 miles to the inch; the detailed geologic surveys are all for publication on a scale of 1 mile to the inch. The special geologic investigations are chiefly those directed to the study of problems connected with the occurrence of mineral deposits. The topographic reconnaissance surveys are chiefly for publication on a scale of 4 miles to the inch, usually with 200-foot contours, though some of an exploratory nature will be published on a scale of 10 miles to the inch. The detailed topographic surveys are for publication on a scale of 1 mile to the inch, with 25, 50, or 100 foot contours. The water-resources investigations have for their purpose the determination of the water supply available for placer mining.

The cost of the surveys of various types per square mile is affected by many factors that vary greatly in different parts of the Territory. Chief among these is the item of transportation, which varies in cost from 5 to 30 per cent of the total expenditure for surveys. The cost of the topographic reconnaissance surveys is from $2 to $4 per square mile; that of the detailed topographic mapping from $25 to $40 per square mile. These variations are partly due to the differences in cost of transportation to different districts and also to character of topography, vegetation, rainfall, length of open season, etc.

It is far more difficult to generalize on the cost of geologic surveys. All the variations which affect the cost of topographic mapping also influence that of géologic mapping. In addition there is a far more important factor in the intricacy of the geology and the knowledge available regarding the problems involved, before the work has been begun. If the general features of the geology of any province are known, areal mapping can be carried on much more rapidly than if the province is entirely unexplored. Obviously, also, where the stratigraphic and areal relations are simple mapping can be carried on far more rapidly than where they are complex. It is therefore not surprising that the cost of geologic reconnaissance surveys varies as much as from 75 cents to $3.50 per square mile. Detailed geologic surveys have been carried over only a few small areas in Alaska, so that there are few data on which to base estimates of cost. The evidence in hand, however, indicates a cost of $14 to $34 per square mile for work of this class. Water-resources investigations, involving the measurement of stream volumes in the same district for a period of years, can not be estimated in cost per square mile.

Progress of surveys in Alaska, 1898–1908.[a]

Year.	Appropriation.	Areas covered (square miles).				Water-resources investigations.	
		Geologic.		Topographic.		Gaging stations maintained part of year.	Stream-volume measurements made.
		Reconnaissance.	Detailed.	Reconnaissance.	Detailed.		
1898	$46,189.60	9,500	....	14,912	....	....	....
1899	25,000.00	6,000	....	8,688	....	....	....
1900	25,000.00	10,000	....	11,152	....	....	....
1901	35,000.00	12,000	....	15,664	....	....	....
1902	60,000.00	17,000	....	20,304	336	....	....
1903	60,000.00	13,000	336	15,008	....	....	....
1904	60,000.00	6,000	....	6,480	480	....	....
1905	80,000.00	8,000	550	8,176	948	....	....
1906	80,000.00	9,000	414	10,768	40	14	286
1907	80,000.00	4,000	400	6,125	501	48	457
1908	80,000.00	4,850	604	3,975	427	53	556
	631,189.60	99,350	2,304	121,252	2,732	....	....
Percentage of total area of Alaska	....	16.94+	0.39+	20.85−	0.47−	....	....

[a] In addition to the above, the International Boundary Survey and the Coast and Geodetic Survey and other government bureaus have covered an area of approximately 50,000 square miles. Most of this work is along the coast line, and has been carried on with a high degree of refinement. The inland surveys are chiefly of a reconnaissance character, except for a narrow strip along the international boundary.

The above table indicates the progress of Alaskan surveys, so far as they can be presented in tabular form and in percentages of the total areas which have been mapped geologically and topographically. The progressive decrease in the area covered annually by reconnaissance surveys is largely due to the fact that since 1903 a large part of the appropriation has been spent for detailed surveys. As the detailed surveys cost from five to twenty times as much as reconnaissance surveys, naturally the total area surveyed for the same money is very much less. Hence, as there has been a growing demand for the detailed maps, there has been a corresponding decrease in areas covered by reconnaissance surveys. Another reason for the decreased areas now covered annually by surveys is the fact that during the first five years practically all the appropriation was spent on exploratory surveys, whereas now much of it is devoted to special investigations. Moreover, the early exploratory surveys were not executed with the same degree of refinement as the present reconnaissance work, and the results were published chiefly on a scale of 10 miles to the inch, as compared with 4 miles to the inch, the present publication scale.

To meet the demands of the mining industry, it does not seem advisable to devote a much larger proportion of the available money to reconnaissance surveys at the expense of detailed surveys and investigations, and therefore, under the present appropriation, the general work can not be extended any more rapidly than it has been during the past decade. As approximately a fifth of the Territory has been covered by reconnaissance maps, both topographic and geologic, it appears that it will require at least fifty years to cover the whole of the Territory with the preliminary mapping. It should be added, however, that the areas that have been chosen for survey are those of most importance to the mining industry, and that at least a fifth or a quarter of the remaining area may not require survey for many years to come. The fact remains, however, that there are about 200,000 square miles in Alaska which should be surveyed at an early date, and that under the present appropriation this can not be accomplished so as to do justice to the mining developments in less than two or three decades.

GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

GENERAL WORK.

The writer's field investigations covered a period from about the end of July to the middle of October. Of the time he actually devoted to field work, about two weeks was spent with Mr. Wright in going over the geology of Kasaan Peninsula, Karta Bay, and the Copper Mountain region—all on Prince of Wales Island. At the same time Mr. Sargent's topographic party, then surveying the Copper Mountain region, was visited. Later a trip to Fairbanks was made by way of the White Pass and Yukon River. Here about ten days was spent with Mr. Covert, Mr. Prindle, and Mr. Katz in becoming familiar with the problems connected with the detailed geology and mining development of the Fairbanks district. The latter part of the season was spent with Mr. Smith in a review of the areal geology of the Solomon and Casadepaga region, together with some reconnaissance work in adjacent regions.

In the office the writer has given most of his time to administrative and routine work, in which he was aided by T. C. Gerdine, who supervised the Alaskan topographic surveys until his transfer to the topographic branch of the Survey. His place was taken by R. H. Sargent. During the writer's absence in the field E. M. Aten looked after the office routine, and also rendered valuable services in the compilation of the mineral statistics of Alaska. Part of the month of June and most of the month of July was devoted by the writer to a continuation of the report on the Mount McKinley region. During the month of December he prepared a summary of the existing knowledge of the mineral resources of Alaska for the Conservation Commission.

SOUTHEASTERN ALASKA.

In 1907 the detailed geologic mapping of Kasaan Peninsula and the adjacent copper-bearing belts of Prince of Wales Island was begun, and this work was completed in 1908 by C. W. Wright. It included not only a study of the areal and stratigraphic geology, but also a detailed investigation of the ore deposits. Mr. Wright has also carried on a similar investigation over the Copper Mountain region, on Prince of Wales Island at the head of Hetta Inlet. The field work was accomplished between June 2 and October 22, about 90 square miles being mapped. These investigations represent the first detailed studies that have been made south of Juneau, and form a part of the general plan to make similar studies of all the important producing mining districts.

The results of Mr. Wright's preliminary studies in the Kasaan Peninsula were published last year;[a] the results of his investigations of 1908 are summarized in this volume (pp. 67–86); and his final report is in preparation. In addition, Mr. Wright has prepared a general statement of the condition of the mining industry throughout southeastern Alaska, to obtain data for which he devoted the last ten days of the season to visiting the more important mining fields not covered by his detailed work.

The base maps needed for the detailed geologic work above noted were begun in 1907, when a large part of Kasaan Peninsula and the adjacent areas were mapped by D. C. Witherspoon. The work was completed in 1908 by R. H. Sargent, who also mapped an area of 53 square miles in the Copper Mountain region. These surveys, for a publication scale of 1 inch to a mile (1:62,500), with 50-foot contours, were completed between May 6 and September 27. The resulting map will be published with Mr. Wright's final report.

[a] Bull. U. S. Geol. Survey No. 345, 1907, pp. 98–115.

COPPER RIVER REGION.

Last year a reconnaissance survey and reexamination of the copper deposits of the Kotsina-Chitina district was made by F. H. Moffit and A. G. Maddren. This investigation covered the southern copper belt, and while it must be regarded as incomplete, yet it furnished an important clue to the character of the ore bodies, and the resulting report (Bulletin 374) contains much information of value regarding this field. In accordance with the plans outlined, Mr. Moffit, associated with Adolph Knopf and assisted by S. R. Capps, during the past season did similar work along the northern copper belt, which extends from the head of Copper River across to White River. This field, like the southern belt, had previously been studied,[a] but the interest taken in the copper deposits necessitated further investigation. The party left Valdez on June 15 and reached the field of operations on July 8. The time up to September 9 was spent in studying the copper deposits and the areal geology of the region lying between the heads of Copper and White rivers. About 1,800 square miles was mapped geologically, and Mr. Capps also devoted one month to topographic surveys, covering an area of 450 square miles. The party returned by way of Skolai Pass into the Chitina Valley in September and there divided, one section coming to the mouth of Copper River by boat and the others going overland to Valdez. A preliminary statement of results is contained in this volume (pp. 161–180), and the final report is in preparation.

As detailed study of the copper deposits of this general province must be undertaken before the laws of their occurrence can be determined, and as such detailed studies require a base map, it was decided to prepare such a map of the east end of the Kotsina-Chitina belt. This area was chosen both because the exposures were such as to afford more data regarding the bed-rock geology than could be obtained elsewhere and because more development work had been done at this end of the Chitina belt than in any other part of the copper-bearing region. To this work D. C. Witherspoon, assisted by R. M. La Follette, was assigned. The party left Valdez about the end of March and on April 19 reached Nizina, to which point supplies had been shipped during the previous winter. This early start was made so that topographic surveys might be begun as soon as the snow was off the ground. The work was continued to September 10, when the party returned to the coast by way of Copper River. During this time an area of 325 square miles was topographically surveyed for publication on a scale of 1 mile to the inch, with contour intervals of 50 feet. It is proposed to use this base map for

[a] Mendenhall, W. C., and Schrader, F. C., The mineral resources of the Mount Wrangell district; Prof. Paper U. S. Geol. Survey No. 15, 1903.

geologic work during the coming year, and it is confidently hoped that the results will throw much light on the occurrence of ore bodies throughout the two copper belts.

PRINCE WILLIAM SOUND.

The Prince William Sound region has been the scene of several investigations by the Geological Survey, the latest previous to 1908 having been made by U. S. Grant in 1905. The extensive prospecting done in this field and the fact that it has been a large shipper of copper ore made further work imperative. Mr. Grant, assisted by D. F. Higgins, was, therefore, engaged to continue his investigations of this field and to complete the general reconnaissance of the ore deposits of Prince William Sound. He began field work on July 7 and continued it until August 23. Special attention was given to Latouche Island, where the mine which is the largest producer of the district is located. Here a detailed topographic and geologic map of an area of 8 square miles was prepared. As many of the prospects in the district were visited as time and circumstances permitted, and a general reconnaissance was carried over the western part of the sound. As a result of this work the general features of the geology have been determined, especially the occurrence of the ore bodies. In addition to the detailed topographic mapping of the upper end of Latouche Island, considerable geologic reconnaissance work was done along the west side of Prince William Sound, embracing an area of about 600 square miles (p. 87).

At the close of the season Mr. Grant also made a hasty examination of some of the ore deposits near Seward, on Kenai Peninsula, but unfortunately the field season was too short to permit an exhaustive study of the prospects of this district (p. 98).

SOUTHWESTERN ALASKA.

The plan of a general study of the coal fields of Alaska, which was inaugurated in 1906, was continued during 1908 by a reconnaissance survey of the coal fields of Alaska Peninsula. This work was in charge of W. W. Atwood, assisted by H. M. Eakin. Field work was begun on May 28 and continued until September 4. During this time topographic and geologic reconnaissance surveys of the more important parts of the Herendeen Bay, Unga Island, and Chignik coal fields were made. The total area surveyed was about 1,500 square miles. In addition to the study of the coals, Mr. Atwood also devoted considerable attention to the investigation of the various types of metalliferous deposits of the district. A preliminary account of his results is contained in this volume (p. 108) and a complete report is in preparation.

YUKON BASIN.

Last year a topographic survey was made of the Fairbanks placer district for the purpose of obtaining a base map for detailed geologic studies. These studies were carried on this year by L. M. Prindle, assisted by F. J. Katz, and between July 1 and September 13 they completed the geologic survey of the area covered by the base map (436 square miles) and made a detailed study of the occurrence of auriferous gravel. The complete report on this work is in preparation and a preliminary statement is contained elsewhere in this volume (p. 181).

To J. W. Bagley was assigned the task of completing the topographic reconnaissance map of the region lying north of Tanana River. Mr. Bagley reached the field of operations July 3, and continued work until September 18. He carried a survey eastward along the north side of Tanana River as far as the mouth of Healy River. The latter part of the summer was devoted to topographic mapping in the vicinity of the mouth of the delta south of Tanana River. In all an area of 1,725 square miles was covered. The results of these surveys will be embodied on the maps of the Circle and Fairbanks quadrangles, which will be published for sale as soon as funds are available.

In 1907 investigation of the water resources of the Yukon-Tanana district was begun in the Fairbanks region. During the past summer this work was extended by C. C. Covert, assisted by C. E. Ellsworth. For the purpose of obtaining data regarding the spring run-off when the melting of the snow takes place, Mr. Covert proceeded to Fairbanks over the ice, reaching there April 3. He devoted the early part of the season to a study of the water conditions of the streams tributary to the Chatanika, and later proceeded overland to the Circle district, where he met Mr. Ellsworth and party, who came inland by way of the White Pass. The remainder of the season to September 13 was devoted to a study of the water resources of the Circle, Fairbanks, Rampart, and Baker regions. Twenty-one gaging stations were maintained during the whole or part of the season, and 273 measurements of stream volume were made. This work furnishes data in regard to the run-off of about 4,690 square miles. An abstract of the results will be found on pages 201–228, and the complete report is in press as Water-Supply Paper 228.

The great influx of prospectors into the Innoko and lower Yukon region led to a demand for a survey of that district. As funds were not available for a large party, it was decided to make a preliminary examination of the region with a view of determining the general facts with regard to the geology, topography, and distribution of mineral resources. This work was intrusted to A. G. Maddren, who

So long as the returns from the operators are incomplete it is necessary to obtain the best statistical information available from other sources. This is done by correspondence and personal conference with the better-informed residents of the various districts, the express companies, bankers, and commercial companies. It is gratifying to the writer to be able to state that nearly every person asked for information of this kind has been pleased to furnish it. It should be noted that the Geological Survey is collecting statistics not only of gold, silver, and copper, but also of all other mineral deposits.

PUBLICATIONS ISSUED OR IN PRESS IN 1908.

The publications printed during 1908 have appeared more promptly than those of some previous years. There are still unavoidable delays in the issuing of the more elaborate reports after the manuscript has been completed, yet as a rule the time occupied in publication does not exceed three or four months. One cause of delay in the submission of manuscript is the fact that nearly all the Alaskan publications are of the nature of progress reports, and as every season's field work adds new information there is always a tendency to defer publication until the new data can be incorporated. During 1908 the Survey published seven bulletins, one water-supply paper, and three separate topographic maps relating to Alaska. The complete list is as follows:

REPORTS INCLUDING MAPS.[a]

Geologic reconnaissance of the Matanuska and Talkeetna basins, by Sidney Paige and Adolph Knopf; including geologic and topographic maps. Bull. No. 327.

The gold placers of parts of Seward Peninsula, Alaska, by Arthur J. Collier, Frank L. Hess, Philip S. Smith, and Alfred H. Brooks; including geologic and topographic reconnaissance maps. Bull. No. 328.

Geology and mineral resources of the Controller Bay region, by G. C. Martin; including topographic and geologic maps. Bull. No. 335.

The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska, by L. M. Prindle, with a section on the Rampart placers by F. L. Hess and a paper on the water supply of the Fairbanks region by C. C. Covert; including topographic reconnaissance maps. Bull. No. 337.

Mineral resources of Alaska; report on progress of investigations in 1907, by Alfred H. Brooks and others. Bull. No. 345.

The geology and mineral resources of the Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright. Bull. No. 347.

Geology of the Seward Peninsula tin deposits, Alaska, by Adolph Knopf. Bull. No. 358.

Water-supply investigations in Alaska, 1906-1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218.

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[a] See list of reports in back of this volume.

MAPS ISSUED SEPARATELY.[a]

Controller Bay region special map, scale 1:62,500, contour interval 50 feet. Topography by E. G. Hamilton. Alaska sheet No. 641A.

Berners Bay special map, scale 1:62,500, contour interval 50 feet. Topography by R. B. Oliver. Alaska sheet No. 581B.

Fairbanks special map, scale 1:62,500, contour interval 25 feet. Topography by T. G. Gerdine and R. H. Sargent. Alaska sheet No. 642A.

Map of Alaska, scale 1:5,000,000, or about 80 miles to the inch, compiled under direction of Alfred H. Brooks. Map A.

REPORTS AND MAPS IN PRESS.

Mineral resources of the Kotsina-Chitina region, Alaska, by F. H. Moffit and A. G. Maddren. Bull. No. 374.

The Fortymile quadrangle, Yukon-Tanana region, Alaska, by L. M. Prindle. Bull. No. 375.

The Yakutat Bay region, Alaska: Physiography and glacial geology, by R. S. Tarr; areal geology, by R. S. Tarr and B. S. Butler. Prof. Paper No. 64.

REPORTS AND MAPS IN PREPARATION.

The following papers and maps are in various stages of preparation and will be published as soon as circumstances permit, but probably, for the most part, during the year 1909, provided the funds for printing are sufficient:

Geology and ore deposits of Kasaan Peninsula and Copper Mountain region, Prince of Wales Island, by C. W. Wright; including detailed geologic and topographic maps.

The Yakutat Bay earthquake, September, 1899, by R. S. Tarr and Lawrence Martin.

The Nabesna-White River copper region, by F. H. Moffit and Adolph Knopf; including geologic and topographic reconnaissance maps.

The geology and mineral resources of the Prince William Sound region, by U. S. Grant; including geologic reconnaissance map.

An exploration in the Mount McKinley region, by Alfred H. Brooks and L. M. Prindle; including geologic and topographic reconnaissance maps.

Geology and mineral resources of parts of the Alaska Peninsula, by W. W. Atwood; including geologic and topographic reconnaissance maps.

Geology and mineral resources of the Fairbanks district, by L. M. Prindle and F. J. Katz; including detailed geologic map.

Water-supply investigations in Fairbanks, Hot Springs, Rampart, and Birch Creek districts, by C. C. Covert and C. E. Ellsworth. Water-Supply Paper 228.

A reconnaissance of the Innoko and lower Yukon placer districts, by A. G. Maddren.

Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Hess, F. L. Hess, and P. S. Smith; including detailed geologic map.

Geology of the Solomon and Casadepaga quadrangles, by P. S. Smith and F. J. Katz; including detailed geologic map.

[a] Sale publications. See list in back of this volume.

Fairbanks quadrangle map, scale 1:250,000, contour interval 200 feet. Topography by T. G. Gerdine, D. C. Witherspoon, and R. B. Oliver.

Circle quadrangle map, scale 1:250,000. Topography by D. C. Witherspoon.

Rampart quadrangle map, scale 1:250,000, contour interval 200 feet. Topography by D. C. Witherspoon and R. B. Oliver.

Nizina special map, Copper River region, scale 1:62,500, contour interval 100 feet. Topography by D. C. Witherspoon.

THE MINING INDUSTRY IN 1908.

By Alfred H. Brooks.

INTRODUCTION.

Measured either in terms of production or in amount of dead work accomplished or planned, the mining industry of Alaska during 1908 not only did not progress as much as was expected but in some ways showed a distinct decline as compared with the previous year. This retrogression might discourage the mine operator were it not due in part to the widespread business stagnation which followed the financial panic and in part to certain conditions which are not unchangeable.

Though the gold placer mines already on a productive basis were not materially affected by the business depression, many of those requiring capital for extensive plants made but little headway. A more serious matter to the placer miner was the drought which prevailed throughout the summer months in nearly all the important districts. The lack of water so curtailed the output of all the Yukon and Seward Peninsula districts that the value of the total output of placer gold from these sources was probably nearly a million dollars less than in 1907. This decrease of the placer-gold production for Alaska as a whole is, however, but temporary, for the maximum annual output of the auriferous gravels has not yet been reached. In spite of the business depression the production of the auriferous lode mines of the Territory in 1908 was about 22 per cent greater than in 1907.[a] On the other hand, the fall in the price of copper from an average of 20 cents for 1907 to 13.2 cents in 1908 led both to a decrease in the output of that metal and to a diminution of the preparations for its future mining. However, the fact that a number of mines continued to ship ore in spite of its low market value indicates the permanency of the copper-mining industry of the Territory.

Among the conditions that are retarding the advancement of the mineral industry are the inadequacy of the public-land laws under which placer ground is acquired and held and the delays in obtain-

[a] The exact figures for mineral production of the Territory are not available at this writing.

ing title to coal lands. In spite of these and other adverse conditions, which will be discussed in another place (see p. 36), the value of the total mineral production for 1908 is $19,929,800. The sources of this wealth, as well as a comparison with the previous year, are presented in the following table of production:

Mineral production of Alaska, 1907–8.

	1907.		1908.[a]		Increase (+) or decrease (−).	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold.........ounces..	936,043.81	$19,349,743	923,962.50	$19,100,000	− 12,081.31	−$249,743
Silver...........do....	149,784	98,857	140,000	74,200	− 9,784	− 24,657
Copper......pounds..	6,308,786	1,201,757	5,050,000	666,600	−1,258,786	− 595,157
Tin..................	....	20,000	....	....	....	− 20,000
Coal.......short tons..	10,139	53,600	4,000	19,000	− 6,139	− 34,600
Marble, gypsum, and mineral water.......	....	63,098	....	70,000	....	+ 6,902
	....	20,887,055	....	19,929,800	....	− 917,255

[a] Preliminary estimates.

NOTE.—In the above table copper is valued at 20 cents a pound for 1907 and at 13.2 cents for 1908; silver at 66 cents an ounce for 1907 and at 53 cents for 1908.

It will be noted that over half of the decrease in the value of the total mineral production is due to the lesser output of copper, which is directly chargeable to the fall in the market value of that metal. This table does not, however, indicate the very marked decline of the placer-gold output, to which reference has already been made and which will be discussed elsewhere. (See p. 31.) The decrease in coal production is not significant, for the coal-mining industry has not yet become established and the present output is from only a few mines. Tin mining was practically suspended during 1908, though a few tons of concentrates were shipped. In the above table the value assigned to the marble and gypsum production is that of the raw material. The figures for these products are not separated, for as there is only one large marble company and one gypsum company such a separation would reveal the output of the individual producers.

Value of total mineral production of Alaska, 1880–1908.

By years.				By substances.	
1880–1890.....	$4,686,714	1901.........	$7,007,398	Gold..................................	$142,030,637
1891..........	916,920	1902.........	8,400,693	Silver (commercial value).............	1,120,562
1892..........	1,096,000	1903.........	8,941,614	Copper................................	4,265,136
1893..........	1,048,570	1904.........	9,567,535	Tin...................................	92,640
1894..........	1,305,257	1905.........	16,478,142	Coal..................................	315,079
1895..........	2,386,722	1906.........	23,375,008	Marble and gypsum.....................	148,647
1896..........	2,980,087	1907.........	20,887,055		147,972,701
1897..........	2,538,241	1908.........	[a]19,929,800		
1898..........	2,585,575		147,972,701		
1899..........	5,703,076				
1900..........	8,238,294				

[a] Preliminary estimate.

The increased gold production from the auriferous lodes came largely from the Juneau district, where some notable advancements were made. In the Ketchikan district one new copper deposit was opened, and one mine continued operations throughout the year, several others making shipments of copper ore during a part of the year. In the coal fields of Controller Bay and the Matanuska assessment work and surveys for patents constituted the bulk of the activities. Considering the discouraging condition of the copper market, there was much systematic prospecting in the copper-bearing belts of Copper River and in the Prince William Sound region. In the latter district one mine was in operation throughout the year and several others made small shipments. The construction of a railway up Copper River, which was one of the most important events of the year for the mineral industry, is referred to under the next heading. Considerable attention was paid to the lodes of the Kenai Peninsula, Kodiak Island, and southwestern Alaska, and one mine in the last-named district was in operation. There was much activity in the placer districts of the Susitna basin, including Yentna River and Valdez Creek, but it was confined chiefly to small operators. Two auriferous lodes are being opened on a small scale in this field.

Of the placer districts Fairbanks was the most prosperous, but here, as well as in other parts of the Yukon basin and in Seward Peninsula, the drought during the summer months much curtailed production. No discoveries of auriferous gravels have been reported for 1908, though the productive areas in several of the districts have been increased.

TRANSPORTATION.

The full development of the mineral wealth of inland Alaska must await improvements in means of communication, which will need to be of a very radical character. The expensive and uncertain mode of reaching the Yukon placer districts by ocean and river boats or long winter sled journeys places so heavy a tax on the gold-mining industry as to make it in most places impossible to exploit anything but the richest placers. The copper deposits of Copper River and the coal fields of Controller Bay and the Matanuska basin must remain unproductive until a transportation system has been developed.

Thanks to the Alaska road commission, and in a lesser degree to local enterprise, much has been accomplished in the way of road and trail building. Much, however, remains to be done, for in this Territory, embracing nearly 600,000 square miles, there are only 452 miles of wagon road, 397 of sled road, and 255 of trail.[a] The coastal service of ocean vessels and the river transportation systems of the Yukon and its tributaries are being much improved. In addition to this,

[a] Ann. Rept. Secretary of War, 1908, p. 97. Unimproved trails are not included in this mileage.

steamboats have been placed on Copper and Susitna rivers. Local transportation facilities have also been greatly bettered by short lines of railway, such as those at the White Pass, at Fairbanks, and in Seward Peninsula. All these improvements in means of communication, together with the military telegraph lines, wireless stations, and long-distance telephone systems, have done much to advance the mining industry. They can, however, be regarded only as supplementary to a system of railways, which alone can make available the mineral wealth of extensive areas. In fact, they serve to emphasize the inadequacy of the existing transportation systems. The industrial demands for better communication can be met only by railways which shall connect the mineral deposits with open ports on the Pacific seaboard. The writer has discussed the matter of railway location at some length elsewhere,[a] but the matter seems to justify a restatement of some of the salient features of the problem.

The known mineral wealth of inland Alaska is embraced in the two copper-bearing belts of Copper River, lying 100 to 300 miles from tide water; the Bering River coal field, 25 miles from the coast at Controller Bay and 100 miles from a good harbor on Prince William Sound; the Matanuska coal field, 150 miles from an ice-free port on the Pacific; and the Yukon placers, from 400 to 600 miles by feasible railway routes from the Pacific. This inland region is separated from the Pacific tide water by high snow-covered ranges, broken, however, by several river valleys. (See Pl. I.)

There are three possible routes of approach to these mining fields. One leaves the coast at Lynn Canal and, crossing by a broad gap from the Chilkat to the Alsek basin, finds there an easy route for railway construction along the inland front of the St. Elias Range to the head of the Tanana Valley, and thence into the heart of the placer fields. Though such a railway would reach only one of the copper belts and would not help to develop the coal fields, it would traverse the Territory from southeast to northwest and make accessible a large area.

A second route is via the Copper River valley to the Kotsina-Chitina copper belt. A railway following this route is under construction; it can reach the Bering River coal field by a branch line and can be extended to the placer districts of the Yukon basin through a pass that connects the Delta and Copper basins, reaching by a branch line the Nabesna-White copper-bearing area. There is a choice of coastal terminals for this route—either Valdez Inlet, Orca Bay, or Katalla. Each has some advantages, but after careful surveys and investigations Orca Bay, with a terminal at the town of

[a] Brooks, Alfred H., Railway routes: Bull. U. S. Geol. Survey No. 284, 1906, pp. 10-17; Railway routes in Alaska: Nat Geog. Mag., March, 1907, pp. 164-190.

LEGEND

- ✱ Gold placers
- × Gold and silver lode mines and prospects
- ⊠ Copper mines and prospects
- [shaded box] Coal-bearing rocks
- [symbol] Areas known to contain workable coals
- S Anthracite, semianthracite, and semibituminous, including the better coking coals
- B Bituminous and subbituminous coals
- L Lignite
- O Petroleum seepages

50 0 50 100 150 200 miles

50 0 50 100 150 200 kilometers

RELIEF MAP OF CENTRAL ALASKA, SHOWING DISTRIBUTION OF MINERAL RESOURCES.

Cordova, has been chosen by the line under construction. It is currently reported, however, that other projects for railway construction from Valdez and Katalla have not been abandoned.

The third possible route is from Resurrection Bay across a low pass to Turnagain Arm, thence up the Susitna Valley and across another pass to the Nenana. This railway would serve the placer district of the Kenai Peninsula and the Susitna basin, but, what is more important from the standpoint of developed tonnage, would tap the Matanuska coal field. A railway now under construction over this route has its coastal terminal at the town of Seward, on Resurrection Bay. (See Pl. I.)

The following table presents the available data regarding the railways of the Territory:

Mileage and terminals of Alaska railways, December 4, 1908.

	Miles.
Southeastern Alaska:	
White Pass and Yukon Railroad, Skagway to White Pass (narrow gage)....	20.4
(Terminal at White Horse, Yukon Territory. Total mileage, 102 miles.)	
Yakutat Southern Railway, Yakutat to Situk River (narrow gage)........	9±
Copper River:	
Copper River Railroad, Cordova to Childs Glacier (September 17) (standard gage)........	47
(Probably 11 miles have been built since September 17. The same company has built a few miles of track at Katalla, where the Alaska Pacific Railway and Terminal Company has also done some work. At Valdez, a few miles of track of the Alaska Home Railway were laid in 1907, and some work was previously done on the Copper River and Northwestern Railway.)	
Kenai Peninsula:	
Alaska Central Railroad, Seward to a point near head of Turnagain Arm (standard gage)........	53
Yukon basin:	
Tanana Valley Railroad, Fairbanks and Chena to Chatanika (narrow gage).	46
Seward Peninsula:	
Seward Peninsula Railway, Nome to Shelton (narrow gage)........	80
Paystreak branch Seward Peninsula Railway (narrow gage)........	6.5
Council City and Solomon River Railroad, Council to Penelope Creek (standard gage)........	32.5
Wild Goose Railway, Council to Ophir Creek (narrow gage)........	5

Portions of the Council City and Solomon River and the Alaska Central railroads are out of repair and not in use.

From all accounts the various projects for railway construction from Katalla and Valdez were dormant during 1908. In contrast to these is the activity of the Copper River Railway Company, which laid about 50 miles of track during the year. The same corporation is also extending its steamboat service on lower Copper and Chitina rivers, so that it is probable that in 1909 the Chitina-Kotsina copper belt may be reached by railway and steamers and thus the long overland journey now necessary may be avoided. Surveys have been made and some work done by the Katalla and Carbon Mountain Railway Company on a project to build a line from Controller Bay directly to the coal field across the broad flat of Bering River. The distance will be about 25 miles.

During 1908 but little construction work was done on the Alaska Central Railroad, which went into the hands of a receiver in the summer. A reorganization of the company is reported to be under way. A feature of importance to the transportation problem in this region is the improvement of the steamboat service on the Susitna, now planned for 1909.

METAL MINING.

INTRODUCTION.

In spite of the decrease of the placer production and the increase of the auriferous lode production in 1908 as compared with 1907, the placers yielded over four-fifths of the value of the precious-metal output. As complete statistical returns are not yet available, it is impossible to give exact figures in regard to the sources of the metal production for 1908. The following table, however, is believed to be less than 10 per cent in error and will serve to show the relative importance of the various sources of the gold, silver, and copper.

Sources of gold, silver, and copper in Alaska, 1908, by kinds of ore.[a]

	Gold.		Silver.		Copper.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.	Quantity (pounds).	Value.
Silicious ores	172,553.63	$3,567,000	28,000	$14,840		
Copper ores	3,773.25	78,000	42,000	22,260	5,050,000	$666,600
Placers	747,635.62	15,455,000	70,000	37,100		
	923,962.50	19,100,000	140,000	74,200	5,050,000	666,600

[a] This table is based on preliminary estimates, before complete statistical returns are available.

The growing importance of the metal-mining industry is shown in the following table, which exhibits the total production of gold, silver, and copper since mining first began, twenty-eight years ago. The figures for years previous to 1905 are not very reliable, as it is only since that year that an attempt has been made to collect statistics of production from individual operators—the only source of exact information regarding output.

Production of gold, silver, and copper in Alaska, 1880–1908.

Year.	Gold.		Silver.		Copper.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.	Quantity (pounds).	Value.
1880	968	$20,000			3,933	$826
1881	1,935	40,000			....	....
1882	7,256	150,000			....	....
1883	14,566	301,000	10,320	$11,146	....	....
1884	9,728	201,000			....	....
1885	14,513	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	61,927	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	536,101	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	1,201,757
1908	923,962	19,100,000	140,000	74,200	5,050,000	666,600
	6,632,885	142,035,237	1,817,159	1,120,562	25,893,352	4,265,136

NOTE.—Gold and silver production for 1880–1904 based on estimates of Director of Mint; for 1908, preliminary estimate. Silver values are average commercial values for year and not coinage value. Copper production for 1880 from Tenth Census (vol. 15, p. 800); for 1900-1904, estimated; for 1908, preliminary estimate. Copper values are based on averages for year.

In the following table the total gold production is distributed according to districts, so far as the information at hand will permit. The error in distribution is believed to be less than 10 per cent, and it is hoped in the future to eliminate it altogether. (See p. 17.) The production from the Pacific coast belt is, for the most part, from the lode mines of southeastern Alaska, but includes also a small placer output, as well as the production from a lode mine on Unga Island. The gold credited to the Cook Inlet and Copper River region is, aside from the output of two small quartz mines, all from placers, and includes the yield of the Nizina, Chistochina, and Sunrise districts and of the productive creeks of the Susitna basin.

The gold output from Seward Peninsula and the Yukon basin[a] is nearly all from placers, though there was a small production from some lode prospects in Seward Peninsula.

[a] This refers, of course, only to the Alaskan part of the Yukon basin, and does not include the production of the Klondike and other Canadian camps.

Value of gold production of Alaska, with approximate distribution, 1880–1908.

Year.	Pacific coast belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula.	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	833,000		200,000		1,033,000
1894	882,000		400,000		1,282,000
1895	1,569,500	$50,000	709,000		2,328,500
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	3,195,800	500,000	1,300,000	4,164,600	9,160,400
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[a]	3,410,000	400,000	10,190,000	5,100,000	19,100,000
	43,721,937	3,742,000	45,204,000	49,362,700	142,030,637

[a] Preliminary estimate.

LODES.

The first auriferous lode known in Alaska was discovered near Sitka in 1877, but the first important production of gold was from the Treadwell mine in 1882.[a] From 1882 to 1908 the auriferous lodes have produced about 1,958,000 fine ounces of gold, valued at $40,573,000, and 934,434 fine ounces of silver, valued at $576,500. The first attempt at copper mining was made in 1881, when a few thousand pounds of this metal were produced from deposits on Prince of Wales Island. Systematic development of copper deposits began on Prince William Sound in 1900 and on Prince of Wales Island in 1905. Of the total copper production up to the close of 1908, amounting to 25,893,352 pounds, 16,160,619 pounds came from the Prince of Wales Island mines and the remainder from those of Prince William Sound.

The search for lode tin deposits began in 1902, since which time some small shipments of tin ore have been made. However, most of the tin output has come from the placers. Antimony, tungsten, galena, and other ores have been found, but so far the production has been insignificant.

Iron ores (magnetite) are known to occur in southeastern Alaska, where they have been somewhat prospected, as well as on Prince Wil-

[a] Some shipments of galena ore were made from the Omalik mine on Seward Peninsula in 1881.

liam Sound and at other localities. There has, however, been no iron-ore production.

During 1908 auriferous-lode mining made considerable advances, both in production and in the discovery of new ore bodies of possible commercial importance. The copper-mining industry was less prosperous as regards production and dead work accomplished; but, on the other hand, probably more systematic prospecting of copper lodes was carried on than in previous years. Though there was some prospecting of tin, tungsten, antimony, and other kinds of ore bodies than those above noted, there was no production from them and relatively little was accomplished in proving the presence of commercially valuable amounts of ore. Worthy of note is the discovery of a small vein of wolframite (tungsten ore) on Deadwood Creek, in the Circle precinct. Though not known to be of commercial importance, this is at least a new locality for tungsten ore.

Twelve gold and silver lode mines were on a productive basis in 1908, as compared with thirteen in 1907. The increase in the output of the auriferous lodes all came from the Treadwell group and other mines of the Juneau district. The tonnage of the auriferous-lode mines of Alaska for 1908 is estimated at 1,700,000 short tons, as compared with 1,209,639 tons in 1907. The average values of the siliceous ores for 1908 can not be computed until complete statistical returns are at hand. In 1907 the average gold and silver values for all the siliceous ore hoisted was $2.30 a ton; for the siliceous ores other than those of the Treadwell group, $3.41 a ton. It will be evident, therefore, that the productive auriferous-ore bodies of Alaska are of a low grade.

Nine copper mines made some snipments of ore in 1908, as compared with thirteen in 1907. The total tonnage of the copper mines in 1908 is estimated at 50,000 short tons, compared with 98,927 tons in 1907. Complete statistics being lacking, it is impossible to give the average metal content of the copper ore. In 1907 the average of all the copper ore mined in Alaska carried $1.30 a ton in gold and silver and 3.18 per cent of copper. It is probable that the copper percentage of the ore mined in 1908 was somewhat higher than that mined in 1907, because, owing to the low price of copper, only the richer ores could be mined at a profit.

All the important lode-mining districts are covered by special reports in this volume, so that they need not be discussed here. Among the features of these reports having special significance is the auriferous lode on Prince William Sound, described by Mr. Grant (pp. 87–97), and the finding of gold values in an ore body in the Fairbanks district, described by Messrs. Prindle and Katz (pp. 181–200). Mr. Atwood's report (pp. 148–152) also indicates the probability of the occurrence of commercial ore bodies in southwestern Alaska in addition to those already productive.

Mr. Grant has described some gold and copper prospects in the vicinity of Seward, on the Kenai Peninsula (p. 98). In addition to these there are other localities where ore bodies are reported. Through the courtesy of Dr. H. O. Sommer, of the United States Coast and Geodetic Survey, the writer received a sample of pyritiferous quartz from Port Dick which carried 0.123 ounce of gold and 1.32 ounces of silver to the ton. This shows a total value of $3.24 a ton for the ore, a value which, considering the fact that the locality is near a harbor that is open throughout the year, is not prohibitively low. No data are at hand in regard to the dimensions and occurrence of the ore body. There is said to be considerable prospecting in this district.

The extension of the Kenai Peninsula belt of metamorphic rocks is to be sought on Kodiak Island, where, indeed, they have been recognized, though but little geologic work has been done. Placer gold has been found at a number of widely distributed localities in the beach deposits of the island, indicating that the bed rock is auriferous. According to Charles W. Fletcher, auriferous beaches have been found at Uyak and Uganik bays, at Red River, at Sevenmile Beach, near Kaguyak, and at several places on Afognak Island, lying north of and adjacent to Kodiak Island. One small gold mine was in operation for a number of years on Uyak Bay, but operations appear to be suspended. Mr. Fletcher also reports the occurrence of copper in the vicinity of Womens Bay, Kodiak Island. In view of the accessibility of Kodiak Island, mining costs should not be great, and further prospecting would appear to be justified.

Considerable activity has recently been shown in prospecting for auriferous quartz on Little Willow Creek, a tributary of lower Susitna River. Here a 3-stamp mill was installed in 1908 and a 5-stamp mill was taken in, though its erection was not completed. Mr. Atwood reports that he saw some specimens of quartz from this district which carried a large amount of free gold. There is no information at hand regarding either the occurrence of the ore bodies or their dimensions. Discoveries of copper and gold bearing veins in other parts of the Susitna basin are also reported, but no further information concerning them is available.

There is an increasing interest in lode prospecting throughout the Yukon placer districts,[a] yet but little work has been done toward proving any particular locality. The finding of a wolframite-bearing vein in the Birch Creek district and of stibnite and gold ores in the Fairbanks region has already been referred to. According to S. J. Marsh some promising auriferous quartz veins have been found on Big Creek, in the Chandalar precinct. These veins are said to occur

[a] As this volume goes to press some very encouraging reports have been received from the development of lodes near Fairbanks.

in mica schist near intrusives of porphyry and to carry high values in free gold. Gold-bearing veins are also reported from the Koyukuk district, but no information is available in regard to them. The writer has received some pyritiferous vein quartz from C. K. Snow, said to have come from the Koyukuk, one piece of which on assay yielded a value of $1.94 in gold with a trace of silver, while the others showed only a trace of gold.

For several years the Kuskokwim Basin has attracted many prospectors who have found some placer gold, but more commonly report promising auriferous veins. The region is so difficult of access that apparently but little attempt has been made to do sufficient work on any of these ore bodies to prove their commercial value. Attention has also been directed to some occurrences of cinnabar, long known on the lower Kuskokwim.

The writer was fortunate in meeting C. Betch, of the Russian mission on Yukon River, who has spent several years in prospecting for lodes in a region lying southeast of the lower Kuskokwim Valley. Mr. Betch describes this region as including some high mountains, with a dominating country rock, where ores have been found, of limestone intruded by granites. The ore bodies are said to be well defined. Specimens collected by Mr. Betch show molybdenite, pyrite, mispickel, and realgar in a matrix which is chiefly quartz. These ores are said to carry gold values.

Placer gold has been known since 1898 to occur on Kobuk River, and during the last five years there has been a small annual production. According to the statement of Lewis Lloyd, of Shungnak, there have been some promising discoveries of metalliferous lodes in the upper Kobuk Valley and the adjacent parts of the Noatak River basin. Mr. Lloyd reports the presence of copper, galena, and free-milling gold ores in this district. One body of chalcopyrite and bornite ore has been opened near the head of Cosmos Creek by a tunnel 70 feet deep. Picked samples of this ore are said to have yielded about $2 in gold and silver and 28 to 58 per cent in copper. Assays of other ores from this district show a copper content of 5 to 11 per cent. Of importance also is the report by Mr. Lloyd of native copper nuggets in the gold placers of this region. This region is a new field for the occurrence of metalliferous lodes, and for this reason the data have been given in more detail than is customary where they are not collected by members of the Survey.

GOLD PLACERS.

INTRODUCTION.

The placer-gold production of Alaska for 1908 is estimated at $15,455,000 in value, as compared with $16,491,000 in 1907. Nearly two-thirds of this output was from the Yukon basin, a little less than one-third from Seward Peninsula, and the remainder from the widely distributed smaller districts. The output of winter mining for the entire Territory was a little less than half of the total. During the summer of 1908 about 770 placer mines were on a productive basis, but probably less than half of these were operated throughout the open season. The data in regard to the number of placer-mine operations in previous years are very incomplete, but it is believed that the number of mines operated in the summer of 1908 was about 10 per cent less than the number operated during the summer of 1907. There is little information at hand in regard to the number of mines worked during the winter of 1907–8, but it was probably less than 500.

The best information available indicates that there were about 4,400 men engaged in productive placer mining throughout Alaska during the summer of 1908 and about 3,400 during the previous winter. In addition to these, at least 2,000 men were employed during the summer in prospecting, installing plants, and other dead work relating to the placer-mining industry. The winter work of this character employed probably less than half as many. The summer population of all the placer-bearing regions of Alaska is estimated at 28,000 and the winter population at 17,000. The above estimates, which are believed to be conservative, though not very reliable, admit of some suggestive comparisons. In using these figures it should be stated that, while they are only approximations, the error in them is probably not sufficient to seriously impair the value of the deductions to be presented.

The value of the average production of gold per placer mine for the whole of Alaska during the summer of 1908 was about $10,000. In the smaller Yukon districts the average was from $4,000 to $7,000; the Fairbanks mines averaged an output of somewhat over $12,000 and those of Seward Peninsula over $16,000. These figures indicate that in the last-named region the operations were conducted on a larger scale. The average output of gold per placer miner engaged in productive work in the whole of Alaska during the summer of 1908 was about $1,700, that for Fairbanks averaging $1,900, and for Seward Peninsula $2,300. If, however, the men engaged in prospecting and dead work are included, as well as the miners, the average production for all Alaska is $1,200, for Fairbanks $1,600, and for Seward Peninsula, $1,400. The higher average per capita production at Fairbanks, compared with Alaska as a whole, is probably due largely to the richness of the gravels exploited rather than to the magnitude of single operations. On the other hand, the large output per miner in Seward Peninsula is due to the facts that there many labor-saving devices are in use, and that during 1908 most of the small plants were closed because of lack of water.

It is evident that the output per man of a single well-managed successful dredge will be enormous as compared with that of an ordinary pick and shovel plant. These estimates of production per miner certainly appear very large, but they are less encouraging when the very high cost of living is considered. It should also be remembered that the bona fide miners and prospectors constitute hardly 25 per cent of the population, which is practically supported entirely by the placer-mining industry of the gold-producing regions. On the basis of the estimates of population presented, the per capita production of Alaska is determined to be only \$270 for the open summer season and \$690 for the entire year. On Seward Peninsula the per capita production is \$210 for the summer and \$640 for the entire year. This low per capita production is to be accounted for by the fact that the population was determined by the successful results of the previous year. On the other hand, the Fairbanks summer output per capita is estimated at \$590, whereas the annual output per capita is over \$1,100. In considering these figures it should be remembered that subsistence, fuel, etc., cost from \$500 to \$800 per man annually in most of the Alaska placer camps. The cost of subsistence is somewhat less in proportion during the open season, but the cost of traveling to and from Alaska, which averages from \$100 to \$300, must be included in the estimate for those who do not remain during the winter.

It has already been stated that, considering Alaska as a whole, the decrease in the value of the placer-gold output is chargeable for the most part to the dry-weather conditions which prevailed throughout the open season in both the Yukon and the Seward Peninsula districts. It is unquestionably true that had there not been a shortage of water for sluicing, the output for 1908 would have exceeded that of 1907. Nevertheless, it can not be denied that even if the season had been favorable the approaching exhaustion of some of the bonanzas, such as the "third beach line" at Nome and some of the older producing creeks at Fairbanks, would have seriously reduced the production were there not other rich deposits which would have been mined had the water conditions permitted. In other words, the maintenance of the present high placer-gold production is dependent in large measure on the discovery of other bonanzas of equal richness to those which have been exploited. This does not signify that a large production is not to be expected from the gravels of low gold tenor, but simply that relatively but little has been accomplished in preparing to exploit these deposits. Therefore, unless some new important finds are made, it will not be many years before the placer output must decrease unless the methods of exploitation are revolutionized. By this statement it is not intended to imply that the auriferous gravels of either the Yukon or Seward Peninsula are even approaching exhaustion, for the low-grade material is almost untouched, but it is intended to point out that the time is not far distant when the inevitable necessity of reduction in cost of operating must be faced.

The discovery of new rich deposits does not change the problem, but simply defers its solution. All placer districts must pass through this period of evolution, and the sooner the fact is recognized the easier becomes the transition from the bonanza camp, with its constant business fluctuations, to the one where the exploitation of large bodies of lower-grade material gives a lasting prosperity. It is unfortunate to delay this transition until all the rich gravels are mined out. Such a policy (and the Klondike is an excellent example of a locality where it has been followed) leads to a long period of business stagnation before the establishment of the new mining enterprises revives activity.

It is only natural that the first comers to a new placer region should devote themselves to the exploitation of the bonanzas in the auriferous gravel, for these give promise of quick and large returns on a relatively small outlay of capital and time. Bonanza mining, however, though it attracts a large population and brings about the rapid opening of a new region, does not make for a permanent mining industry. Usually a large percentage of the operators attracted by this exploitation of bonanza placers have neither the experience, the capital, nor the patience necessary for the economic exploitation of large gravel bodies carrying lower values. Even where the bonanza miner has the technical skill and capital, he is only too often made careless by the expensive methods employed in mining the very rich gravel beds. The pioneer miners, therefore, who must be credited with the discovery and opening of new districts, often take but little part in the development of large enterprises.

In both Seward Peninsula and the Yukon districts bonanza operators still predominate among the mining population. As a result, with some notable exceptions, there has been but little progress in the improvement of mining methods. Though considerable capital has been brought into Seward Peninsula, much of it has been expended on ill-advised or mismanaged schemes. Many of these enterprises have failed because of the lack of proper technical supervision. To prove this it is only necessary to cite the miles and miles of expensive ditches built on Seward Peninsula, the money on which has been utterly wasted, because no proper measurement of the water was made before their installation.

The effect of bonanza mining is well illustrated by the changes brought about through the discovery of the "third beach line" at Nome in 1905. At that time many of the miners were becoming attracted to the working of some of the lower-grade gravels in various parts of the peninsula. The finding of this fabulously rich beach line, however, led to the centering of all interests on its exploitation. Much of the best technical talent and capital available for mining was expended in exploiting this beach line or in searching for other similar deposits. As a result there was a retardation, or even a retrogression, in the development of other phases of the mining industry. Although there is no case exactly comparable to this in the Yukon district, yet the rich creek placers found near Fairbanks led to the neglect of enterprises looking to the exploitation of the extensive gravel deposits carrying lower values. It is gratifying to note, however, that during the past season there was a marked increase of activity in both Seward Peninsula and the Yukon districts in making preparations to mine deposits of this type.

Though new bonanzas will undoubtedly be discovered and new eras of prosperity be inaugurated thereby, there can be no doubt that the future advancement of the placer-mining industry in both the Seward Peninsula and the Yukon camps will depend mainly on an improvement in mining methods and a reduction in costs, which will enable the operator to profitably exploit the lower-grade gravels. The term low grade is, of course, only relative and is not intended to include all deposits carrying values that might be profitably exploited in the States. It is probably true that at present there is little placer mining done in Alaska on ground which averages less than $2 to the cubic yard, and that much the larger part of that now mined carries values exceeding $3 or $4 to the cubic yard. These figures are only approximate, because there are but few operators who have any definite knowledge of the values contained in the ground they are exploiting. At Fairbanks it is generally conceded that ground that runs less than a dollar to the square foot of bed rock can not be mined at a profit. This ratio, interpreted in figures more familiar to the average mining man, indicates values of about $3.50 to $4 to the cubic yard. (See p. 199.) The cost of deep mining in Seward Peninsula is probably somewhat less than at Fairbanks, because of the lower freight rates. In Seward Peninsula, moreover, there are many mining enterprises (such as dredging, hydraulicking, and probably also some open-cut mining) where the cost of operation is far less than $2 to the yard. The above figures, though only rough approximations, will serve to indicate at least how high operating costs are in Alaska as compared with those in the States.

Evidently there is a large field here for the introduction of improved mining methods, but it is not so easy to forecast the direction these improvements will take. This is, in fact, a problem for the mining engineer and should be treated by him. As a rule each property will have to be carefully studied by a competent engineer to determine the best methods of exploitation. It is undoubtedly true that the lack of experienced engineers in this northern field has been responsible for the many failures which have been made in placer mining. The pioneer is too prone to believe himself fully capable of solving any problem that he may meet and is usually very ready to experiment in spite of the high cost of such a procedure.

MINING CONDITIONS.

In last year's report Mr. Hutchins [a] discussed at some length the factors which control placer mining and dwelt on those conditions which are peculiar to Alaska. It will not be necessary to repeat here what he has already said; for the purposes of this discussion, however, certain conditions will be considered, but without attempting to cover the entire field. This again is evidently a problem for the engineer and not the geologist.

Analysis of the conditions affecting placer mining in Seward Peninsula and the Yukon districts shows one dominating feature common to both regions—the inadequacy of the water supply at a sufficient altitude for use under gravity. It appears that this fact has not always been recognized by those engaged in placer mining. The misconceptions prevalent in regard to the available water supply at Nome are probably due to the fact that the rainfall during the first few years of mining happened to be abnormally large. Unfortunately the records of the last decade, incomplete though they are, all point to the conclusion that seasons of low precipitation are normal and seasons of high precipitation abnormal. (See pp. 223 and 397.)

In the Yukon region the precipitation is better known, though actual records here also are exceedingly meager. The pioneer miners in this region required only a relatively small amount of water, and hence the scantiness of the supply available was not forced on their attention. So long as operations were confined to the sluicing of a few claims in a drainage basin, the water supply being adequate, the semiarid climatic conditions were not always recognized. When, however, a large number of operators began utilizing the water on any one creek, it soon became evident that the water supply was inadequate. This of course applies only to the dry seasons, for during wet seasons there is usually ample water for mining operations, though even then it is often only the larger creeks that will furnish a supply sufficient for hydraulic mining. The rainfall records of the Yukon district, so far as they are understood, seem to indicate that the rainfall is exceedingly local and that probably the total precipitation for the year does not exceed 10 to 18 inches. (See p. 223.)

[a] Hutchins, J. P., Prospecting and mining gold placers in Alaska: Bull. U. S. Geol. Survey No. 345, 1908, pp. 64-77.

The general topographic condition has an important bearing on the question of water supply. The absence of high mountain ranges, which would be the centers of snow accumulation during the winter and the loci of more abundant precipitation, is characteristic in the placer districts of both provinces. In Seward Peninsula there are several mountain masses where the precipitation is considerable. (See p. 397.) The most prominent of these ranges are the Kigluaik and Bendeleben Mountains, which form the most important source of water supply of the peninsula. Though some of the mountains in the Yukon basin are equally high, most of them are rounded domes and lie far below the altitude of permanent snow. The only exception is the Alaska Range, which bounds the Yukon basin on the south. The streams that have their sources in this range are fed in part by glaciers and in part by perpetual snow fields and furnish abundant water supply. This water has not been utilized, because no considerable placer mining for which it would be available has been done.

The relief and the character of the river valleys also affect the conditions of placer mining. In both Seward Peninsula and the Yukon basin the streams are characterized by very low gradients, and this is also true in most places of the bed-rock floors under the alluvium. These low gradients necessarily have an effect on the cost of mining, because they increase the difficulties in the disposal of tailings and decrease the cutting power of the water used for hydraulic purposes.

Undoubtedly the heaviest item of expense in all Alaskan placer-mining operations is that of transportation. This affects not only the cost of the initial installation of the plant, but also operating expenses, including labor and fuel. It is difficult to make any generalization as to the cost of transportation to the various placer districts. The freight rates to the various camps are easily obtained, but these rates usually represent only a small fraction of the cost of the transportation to the mines. Thus the freight rate to Nome is about $15 a ton, but it often costs several times this rate to move the supplies from Nome to the scene of mining operations. Again, the cost of shipment of freight to the various camps on the Yukon is about $75 to $110 a ton, but after the steamer has delivered the supplies on the bank of the river the heaviest cost of transportation often begins, for the amount paid for transshipping the supplies from the steamboat landing to the mines varies from $60 to several hundred dollars a ton, even under the best conditions.

The high cost of transportation also affects the cost of labor. A laborer may be taken to Nome during the summer months for $30 to $40, yet he can not be landed there until several weeks after the open season has begun. Transportation for a laborer to Fairbanks costs about $100, but whereas the mining season begins in the latter part of April, steamboat communication with the outside world is not to be had until the middle of June. Moreover, though the mining season may last through October, the last passengers for the outside by steamer usually leave Fairbanks by September 20. Hence, to utilize the services of a man during the entire mining season in either Seward Peninsula or the Yukon district, it is necessary to employ him throughout the year or to send him both in and out of the country by long and expensive journeys over the snow. Therefore, if the wages of $5 or $6 a day appear to be high, it must be remembered that the working season is short and the laborer at a very large expense for getting into and out of the country. At Fairbanks and to a certain extent at Nome laborers are employed throughout the year, and these men are to a less extent affected by the cost of transportation. As, however, the force employed during the summer months is always very much larger than that employed during the winter, the rate of wages is determined to a large extent by the summer conditions.

In addition to the $5 and $6 a day wages, the laborer also receives his subsistence, the cost of which is directly determined by the transportation charges. It is probable that in some of the camps near Nome the cost of subsistence does not exceed $1 or $1.50 per man per day, but in most of the Yukon camps it is usually estimated at $2.50 to $3.

The high cost of transportation also affects the cost of fuel, which is an important element in operating large plants. Seward Peninsula has no local fuel supply except a scanty amount of timber in the eastern part and a small coal field in the northeastern part. Most mining operations utilize coal brought from British Columbia or Washington or oil brought from California. This coal costs from $15 to $18 a ton landed at Nome. To this cost must be added the price of transporting the coal from the beach to the scene of mining operations. The Yukon camps, on the other hand, depend entirely on the local fuel supply. Up to the present time the timber has been sufficient to meet the demands, but the available timber is being rapidly consumed, and it will not be many years until wood will have to be brought a considerable distance or some other source of fuel found. The cost of wood on the Yukon is variable, and no general figures can be given. It is probably safe to say that it ranges from $7 to $12 a cord delivered at the mines. It must be noted that the Yukon timber is all soft wood and of low fuel value.

Among the many factors that affect mining is the frozen character of the ground. The permanent ground frost has been briefly described in the various publications relating to Alaska, and its general occurrence throughout the Yukon basin and Seward Peninsula noted. As a matter of fact, however, the ground is not all frozen, though probably much the larger part of it is. But the laws governing the distribution of ground frost have not been determined. Where the ground is permanently frozen the frost usually extends to bed rock, which in one place in the Fairbanks district is known to be 325 feet deep and on some of the benches at Nome more than 150 feet. This ground frost, while it is advantageous to underground mining, increases the cost of most other forms of exploitation, especially dredging. However, although a few years ago it was considered impossible to dredge frozen ground profitably, experience has shown that this is not always the case.

NOTES ON PRESENT COSTS AND METHODS OF PLACER MINING.

With the exception of the Fairbanks district and some parts of Seward Peninsula, but a small percentage of the mining operations in the central and northern portion of the Territory have progressed much beyond the open-cut method, the work being done largely by manual labor, but also by ground sluicing, horse and steam scrapers, steam hoists, etc. During the last three years the methods of mining the deep gravels of the Nome and Fairbanks districts have been much improved. Artificial thawing is carried on with a more complete utilization of the fuel than formerly, steam hoists are in general use, and in most places the buckets are self-dumping. In addition to these simpler forms of equipment, dredges, steam shovels, and hydraulic plants are being successfully operated in various parts of the Territory. Hydraulicking has long been carried on in southeastern Alaska and in the Cook Inlet region and has recently been introduced into the Nizina district of the Copper River valley. It has been less extensively used in the Yukon districts, largely because of the lack of sufficient water under head. In Seward Peninsula also a number of hydraulic plants have been successful, though the available water supply does not, as a rule, encourage this form of exploitation. In addition to these true hydraulic-mining operations, the use of water under pressure for moving alluvium in combination with other forms of extraction is a common practice throughout Alaska where conditions permit.

The dredging of some of the auriferous deposits in Alaska has long been advocated and many experiments with this form of exploitation have been made during the last decade. Up to three or four years ago most of these attempts were either total failures or met with little success. This result discouraged even experienced mining men, and there grew up a feeling of general skepticism as to the adaptability of this form of recovery to the auriferous alluvium of the northern placer fields. The arguments for and against dredging in Alaska have been set forth in the technical press, as well as in the publications of the Geological Survey. In spite of the adverse opinions and the failures of the first attempts, many experienced engineers persisted in the opinion that dredging was economically possible, though experimentation to meet the local conditions must be carried on. These men have now been proved to be in the right, for a number of dredges are being successfully operated in Alaska and adjacent parts of Canada.

At present the largest dredging enterprises in this northern field are in the Klondike district, where conditions affecting operation are similar to those in the Alaska part of the Yukon basin. Several dredges have been in successful operation in the Fortymile region, in both Alaskan and Canadian territory. In Seward Peninsula two large dredges were operating during the summer of 1908, one of which has been successfully used for three years. A number of small dredges are in use in Seward Peninsula, and other dredges are in construction or planned.

The above facts prove that dredges are to play an important part in the exploitation of these northern placers, but it by no means follows, as seems to be sometimes believed by those inexperienced in their use, that all auriferous deposits which can not be economically exploited by other methods are suitable for dredging. Unfortunately, the success of these dredges may lead to many ill-advised dredging enterprises promoted by inexperienced men, and a mania for dredge construction may develop, similar to that for ditch construction which prevailed in Seward Peninsula a few years ago. If this proves to be the case, much money will be wasted, and the placer-mining industry will suffer. In spite of the failures that will undoubtedly come, a legitimate dredging industry will nevertheless grow up under the guidance of experienced engineers, for there can be no question that there are large areas of auriferous gravel, both in the Yukon basin and in Seward Peninsula, which can be profitably exploited by dredging. Some of this gravel is thawed, but probably the larger part is frozen. In the past the necessity of thawing the alluvium has seemed to be prohibitive to successful dredging. It now appears, however, that under favorable conditions the cost of thawing may be low enough to permit the economical dredging of alluvium whose gold tenor is so low as to prohibit any other form of exploitation. It must be conceded, however, that so far the most successful dredging operations in Alaska have been in thawed ground.

During the first four or five years of extensive mining the cost of artificial thawing was generally estimated at 25 to 40 cents a yard, depending on the character of material, the price paid for fuel, etc. Recent developments at Dawson, Fortymile, and elsewhere indicate, however, a much lower cost for artificial thawing. T. A. Rickard, who last summer made a comprehensive study of the more important placer districts of the North, reports the cost of thawing dredging ground in the Yukon basin with steam at 9½ to 12 cents a yard.[a] These figures should not be exceeded in Seward Peninsula. Wood for fuel in the Yukon district costs from $7 to $12 a cord, which is equivalent to coal at about $18 to $24 a ton, whereas the average price of coal in Seward Peninsula is only $15 to $18, and petroleum is probably still cheaper per heat unit.

A still greater reduction in costs can be counted on where thawing by exposure to the air and sun is possible. This practice has long been in vogue in open-cut mining. For this purpose the nonconducting surface mat of vegetation is removed by ground sluicing when possible—by scrapers and manual labor when necessary—and the frozen ground, thus exposed to the long Arctic day, rapidly thaws. The depth to which such natural thawing will take place without further stripping varies according to the character of the material. Rickard states that on a property which he visited in the Klondike natural thawing by this means will reach a depth of 14 feet in two years. An improvement on this method is possible where sufficient water is available. The plan formulated by O. P. Perry, the engineer of the Yukon Gold Company (Klondike), is thus described by Rickard:[b]

The method of using water in preparing the ground for dredging will be as follows: First, stock lines will be laid along the edge of the creek carrying water under high pressure, tapped from the main trunk line. The moss and muck will be stripped by "piping" (that is, the use of a large volume of water under pressure), driving from both sides to a longitudinal cut down the center of the claims. This work will be carried forward about 2 miles ahead of the dredges. When the ground has been stripped, the water will again be applied (at the lower end first), so as to crosscut the gravel with trenches at intervals of from 20 to 50 feet. The effect of this exposure of faces of gravel to the air is to accelerate the natural thaw. After the cross trenches have been made, the longitudinal trench will be deepened so as to drain the entire area. The depth of the trenches and the extent to which this work is carried will depend upon the depth to bed rock and the rate of thaw. Experience thus far indicates that when the stripping has been completed, not much trenching is necessary to carry the thaw to bed rock when the gravel is not more than 18 to 20 feet deep. Each successive season will extend the thaw farther, so that the depth and amount of trenching will depend upon the nearness of the dredge. By this method the total cost of preparing the ground for dredging should not exceed 5 cents per cubic yard, for there is no installation and maintenance of sluices, and many of the other expenditures incidental to hydraulic mining are lacking. The actual work of mining is done by the dredge, the amount of ground moved in the preliminary operation being small compared to the yardage dug subsequently by the dredge itself. By thus making the most of the natural thaw and preparing the ground for rapid dredging, the total cost of mining the gravel should not average more than 20 to 25 cents per cubic yard. The result obtained with artificial thawing in advance of dredging actually shows a cost of 19 to 35 cents per yard.

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[a] Rickard, T. A., Dredging on the Yukon: Min. and Sci. Press, vol. 97, 1908, pp. 290-293, 354-357.
[b] Op. cit., p. 355.

There is every reason to believe that this method of natural thawing will be a success, though it has not yet been tried in a large way. Its difficulty of general application to Alaska is the scarcity of sufficient water under head to permit any such extensive channeling as is planned in the Klondike. This feature of the operations of the Yukon Gold Company has probably less bearing on the dredging problems of the Alaskan Yukon than have some others. It certainly is of great importance to know, as Rickard points out, that the actual cost of operating dredges in frozen ground is as low as 19 to 35 cents a cubic yard.

Lest the above-quoted figures for thawing be considered applicable to all forms of mining, it may be well to state that in Seward Peninsula the mean of the figures furnished by several experienced operators in drift mining was nearly 35 cents a cubic yard. It is generally recognized that thawing for deep mining is far more expensive than for dredging. There are no figures available on the cost of thawing for dredging in Seward Peninsula, where, indeed, the frozen condition of the ground is generally regarded as a serious if not an insurmountable obstacle to dredging.

In Seward Peninsula the cost of dredging alone is generally placed at 20 to 25 cents a cubic yard, with probably a considerable reduction by the use of central power plants, either hydroelectric or using imported or local coals. Rickard places the present cost of dredging in the Yukon basin at 18 to 32 cents a cubic yard, with possible reductions to 10 or 15 cents.

Among the many important factors to be considered in dredge mining is the character of the bed rock. The schists that form the predominating country rock in many of the placer districts weather deeply and are readily excavated. In some operations, however, the fact has been overlooked that in the absence of definite knowledge to the contrary, other types of bed rock, such as massive intrusive rocks or blocky limestones, may predominate. The difference between success and failure may rest solely on the character of the bed rock. Of course, no dredging enterprise should be launched without the exhaustive prospecting which will give definite information as to the dimensions of the alluvial deposit, its gold tenor, the character of the bed rock, etc. There appears to be no reason why the speculative element should not be practically eliminated from a dredge-mining enterprise, provided it be in the hands of a competent engineer.

It has been shown that true hydraulic mining has been carried on at comparatively few places in Alaska, though it has been extensively used to supplement other forms of exploitation. Nor does it seem likely that this method of mining will ever be extensively practiced in the Territory. The low gradients make it difficult to dispose of the tailings, and the small amount of water available under head in most of the important placer fields makes it probable that hydraulic mining will never be an important feature in the districts which are now productive. There are, however, exceptions to this rule. In southeastern Alaska, in the Cook Inlet region, and in portions of the Copper River district there are considerable bodies of gravel, which are so situated that they can be economically handled by hydraulic means, and water is also to be had. South of the Tanana, along the northern slope of the Alaska Range, there are extensive bodies of gravel, some of which are auriferous and are favorably situated for hydraulic mining. It appears, however, that it has not been determined that these gravels carry values.

Bench gravels occur in most of the Yukon districts, as well as in parts of Seward Peninsula, and for some of these deposits water for hydraulicking is available, though in most places the water supply is insufficient to assure continuous operation throughout every field season. Many of these gravel deposits can, however, probably be economically handled by utilizing the water either directly during wet periods or by storing it in small reservoirs, but this will mean mining on a comparatively small scale. The possibility of hydraulic mining by the use of pumped water is dependent on cheaper power than can now be had, but, as will be shown, there are places where hydroelectric or steam plants, using local fuel, can be developed. No data are available on the cost of hydraulic-mining operations, which vary so greatly in different parts of Alaska that, even if detailed facts were at hand regarding the operation of successful plants, they would probably have little general bearing. If allowance is made for difference in wages, the cost of transportation, etc., there is no reason why the handling of gravel by hydraulic methods should be more expensive than in other regions of similar topography, provided sufficient water is available during the open season.

The removal of the overburden by hydraulic means, such as ground sluicing or elevators, has been a general practice. Hydraulic elevators have been considerably used in many parts of Seward Peninsula and to a less extent in the Yukon basin. The cost of these operations will not here be considered, but it is generally conceded by engineers that it is not an economical use of water. It should be noted that in Alaska the term hydraulic mining is often applied to operations in which, as a matter of fact, water under head is used only to remove the overburden. The gravels carrying the values are then handled by open-cut methods, being shoveled or scraped into sluice boxes. This is of course an expensive method of handling ground, yet its extensive use among experienced men indicates that it has a legitimate place in Alaskan placer mining.

Deep gravel mining is confined chiefly to the Fairbanks district, where the alluvial deposits range from 15 to 300 feet in depth, averaging about 100 feet. In these gravels the high values are chiefly concentrated in the lower 4 or 5 feet, and hence they can best be mined by stoping. Messrs. Prindle and Katz report (see p. 199) that the lowest-grade ground now mined by this means yields about $3.50 to the cubic yard. The chief criticisms to be made of the methods employed are that the ground is usually not prospected except by working shafts and that only the richest pay streaks are extracted, leaving the ground in very poor condition for future exploitation. During the last two years churn drills have been successfully introduced for tracing the pay streaks, and by this means the cost of prospecting is much reduced. The distribution of live water is another feature to which little attention has been paid. Very often water is encountered in sinking, and the workings have to be entirely abandoned, because no method has been provided for handling it. Hoisting is done by steam, and automatic dumping buckets are generally used. In many places the water pumped from the mine is used for sluicing, and this plan makes the operations independent of a surface supply, though the necessity of using pumps much enhances the cost of extraction. Similar methods have been extensively used on the ancient beach placers near Nome and to a small extent in other districts.

Much of the mining in the Fairbanks district is done on borrowed capital at an excessive rate of interest,[a] which largely increases the operating costs. Another feature of mining at Fairbanks, and to a less extent in Seward Peninsula, is that many of the operators are working under leases or "lays," as they are locally termed. These men usually have little capital and some of them no great amount of experience. Working, as they do, on borrowed capital with high interest charges, they are compelled to leave untouched all but the richest gravels. Moreover, as they have no interest in the future of the mining claim, they pay small heed to the condition in which they leave the ground. As a rule the leases are made for one or two seasons only. The lessees as a class exploit only the bonanzas, and after they get through their work the ground is so gutted as to make the recovery of the remaining gold difficult and expensive. Mining of this type, while it makes for rapid production, is ruining some of the best properties in Alaska for future exploitation.

Operating costs can be roughly classed under three headings—labor, supplies, and equipment. It will be at once recognized that the cost of all these items is in a large measure determined by the transportation charges. Transportation is the most important factor in considering possible economies in mining methods. It not only deter-

[a] In 1908 the usual rate of interest was 2 per cent a month.

mines the direct cost of labor, supplies, and equipment, but also indirectly affects the cost of these items because of the losses of time frequently involved. This indirect influence of transportation on cost may be illustrated by the course taken when a mining plant is to be installed. After the equipment has been assembled at some convenient seaport on the coast, it is shipped by steamer and by river boat to the nearest place to the property to be developed in Alaska that is accessible by water communication. If the plant is a large one, this transportation may take the best part of the first summer. Where there are no local railways, the equipment is then transported by horse sled to the mine during the following winter. A second summer is usually consumed in installing the machinery. If, therefore, the plant, and then only if it be a small one, is ready for operating at the beginning of the third season, its installation will not have required much more time than is usual in such an enterprise. Time may be saved, however, in Seward Peninsula and at Fairbanks on properties that are accessible to the railroad; such plants may be in operation before the close of the second season. It is evident that the loss on interest charges for a large investment is considerable under the conditions outlined above.

The present price of labor in the more important placer camps in Alaska varies from $5 to $6 a day, with board, making a total cost per man per day of $6 to $8.50. This may appear to be a high charge for manual labor—for much of the work requires little skill [a]—yet it must be remembered that the price is largely determined by the demand for laborers during the open season. On an average twice or three times as much labor is required during the summer months as during the winter. As a result this labor either has to be imported in summer, or must be supported during the winter by the wages earned in the open season. It costs from $40 to $75 to bring in a laborer for the summer work. Moreover, he can not reach the camp until some weeks after the mining season has opened. These conditions make it improbable that the cost of labor will be reduced, unless there is a material change in the transportation situation, or more encouragement is given to the individual miner to prospect for himself for a part of the season. Railway communication with the camps appears to be the only solution of the labor problem. If a laborer could be brought from Seattle to Fairbanks at the time he was needed, in four or five days, and returned, when there was no more work for him, in the same length of time, at a cost of, say, $50, he could afford to work for considerably less than he now receives. The cost of food for the laborers would also be reduced if railroad transportation were available. Such facilities

[a] This statement applies more especially to open-cut work; the deep mining at Fairbanks requires skilled miners.

appear to be very remote for Seward Peninsula, but the outlook for a railway to the Yukon is more hopeful.

It should be stated that the completion of a wagon road between Valdez and Fairbanks, now begun by the Alaska Road Commission, will in a measure tend to reduce the cost of labor. Even now, as the winter trail is good, many men make their way to Fairbanks late in the winter for employment when the open season begins.

If lode mines are developed in any part of the inland district of Alaska or Seward Peninsula, they will furnish employment throughout the year and thus materially help the labor situation. This opportunity would attract a more permanent laboring population, which is now almost lacking in the placer districts. The greatest need of the Fairbanks district, as well as of others in the Yukon basin, is a larger population. There are now hardly men enough to work the developed placers, much less to prospect. Although it is true that the deep placers of Fairbanks are operated throughout the year, winter mining appears to be rather on the decrease, and it seems probable that unless lode mines are developed, there will be less employment during the winter months in the future than there has been in the past.

The outlook does not appear very hopeful for a material reduction of the percentage of manual labor employed in placer mining. This statement, of course, does not refer to dredging, and, as has been shown, the employment of labor-saving devices is constantly increasing. Unfortunately, the water supply is not such as to encourage the outlook for hydraulic mining, though there are possibilities of developing cheaper power. It appears, therefore, that in the two important placer fields the most promising feature for the reduction of cost is the introduction of dredges where their use is economically feasible.

The high freight charges can best be appreciated when it is stated that the cost of transportation of supplies delivered at the mine will vary from $75 to $500 a ton, or even more in some of the isolated camps. The reduction of these costs is dependent on additional railways and wagon roads, and those already completed and now in progress have materially lessened operating expenses in some of the placer camps. Even were the cost of transporting a ton of supplies by rail from the seaboard to Fairbanks as much as that of bringing it by the long water route, yet there still would be a saving, because of the saving of time and the certainty as to the date of delivery. It is estimated that the transportation of supplies and equipment to Fairbanks costs the district nearly $2,000,000 annually, and to this must be added about $1,000,000 more for transportation of that part of the freight which is sent to the creeks. In other words, about 30 per cent of the value of the entire gold production of the Fairbanks district is required to pay the transportation charges alone.

Another direction in which economy in mining may be introduced is by lowering the cost of power. There are two ways in which this may be done—one by the utilization of water power and the other by the reduction of the cost of fuel or, what amounts to the same thing, greater economy in its use. The investigations made by the engineers of the Geological Survey have shown that there are probably available water powers both in the Fairbanks district and in Seward Peninsula. (See pp. 227 and 373.) It is likely, however, that, even if all the water powers available are harnessed, there will in time still be demand for more power. Moreover, the utilization of these water powers presents many difficult problems, some of which have not yet been studied in detail.

The lowering of the cost of fuel does not seem feasible. At the rate at which the timber is being used up in the Yukon region the chances are that the cost of cord wood will continue to go up, as it has during the past few years. Here, again, the item of transportation has added to the cost to a very large degree, and the improvement of the wagon-road system and the introduction of railroads may have a material effect on the price of fuel. This is especially true in Seward Peninsula, where most of the fuel is imported from Puget Sound and other places. The more economical use of fuels is probably another direction of possible saving, but falls outside of the present discussion.

Another method that might reduce mining costs is the utilization of local deposits of lignitic coal for the production of electric power to be transmitted to the mining camps. A plan has been under consideration during the past year for using the Chicago Creek coal in the northeastern part of Seward Peninsula in this manner. (See pp. 362–364.) Similar coals occur south of the Tanana within 30 or 40 miles of Fairbanks. If Seward Peninsula and the Yukon districts, as is believed, include considerable areas of dredging ground, it is possible that such local supplies of lignite may furnish the needed power. In any event, it appears that it would be more economical to utilize the lignitic coal in a power plant located at the mine than to attempt to transport it to the various districts. A company undertaking such an enterprise will naturally make a careful study of the possible competition of a coal-consuming power plant with any water powers that may be developed.

MINERAL-LAND LAWS.

The inadequacy of the public-land laws under which placer ground is preempted and held is seriously retarding mining advancement. At present large tracts of public land in regions believed to be auriferous are located and held by individuals and groups of individuals for purely speculative purposes, without any attempt at mining development or even the proving of the mineral character of the land. This is clearly an evasion of the spirit of the mineral-land statutes, whose sole purpose was to bring about the discovery and development of the mineral deposits. It is difficult to prove that there are many cases of actual evasion of the letter of the law, though it is generally conceded that some statements of annual assessment work performed will not bear close scrutiny.

To understand the present conditions it is necessary to bear in mind the fact that but a small percentage of the placer claims are ever patented. Hundreds and thousands of claims have changed hands, and in many of them all the gold has been extracted without any title having been acquired, except through the original staking and the annual assessment work required by law. In districts of mining activity the annual assessment work is usually performed, for every property is watched closely by a numerous class of so-called professional "claim jumpers." In the more isolated districts, however, many claims are staked and restaked by the same individuals without the slightest attempt at prospecting the ground. One instance may be recited where, in an isolated district of no mineral production but possible values, the claim holders had a "gentlemen's agreement," by which they agreed to do no assessment work and not to jump each other's claims, restaking the first of each January. If, however, a stranger appeared in the district, each man betook himself to his property and either restaked it or went vigorously to work.

Some years ago it became the established practice to take up public land believed to be valuable for placers in so-called "association claims" of 160 acres, for it was found that the present law allows the same amount of assessment work to hold the larger tract as the individual 20-acre claim. As it is easy to obtain powers of attorney for staking placer ground, either from residents or nonresidents, and as there is no limit to the number of claims that such an association of individuals can locate, there is nothing to prevent one man preempting thousands of acres, provided he be first in the field. As a consequence the systematic prospecting of supposed placer ground previous to location and recording, is almost unknown in Alaska. When a so-called "stampede" into a new district takes place each man strives to be the first on the ground, and to stake as many claims as his ability to travel across country will permit. Having located the ground, the "claim staker" is not required to do anything, except to make record with the United States commissioner, until a year from the first of the following January, when he may continue to hold his 160-acre claims by doing $100 worth of assessment work on each claim. As has been shown, even this requirement is often evaded.

The bona fide prospector is usually later in the field, for he is burdened by his prospecting equipment and supplies, whereas the claim staker needs only a pencil and hatchet and a few days' provisions. These later arrivals are then given opportunity to prospect under a lease the claims already taken up. If the ground proves to be valuable, the claim staker and his associates, who may be thousands of miles away, receive a royalty from mineral lands on which they have usually expended nothing but a few days' or weeks' time. On the other hand, the man who prospects the claims under lease receives nothing for his labor if the ground is found to be worthless, and at best his reward is usually little more than the average wages of the district. In an unproved field it is often difficult to find prospectors to work under a lease, and as a consequence, though the lands are taken up under mineral entry, no mining is attempted for a year or two. That this account is not overdrawn will be admitted by all who are familiar with the conditions. Mr. Maddren elsewhere in this volume (pp. 234 and 238) describes the conditions in some of the newer placer camps.

All this is clearly an evasion of the purpose of the statutes, but it probably can not be rectified except by a change of law. As a matter of fact, the laws under which the mineral lands of the public domain are acquired by the individual are of a very general character, and it was intended that they should be supplemented by state and territorial statutes, or, in the absence of other forms of local government, by the regulations of the "miners' meetings."[a] Alaska has, of course, no local government, but up to 1900 it was the general practice for the miners of each district to elect their recorders and make regulations with reference to size of claims, etc. These regulations had a standing in law so long as they did not conflict with the United States statutes. In the pioneer days, with the small population of miners and prospectors, this system worked admirably. With the sudden influx, during the Klondike and Nome excitements, of a large population which had not been schooled to frontier conditions, regulations by "miners' meetings" were far less successful and fell into disuse. The civil code of Alaska, enacted in 1900, still recognizes the right of miners to make local regulations,[b] but advantage is now seldom taken of this privilege, largely because miners of the best class realize that it is no longer applicable to the present conditions.

[a] See Rev. Stat., sec. 2324.

[b] See An act making further provision for a civil government for Alaska and for other purposes, Title I, sec. 16, Stat. L., 56th Cong., 1st sess., p. 328.

These conditions have undoubtedly discouraged systematic prospecting in Alaska placer districts, and as a consequence the number of real prospectors and miners appears to be decreasing. It is unfortunate that in a region where there are such great fields that should receive careful investigation by experienced men, such men are not encouraged to prospect. There are hundreds of miles of valley bottoms staked for placers where no attempt has ever been made to excavate to bed rock. The nominal holders of many of these claims are residents of the towns, if they live in Alaska at all, and support themselves by other means, while the experienced miner, if he desires to work for himself, is forced to seek very isolated districts which the professional claim staker has not reached.

Of the necessity for a change in the statutes and regulations applying to the taking up of placer ground, nearly all familiar with present conditions are agreed. There is, however, far from unanimity of opinion as to the changes that should be made. It seems to be generally agreed that the advantages of the association claim are less than its disadvantages and that the former practice of taking 20-acre claims is best. There can be no doubt that for the encouragement of gold dredging the larger claims would be desirable. If, however, in the statutes no difference is to be recognized between ordinary placer ground and dredging ground, the larger claim would best be abandoned. It appears also that a man should not possess the unlimited right of staking claims for himself or his friends. If only 20-acre claims were permitted and a more rigid assessment law was enforced, attempts to preempt large tracts of the public domain would be somewhat discouraged. The speculative feature in an unproved district would, however, still remain and tie up the supposed mineral land for a year or two. Possibly the difficulties could be met by requiring the assessment work to be done within six months or even three months from the time the claim is staked. Any statute that reduces the time in which assessment work is done should take cognizance of the fact that in some localities the work can best be done in winter, in others only in summer.

In his recent report [a] the governor of Alaska recommended that a law be enacted defining the length of tunnel or depth of shaft which shall constitute the assessment work.[b] Such a law has long been in force in the Yukon Territory, where conditions of mining are practically the same as in Alaska. It should be noted, however, that Canada maintains a regular force of trained engineers and inspectors to see that the mining laws are obeyed. That an inspection of assessment work would be desirable can not be doubted, but it can

[a] Report of the governor of the district of Alaska to the Secretary of the Interior, 1908, p. 16.

[b] If this were enacted in a law, other methods of prospecting, as by churn drill, dredge, etc., should also be recognized.

hardly be expected that the few underpaid United States commissioners, who are at present charged with a great variety of duties, could undertake such an additional task, even when fitted for it by training and experience.

SUMMARY OF PLACER MINING BY LOCALITIES.

PACIFIC COAST REGION.

For the purposes of this discussion, the Pacific coast region will here be made to include not only the seaboard but also the drainage basins tributary to it. No extensive placer fields have been developed in this region, but there are a number of small districts whose aggregate production in 1908 was valued at about $450,000, as compared with $275,000 in 1907. The increase is to be credited entirely to the Susitna basin, and for the most part to Valdez Creek. The placers of the Copper River region included in this estimate of production are described by Mr. Moffit on p. 156.

Southeastern Alaska.—The only placer-mining operations in southeastern Alaska during 1908 were on Gold Creek, in the Juneau district, where some hydraulicking was done, and on Porcupine Creek, a tributary to Klehini River, in the Skagway district. In former years there was considerable mining on Porcupine Creek and 30 miles northwest of Haines, but since 1904 there has been only a small production from this locality. In 1908, however, a flume 6,280 feet long, 38 feet wide, and 7 feet deep was completed along the sides of the creek bed, and through it the stream is diverted, thus giving access to the auriferous creek gravels. A little sluicing was done at the close of the season, and a small output is reported.

Beach mining.—Beach placers are widely distributed along the Pacific seaboard, notably at Lituya Bay, Yakataga, Yakutat, Anchor Point, Cook Inlet (see p. 148), at a number of localities on Kodiak Island (see p. 30), and on Popof Island, near Unga (see p. 149). So far as these placers have been studied, they appear to be mere surface concentrations due to wave action. Prospectors report that enrichment of deposits of this type takes place after heavy storms. Under such conditions the waves cut back into the coastal-plain sediments and concentrate the heavy material as a surface layer. Several attempts have been made to mine these beach deposits in a large way with the use of machinery, but they have all failed, probably because the quantity of material at any one locality is very small. It is worthy of note that these deposits do not compare in bulk or richness with the famous beach placers of Nome. Aside from the fact that the mining of the Pacific beaches furnishes spasmodic employment to possibly half a hundred men who are probably otherwise engaged for most of the year, these placers appear to have no great economic importance. Their occurrence is of interest, however, because they indicate that certain regions are auriferous which have so far yielded no gold except from such deposits. The population engaged in beach mining is so ephemeral in character that there is no means of obtaining statistics of production. Yakataga still seems to be the chief center of this industry, but some beach mining is also done on Kodiak and Popof islands. The total output from the beach placers in 1908 is estimated at $20,000 to $30,000.

Sunrise district.—The Sunrise placer district, in the northern part of the Kenai Peninsula, continues to be a small producer. Several small hydraulic plants are operated, but most of the gold is taken by more primitive methods. Mills, Canyon, Lynx, Gulch, East Fork, and Sixmile are the productive creeks of the district. It is estimated that about 50 men were engaged in mining during 1908, and that 10 claims yielded more or less gold. The value of the entire output of the district is probably about $20,000.

Susitna basin.—The exploitation of some rich placers on Valdez Creek, a tributary to the upper Susitna, and the continuation of mining in the Yentna and Little Willow Creek basins has stimulated prospecting throughout the Susitna River basin. Discoveries of workable placers in various parts of this region are reported, but details are lacking. Several small steamers are now used on the Susitna, and a more complete water-transportation system is promised for 1909. According to current reports, a number of large steamers are to be placed on the Susitna and a comparatively easy route to the Valdez Creek and Yentna placers is to be established. The Valdez Creek placers are described by Mr. Moffit elsewhere in this volume (pp. 157–160).

There is little information at hand regarding the Yentna district. One or two hundred miners and prospectors were reported to be in this district in 1908, and the value of the gold output is estimated at $100,000.

YUKON BASIN.

The total output of gold from the Yukon region in 1908 is estimated to have a value of $10,200,000, as compared with $9,183,000 for 1907. This increase of a million dollars must be credited entirely to the area tributary to Fairbanks, which is described by Messrs. Prindle and Katz elsewhere in this volume (p. 181). Most of the smaller districts showed a falling off in production as compared with previous years, largely because of the scarcity of water for sluicing, but partly because on certain groups of claims that have been consolidated for exploitation in a large way the equipment has not yet been installed and so there was no output. Outside of the Fairbanks district the most important features of the mining industry in the Yukon basin were the successful operation of dredges in the Fortymile district, some discoveries of placer ground in the Hot Springs district of the lower Tanana Valley, the finding of auriferous gravels in the Beaver Creek basin, and the exploitation of some deep gravels carrying a high gold tenor in the Koyukuk district.

Fortymile district.—It has been found impossible to obtain complete data on the gold output of the Fortymile district. Reports received from 20 different operators show an aggregate output of $66,000. It is believed, however, that there were at least twice as many operators and that the value of the production was greater than that of 1907, which amounted to $140,000.

Two dredges were operated for most of the season on Walker Fork and are said to have been successful. A smaller prospecting dredge was used for a part of the summer near the international boundary. The dredge on Pump Bar, Fortymile River, installed in 1907, was wrecked by the spring freshets of 1908. It appears that the Fortymile district was better supplied with water during 1908 than any of the other Yukon districts, and this led to many small operations. As in previous years the most work of this kind was on Wade Creek, but the Ingle, Napoleon, Chicken, Lost Chicken, Berkshire, Meyers, and Flat Creek placers also were productive. Some mining was done on American, Nugget, Flume, and Barney creeks, near the town of Eagle. These operations were all on a small scale, the total production being about $10,000.

Circle precinct.—Returns were received from only 14 operators in the Circle precinct. It is believed, however, that about 30 different mines were productive in 1908. This is another instance to show that neglect of the individual operators to furnish statistics of production is liable to result in injustice to the precinct in the Survey reports. Fortunately the writer has had the cooperation of A. J. Childs, Samuel Sim, and others in procuring general estimates of production, and these data indicate a total output for the precinct of $175,000 in 1908 as compared with $200,000 in 1907. Nearly half of the output was obtained by drift mining during the winter months. The decrease is chargeable to the lack of water for sluicing during the open season. (See p. 216.) It is estimated that 36 different mines, employing 110 men, were worked during the summer af 1908, and that during the preceding winter 24 mines, employing 64 men, were on a productive basis. Winter work on Deadwood Creek was hampered by the mild weather, as the seasonal frost did not reach bed rock until February and the ground water prevented mining.

The completion of about 20 miles of wagon road from Circle, on the Yukon, to Jenny Jump, Birch Creek, will help to solve the transportation problem in this region. A wireless station, which has been installed at Circle, will put the precinct into telegraphic communication with the outside world.

As in previous years, Mastodon Creek made the largest production and Deadwood Creek was second. Some prospecting was done on the lower part of Deadwood Creek to test the ground for dredging. There has also been considerable prospecting in the Birch Creek district, with a view of finding dredging ground. This district includes considerable bodies of gravel 12 to 40 feet in depth that carry values too low for operating by the open-cut method, and some of this gravel is thawed. The small amount of water and the low grades of the streams will probably make it impossible to hydraulic these gravel deposits, but it seems possible that some of them may be worked at a profit by means of dredges. In any event, it is certain that parts of the main Birch Creek and Harrison, Deadwood, and other creeks are worthy of investigation. The reported discovery of a small vein of wolframite on Deadwood Creek (see p. 29), is of interest, though not known to be of commercial importance.

A 6-mile ditch was completed in the late summer to bring water from Bonanza Creek, a tributary of Porcupine Creek, to the placers on Mammoth Creek. This ditch gives about 500 feet of working head, and the water will be used to hydraulic an extensive tract of auriferous gravels. It has long been known that the gravels of Mastodon Creek carried values, but there has been practically no mining on this creek since 1905, when a steam-shovel plant was used experimentally on the upper part of the creek. These operations showed that the ground carried gold, but the values were not sufficiently high to permit profitable exploitation by this method.

A storage reservoir was completed on Mastodon Fork of Eagle Creek during the summer, but the season was so dry that the water was sufficient only to do some ground sluicing of overburden. Most of the known productive part of Eagle Creek is now controlled by one company, which has been engaged during the last two years in installing its equipment. The ground formerly worked on Eagle Creek carried values high enough to make it worth while to drift thawed ground, a process which entailed the expense of timbering. In addition to the above-mentioned operations, there was a small production on Woodchopper, Coal, and other creeks tributary to the Yukon above Circle.

An important feature of the mining development in this region in 1908 is the discovery of gold on tributaries of Beaver Creek. It is reported that good prospects are found on Loper Creek, a tributary of Preacher Creek. Here the ground is said to be thawed and less than 8 feet in depth. Pick and shovel mining is said to yield $4 to $5 to the man. Encouraging prospects are also said to have been found on Bachelor Creek, in this same general field. The bed rock throughout the district is said to be mica schist similar to that occurring on the Birch Creek side of the divide.

Chena-Salcha-Tenderfoot region.—The reported discovery in 1907 of rich placers in the upper Chena basin has not been verified by the later prospecting. There appears to be no doubt that the region is auriferous, however, and as it lies in what would seem to be the normal extension of the Fairbanks gold belt, there is good reason to suppose it may yet yield commercial placers. It can not be denied that the prospecting that has been done during the last two years has not met with any great amount of success. Some of the creeks, however, have made a small production, and there are still in this field a number of prospectors who are sufficiently encouraged to continue their work. The placers of the Salcha and Tenderfoot basins were hampered by the same dry-weather conditions that prevailed at Fairbanks. In spite of this, the production has continued about the same as in 1907, which is estimated to have a value of $300,000 to $450,000. On Tenderfoot Creek, the largest producer, 7 claims were worked by 100 men during the winter and 8 claims, employing about 120 men, during the summer. Two claims were worked on Banner Creek and 2 on Democrat Creek, a tributary of Banner Creek.

Rampart district.—The Rampart district, as here defined, includes the drainage basins of Minook Creek and of some other streams tributary to the Yukon near the town of Rampart. Only seven operators in this district replied to requests for statistical information, giving a total production of $9,000. This, of course, represents only a part of the total output of the district. It seems probable that the production of 1907 was nearly twice as great as that of 1908.

Mining was almost entirely suspended in this district during July and August because of low water. (See p. 226.) The more important operations during the rest of the summer included work with two hydraulic plants on Hunter Creek and one with an elevator on Hoosier Creek. Three automatic dams were in operation on Little Minook Creek and one on Hoosier Creek. A small amount of open-cut manual work was done on Ruby, Slate, and Little Minook, Jr., creeks. Some sluicing was also done on Quail Creek.

During the last two years some prospecting has been done on Morelock and Shevlin creeks, which flow into the Yukon from the north about 20 miles above the mouth of the Tanana. The gravels of these streams have been found to be auriferous, and some sluicing was done in 1908 on a bench claim at the confluence of Morelock and Bonanza creeks.

Hot Springs district.—The Hot Springs district is comprised in the basins of Baker Creek and other tributaries of the lower Tanana. This region was a focal point of interest during the summer of 1908, and there was a considerable influx of miners from other parts of the Yukon basin. In 1907 good prospects were found on Sullivan Creek, and in 1908 these placers made a considerable production in spite of the low-water conditions. In addition, other workable deposits of auriferous alluvium were found in the region lying between Sullivan Creek and the northern tributaries of Baker Creek. The auriferous belt thus roughly blocked out stretches from Sullivan Creek to Elephant Gulch, being about 25 miles long and 5 to 10 miles wide. Within this area some rich ground has been found, notably on Glenn and Thanksgiving creeks, as well as on tributaries of Pioneer Creek, and the district promises to become a large producer.

The low-water conditions of 1908 (see p. 213) prevented any very extensive mining operations, but the total production for the year is estimated to be about $150,000, about one-sixth of which was taken out during the winter. It is estimated by W. B. Ballou, United States commissioner at Hot Springs, that 4 claims were worked during the winter by 8 men and 12 claims during the summer by about 100 men, including those that were doing dead work.

On Thanksgiving Creek a considerable area was stripped of moss preparatory to ground sluicing and a bed-rock flume was excavated. Water was almost lacking, so very little sluicing was done. On Glenn Creek, Seattle bar, and What Cheer bar some open-cut mining was accomplished. On Eureka Creek two open-cut plants were in operation when water permitted, and an extensive system of flumes was installed. A mile of ditch was built on Sullivan Creek for open-cut mining on Tufty Gulch. Several smaller ditches were also in part completed on Sullivan Creek, where during the winter some deep mining was done, considerable ground was stripped, and some bed-rock flumes were excavated.

Bonnifield and Kantishna region.—The Bonnifield and Kantishna placer districts, lying along the northern margin of the Alaska Range, continue to encourage a small mining population. Gold has been found on six or seven creeks, and a small production is made annually. No rich diggings, however, have been found except on a few claims located the first year in the Kantishna region. The large bodies of gravel, though known to be auriferous, have not been proved to carry gold in commercial amounts, and the most encouraging feature of the gold deposits of this district is their close proximity to the high mountains, which will furnish a water supply for hydraulic purposes—a condition almost unique in the placer-mining districts of the Yukon region. It is estimated that the total value of the gold output of these two districts for 1908 was less than $20,000.

Chandalar district.—According to S. J. Marsh, United States commissioner at Caro, 11 claims, employing 23 men, were worked in the

Chandalar district during the summer of 1908. The largest production came from Big Creek, but there was also a considerable output from St. Marys Creek and a small amount of gold was obtained from other streams in the course of prospecting.

As in the other Yukon camps, scarcity of water considerably curtailed production. The district also labors under a great disadvantage because of the cost of taking in freight. All supplies must now be brought by poling boat in summer or dog team in winter from the head of steamboat navigation on the Chandalar, a distance of 60 miles, or from Fort Yukon, a distance of 150 miles. Considering these disadvantages the production last year of about $25,000 worth of gold is very creditable and exceeds that of the previous season. Efforts are now being made to have a direct road constructed from Yukon River, a distance of about 100 miles, following a route along which a trail has in part been established. The reported discovery of auriferous lodes in this field has already been referred to (p. 30).

Koyukuk district.—There is little information at hand regarding the Koyukuk district beyond the fact of its general prosperity, in spite of the low-water conditions that prevailed during the summer of 1908. This prosperity is due chiefly to the impetus given to prospecting by the discovery of rich placers at a depth of 130 feet on a claim on Nolan Creek. During the fall of 1908 an extension of the rich ground on Nolan Creek is said to have been found.

There were no changes in the cost of operating, which are still very high. The low-water conditions not only curtailed mining, but also disorganized the steamboat transportation service. In former years steamers from the Yukon have usually reached Bettles by June 20, but in 1908 the first boat did not arrive until July 4, and on account of low water was forced to discharge its freight 6 miles below Bettles.

Only eight operators replied to requests for statistics on production in 1908, and their total output aggregated $116,000. It is confidently believed, however, that the output of the district exceeded $200,000, and hence was more than twice as much as that of 1907.

Lower Yukon and Kuskokwim.—Mr. Maddren presents an account of the gold placers of the Gold Hill, Ruby Creek, and Innoko regions elsewhere in this volume (pp. 229–266). The results of his investigations are of importance to the mining industry in indicating the presence of what seems to be a southwesterly extension of the gold-bearing rocks of the Yukon-Tanana region. Though the entire production from these districts during 1908 was less than $100,000, yet the mere presence of gold should give impetus to prospecting. In this connection it may be noted that auriferous gravels have long been known to occur on the Melozitna and also on the Anvik, though no workable placers have been developed.

During the past summer discoveries of rich placers were reported on Tuluksak River, which flows into the Kuskokwim from the east, about 60 miles above Bethel. It appears that some prospectors took out several thousand dollars' worth of gold from creeks in this region with the aid of rockers alone. The information in regard to this find is not very definite, but it is a significant fact that the reported locality of this discovery lies in what would be the extension of the Innoko gold-bearing belt. The district is at least worthy of further investigation.

NORTON BAY.

So far as known, the only productive placers of the Norton Bay region are those of Bonanza Creek, which flows into Ungalik River,[a] the first large easterly tributary to Norton Bay, its mouth being about 10 miles east of Cape Denbigh. The creek is reported to have only a few claims on it, but these have been considerable producers for several years. Gold is also said to have been found near the hot springs in the Tubutulik River basin, but the amount has not been determined.

SEWARD PENINSULA.

The mining conditions in Seward Peninsula during 1908 are fully summarized elsewhere in this volume by Mr. Smith (p. 267) and Mr. Henshaw (p. 355). Mr. Smith shows that the low-water conditions and the approaching exhaustion of some of the ancient rich beach placers largely curtailed the gold production. Great difficulty has been experienced in obtaining accurate statistics of the gold production of Seward Peninsula, owing to the neglect of many operators to furnish statistical data of output, or even to reply to the communications sent to them. At this writing replies have been received from only 77 mine operators, a number which is believed to be only about 50 per cent of those who were producing gold in 1908. (See p. 17.)

KOBUK DISTRICT.

Mention has already been made (p. 31) of the reported discovery of gold and copper bearing lodes in the Kobuk River region. This district, in spite of its inaccessibility, has maintained a small placer-mining population for several years. Supplies for this camp are sent up Kobuk River by steamer to Shungnak, about 200 miles, and thence freighted by poling boats or dog teams to the placer mines. Another route of communication is up Dakli River, a northerly tributary of the Koyukuk, thence by an east portage through Zane Pass and down Pah River to the Kobuk. Data in regard to the mining development in this field are available through the courtesy of Lewis Lloyd and M. F. Moran, of Shungnak.

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[a] Locally known as Ungatalik.

The area in which gold placers have been found is, roughly, about 10 miles square and drains into Kobuk River. Of the several streams in this area, Shingnek [a] and Dahl creeks have been found to carry workable placers. The bed rock in the mineralized area is said to be mica schist, slate, calcareous schist, greenstones, and granite, and the statement corresponds to the observations made by Mendenhall [b] during his hasty exploration of this stream in 1901.

There has been some mining on Shingnek Creek for nearly ten years, and the entire production is estimated to have a value of about $50,000. This gold has been taken out of seven or eight claims, located about 9 miles from the Kobuk. The bed rock is mica schist and greenstone schist, and the gravels are only from 1 to 3 feet in depth. Most of the gold is fine, but one nugget has been found which weighed 2¾ ounces. In 1908 three or four men were mining on this stream. The work is accomplished with the aid of wing dams, and periods of high water interrupt operations.

Dahl Creek is about 10 miles in length and its productive placers are distributed along the upper 6 miles of its course. The bed rock is reported to be schist and the gravels from 2 to 8 feet in depth. The gold recovered contains a large proportion of nuggets, and one of these weighed 3½ ounces. At the head of the creek is found angular gold that seems to be practically in place. The adjacent schist is full of quartz stringers, some of which carry free gold. Mining on this creek has been spasmodic. The total production is estimated at about $40,000, taken chiefly from claims Nos. 1, 2, 5, 6, 7, and 8. Values as high as $15 to the shovel are reported.

Placer gold has also been found near the head of the Noatak and at other localities in this district, but not in paying quantities. The occurrence of copper nuggets in some of the stream gravels of the Kobuk district has already been noted (p. 31). The white population of the district is estimated at about 20 men, and the annual gold production at about $10,000 to $15,000. An interesting feature of the mining is that Eskimo [c] laborers are very largely employed, and are said to make very good workmen.

NONMETALLIC MINERAL DEPOSITS.

During 1908 the mining of nonmetallic deposits was confined to the operating of a few widely distributed coal mines, some marble quarries, and a gypsum mine in southeastern Alaska. There was also a small production of mineral waters from southeastern Alaska. The marble and gypsum deposits, described by Mr. Wright elsewhere in this report (see pp. 84–85), show a production valued at $70,000 [d] in

[a] Locally known as Shungnak.

[b] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska: Prof. Paper U. S. Geol. Survey No. 10, 1902, pp. 31-35.

[c] The native population of this part of Alaska is Eskimo and not Indian.

[d] This is the estimated value of the raw product at the locality of production.

1908, as compared with $63,908 in 1907. The following is a statement of the value of these two products during the last eight years:

Value of marble and gypsum produced in Alaska, 1901–1908.

1901	[a] $500
1902	[a] 255
1903	[a] 389
1904	1,700
1905	710
1906	11,995
1907	[b] 63,098
1908	[b] 70,000
	148,647

In 1908 four coal mines were in operation—the same as in 1907. Preliminary estimates of production indicate that only about 4,000 short tons of coal were mined in 1908, as compared with 10,139 short tons in 1907. The coal mined is used only for local consumption, and the decrease is therefore not significant. One of the coal mines, the largest producer, is on Seward Peninsula (see p. 362); the others are on the Pacific seaboard (see pp. 116–145). In addition to these mines, which are regularly operated and from which statements of production are available, a little coal is extracted for domestic use at probably five or six other localities. One of these is on Wainwright Inlet, in the extreme northwestern part of Alaska, where Eskimo mine a little coal for their own use. Another is at Cape Lisburne, where a little is probably furnished to the local shipping. There are also several places in the Yukon basin and on the Pacific seaboard where a few tons of coal are extracted each year.

The subjoined table shows the production of coal in Alaska for the last twenty years:

Production of coal in Alaska, 1888–1908.

Year.	Amount (short tons).	Value.	Year.	Amount (short tons).	Value.
1888–1896	6,000	$84,000	1904	1,694	$7,225
1897	2,000	28,000	1905	3,774	13,250
1898	1,000	14,000	1906	5,541	17,974
1899	1,200	16,800	1907	10,139	53,600
1900	1,200	16,800	1908	4,000	19,000
1901	1,300	15,600			
1902	2,212	19,048		41,507	315,079
1903	1,447	9,782			

NOTE.—The production for 1888–1896 is estimated on the best data obtainable. The figures for 1897 to 1907 are based for the most part on data supplied by operators; those for 1908 on preliminary estimates.

Mining developments in the Bering River coal field of the Controller Bay region and in the Matanuska coal field of the Cook Inlet region were practically confined to surveys for patents, assessment work, and trail building. The most important features are connected with the problem of railway construction, which has already been

[a] Estimated.

[b] The value for 1908 is in part based on statements from the producers, but the full returns are not obtainable at the date of the publication of this report.

referred to (p. 23). Certain features of the coal-land law have appeared to discourage capitalists from entering into projects of developing these coal fields.

Little advancement was made in the Controller Bay region in 1908. Up to the close of the year no patents for coal land had been granted, and this discouraged all mining and transportation enterprises. A few trails and telephone lines were constructed, however, and a little prospecting of coal beds was done. The construction of railways to the coal field appears to have been practically suspended in the early part of the year, but a survey was made for a new railway to connect the field with a wharf to be located on one of the small islands in Controller Bay.

Some bituminous coal was mined on Bering Lake during the early part of 1908 and shipped to the coast in barges. This output, with that of the previous year from the same source, was important, inasmuch as it made possible the commercial testing of these fuels.

It is reported that more coal has been found in the Matanuska field south of Matanuska River. There was considerable prospecting in this district during 1908, and the results are said to have been encouraging.

The two oil wells near Katalla furnished a small production of petroleum in 1907, which was used for fuel for the construction work then going on in the vicinity. No further drilling has been done in the oil fields, and probably none will be attempted until transportation facilities are improved.

Through the courtesy of E. De K. Leffingwell, who is engaged in making geographic and geologic studies along the north coast of Alaska, the writer has learned of the occurrence of what appears to be a petroleum residue about 100 miles east of Point Barrow. Mr. Leffingwell describes this material as occurring near Smith Bay, in a mound several hundred yards in diameter and standing about 150 feet above the level of the tundra. The material resembles asphalt, but contains considerable vegetable matter and silt. It would appear to be the residue from petroleum which had impregnated peat, and the volatile constituent of which had mostly evaporated. David T. Day made an examination of a specimen of this substance collected by Mr. Leffingwell, and reported the following results:

Composition of petroleum residue from Smith Bay.

Water and water-soluble matter	22
Alcoholic extracts (resins and some oil)	8
Naphtha extracts:	
Light oil	12
Heavy oil	16
Benzol extract (asphaltic material)	11
Clay and vegetable fiber	29
	98

This material resembles that described by Martin[a] from Cold Bay, Alaska Peninsula, which was formed by the soaking of a peat bog in the emanations from a petroleum seepage. At Cold Bay, however, the petroleum has a paraffin base, whereas that at Smith Bay has an asphalt base. It seems probable, then, that the material collected by Mr. Leffingwell owes its origin to a petroleum seepage. Occurrences of similar substances have been reported by whalers from the north coast of Alaska, but the localities are not definitely known. So far as known, the region near Smith Bay is underlain by Tertiary beds.

In this connection, it is worthy of note that W. Howard, U. S. Navy, during his exploration of upper Colville and Chipp rivers, reported a similar occurrence.[b] It seems worth while to quote Dall's description of this occurrence in full:[c]

> Here they found on the surface rather abundantly scattered masses of a brown material resembling powerfully compressed peat, recalling pitch in hardness and weight, but not brilliant nor disposed to melt with heat, but making a clean cut, like "plug" tobacco, when whittled with a knife. This material was sufficiently inflammable to ignite and burn with a steady flame on applying a match to a corner of it, so that in their cold and weary journey it formed a most welcome substitute for wood or other fuel for the camp fire.

These fragmentary data point to the conclusion that there may be a petroleum field in this extreme northern part of Alaska. Were the region not so inaccessible, it would certainly be worth while to investigate these occurrences, but as it is, even if petroleum is found, it could not now be brought to a market.

[a] Martin, G. C., Petroleum of the Pacific Coast of Alaska: Bull. U. S. Geol. Survey No. 250, 1905, pp. 56-57.

[b] The exact locality of Howard's observations is not known, but it is significant that he was also in the neighborhood of Smith Bay during his journey.

[c] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 818-819.

THE POSSIBLE USE OF PEAT FUEL IN ALASKA.

By Charles A. Davis.

More than 10,000,000 tons of peat are prepared and used annually for fuel in the countries of northern Europe, while in the United States and Alaska not 1,000 tons were used in 1908. The high price of coal and other fuel in Alaska, due to the fact that it has to be taken from a distance to the more remote communities away from water transportation routes, and the very general occurrence of peat beds throughout the Territory make it especially pertinent to consider briefly at this time the possibility of utilizing peat prepared by some of the simpler and cheaper methods in use in Europe.[a]

Peat is partly decomposed vegetable matter that is intermediate in character and fuel value between wood and coal. When properly prepared and air dried it burns freely and gives off more heat than the best wood, but not so much as bituminous coal of good quality.

It is of widespread occurrence in the moister parts of the earth and, in a somewhat fibrous form, covers great areas in Alaska, especially in the regions where tree growth is sparse or lacking. In this part of the world it is formed chiefly by the growth and partial decay of mosses, grasslike plants, water plants, shrubs, and more rarely trees. It develops only in places where the ground is covered by water, is very wet, or is frozen, or where the air is very moist. One of the forms of peat is the brown vegetable matter that covers the great barrens and tundras of the northern part of Alaska.

The chief difficulty in using peat for fuel is that it is always saturated with water, or nearly so, as it is found in the beds, and has to be dried before it can be burned. The drying can be done most cheaply and quickly by exposure to the wind and sun.

In northern Europe peat is used for heating and cooking by the common people, and to a considerable extent also for producing steam and for making gas for illuminating and power purposes.

[a] For a more detailed discussion of the uses of peat and the processes of preparing it, the reader is referred to Bulletin 376 of the U. S. Geological Survey, entitled "Peat deposits of Maine," and to a forthcoming bulletin on the peat deposits of the eastern Coastal Plain of the United States. These may be had by applying to the Director, U. S. Geological Survey, Washington, D. C.

For these uses it is prepared and sold as (1) cut peat; (2) machine peat, or pressed peat; (3) peat powder; (4) briquetted peat; (5) peat coke or charcoal. Peat gas is also made, either in retorts, with coke or charcoal and various chemical substances as by-products, or in the gas producer, in which the peat is all converted into a low-grade fuel gas, called "producer gas." This gas may be used for power production, by burning under boilers or, more economically and with greater efficiency, in gas engines of the explosive type. Used in this way, peat is a better fuel than the best grades of bituminous coal burned under steam boilers of the ordinary types.

Peat is also used extensively in Europe and to a less degree in the eastern United States as stock bedding, for which it is especially adapted. It is also used in the manufacture of chemical fertilizers as a filler.

As peat is successfully prepared and used for fuel as far north as 66° 39′ north latitude in Sweden, and in Iceland, where the season is very short and the air very moist, there seems to be no reason why it should not be used in Alaska, in places where other fuel is costly, even if labor is high. In the expectation that the great stores of fuel in the peat beds of Alaska may be used to some extent, the following brief statement of simple ways of preparing the peat for use is given.

Cut peat is made by cutting out the denser layers of peat beds with spades. The part of the bog to be used is drained, if necessary, by ditches from 30 to 50 feet apart and 1 foot wide. The peat is cut from a working trench started at right angles to and at the head of the ditches. The cutting is done with sharp, straight, narrow spades in regular courses, which are as wide as the bricks are long and as thick as the length of the spade will permit. The courses are further divided by horizontal cuts which regulate the thickness of the bricks. The size of the bricks depends on the readiness with which the peat dries and its density. Small bricks should be made if the climate is moist and the peat dense. In Europe the bricks are cut from a foot to a foot and a half long and from 4 to 6 inches wide and thick. In some localities the spade used for cutting has a narrow steel lug welded at right angles to the point, so that two sides of a brick can be cut at once.

As fast as the bricks are cut they are laid on the surface of the ground near the opening, where they are left for one or two weeks until dry enough to handle. They are then stood on end in groups of six or seven, with two others laid crosswise on the top of the pile. At the end of another two weeks, more or less, the bricks are turned and piled into larger heaps, being laid up in crib or cob fashion. They may be left in these piles until dry, or after a time piled into open stacks, the tops of which should be covered with turf or other covering that will shed water, as the bricks are very absorbent. The only tools needed for making fuel by this method are sharp, strong spades, or strong, long-bladed knives. Coarse and poorly decomposed peat is not very satisfactory fuel when prepared in this way. In Europe the diggers are paid by the thousand pieces cut and laid out, and in the same way for turning and drying. The cost per ton for the production of air-dried bricks varies from as low as 53 cents to $1.75, according to the kind of peat cut, the wages paid, and the efficiency of the men.

Another form of peat fuel is machine peat, also known as pressed or condensed peat. Coarse, fibrous peat makes a better fuel when it is reduced to a pulp by grinding it with the addition of water, and afterward shaping it into bricks and drying it as for cut peat. The grinding may be done by throwing the peat into a hole in the bog, mixing with water, and trampling it until the mass is reduced to a thick porridge. Instead of the hole, a box or trough of wood or metal may be used, and the trampling may be done by a horse. Sometimes a shaft armed with knives, curved screw-fashion, is placed lengthwise in the box, and by means of simple mechanical gearing is turned by horsepower. The peat must be made very wet to be successfully ground in this form of machine and the trough must be at least 15 feet in length.

After the peat is reduced to a thin, fine pulp it is removed in barrows and spread out on the cleared and smoothed surface of the peat bed, in a layer 6 to 8 inches thick, and marked off into bricks of the desired size with a knife or by hand. The bricks soon become dry enough to handle, shrinking apart as drying goes on, and may then be treated in the same way as the cut bricks.

A more modern way of making this product is with a peat machine, which is, in effect, an iron cylinder, with a hopper for receiving the peat at one end and a square nozzle for shaping the peat into a prismatic strand as it is pressed out at the other. Inside the cylinder is a revolving, knife-armed shaft, with the knives curved to form a screw, as in a brickmaker's pug mill or in some of the meat grinders so commonly used. The bricks are formed as the wet peat is forced from the nozzle. Such machines are made in all sizes, from one requiring a single horse for motive power and turning out from 3 to 5 tons of peat fuel a day (air-dry weight) to those run by powerful steam engines and making 50,000 or more bricks a day.

Machine peat, in whatever way it is prepared, is more compact and more easily handled, breaks up less readily, and dries more quickly and thoroughly than cut peat and is nearly waterproof after the outside is once dry. The cost of making it in Europe varies from 85 cents to $2 a ton, but is generally about $1 a ton.

The other processes mentioned for preparing peat for fuel are probably not adapted to conditions existing in Alaska, although peat might be used as a source of producer gas in many localities where electric or other power is required, as in mining operations. For use in the gas producer, the peat should be machined and at least partly dried.

The amount of fuel in a peat deposit may be roughly estimated by finding the area in acres and average depth in feet, and multiplying the product of the two by 200, the number of tons of air-dry fuel which can be made from an acre of peat 1 foot in depth.

The proper time to make peat fuel is in the early part of the spring and summer, the season running from the middle or last of April until early September. If frozen while wet, the bricks are very spongy and fall to pieces readily.

If peat is to make good fuel, it must be dried clear through to the air-dry state; when it is in this condition it burns with a clear, bright, long, nearly smokeless flame and gives out a strong and lasting heat; if it smoulders and requires much draft to keep it afire, it has not been properly dried, for dry peat burns in a common stove with but a very slight draft, and a fire once started in it will not go out until the last bit of the fuel is gone, even if the draft is cut off entirely. Early cutting, thorough drying, and some protection from the heavy rains are the chief secrets of success in making and using this material for fuel.

Peat litter for bedding horses is made by drying and pressing into bales the more fibrous kinds of peat. A bed of this material 6 inches thick will last for months and is greatly superior in springiness and absorbent qualities to the best hay or straw. The moss growing on the top of many of the peat beds, when dried, is a good material for packing all perishable articles of food, as it is strongly antiseptic and serves also as a protection against freezing and breakage.

MINING IN SOUTHEASTERN ALASKA.

By Charles W. Wright.

INTRODUCTION.

The year 1908 has marked but little advance in the mining industry of southeastern Alaska as compared with previous years. At some of the gold mines in the Juneau district—the Treadwell group and the Perseverance and Eagle River mines—a substantial gain was made and extensive mining and water-power projects have been undertaken which promise well for considerable activity during 1909. The copper mines of the Ketchikan district, on the other hand, have suffered a considerable setback because of the decrease in the market value of the metal, and some of the mines were idle throughout the year.

As each successive year has added to the general knowledge of the distribution of the rock formations and ore deposits in southeastern Alaska, it has been customary to give a résumé of the general geology in the annual progress reports. This year a repetition of these facts is deemed unnecessary in view of the fact that detailed reports on the Juneau, Ketchikan, and Wrangell mining districts have been issued. This summary report will therefore deal mainly with the progress of the mine developments in southeastern Alaska during the year and will include a preliminary statement regarding the geology and ore deposits of Kasaan Peninsula and Hetta Inlet, areas which were mapped in detail during the last summer.

GOLD MINES AND PROSPECTS.

GENERAL STATEMENT.

There are a large number of prospects in southeastern Alaska on which auriferous quartz veins have been developed to a greater or less extent, and many of them yield high gold values. Many of such deposits, however, lack the required tonnage of ore to make mines, and only a few of these veins have been large gold producers. The greatest output has been obtained from the extensive low-grade lode deposits, and on these the future of the district as a gold producer largely depends. The lode deposits have been found principally along the mainland in the Juneau district, and consist of the more heavily mineralized portions of the country rock within the mineral zone which has been described as the "Juneau gold belt."[a] Many of these mineralized bodies carry only valueless traces of the precious metals, but there are doubtless some unexplored deposits that carry sufficient valuable ore to make mines, and a greater effort should be made to find and develop such ore bodies.

It has been shown at the Treadwell, Perseverance, and Alaska-Juneau mines, where a large tonnage is available, that ore can be mined and milled for about $1 a ton. However, the fact must not be overlooked that a large daily production and a plant adequate to handle it is necessary for such economical mining. The greater part of the gold contained in the deposits mined is extracted by amalgamation, though the sulphide minerals carry considerable gold and most of the stamp mills are equipped with a concentration plant, the concentrates from the ores being shipped to the smelters for treatment.

GOLD PRODUCTION.

The production from the gold mines in southeastern Alaska for 1907 and an approximation of their output for 1908 are given in the following table:

Production of the gold mines in southeastern Alaska.

Year.	Ore mined.	Gold.		Silver.		Average per ton.			
						Gold.		Silver.	
		Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
	Tons.	*Ounces.*		*Ounces.*		*Ounce.*		*Ounce.*	
1907	1,206,639	132,300	$2,734,885	22,203	$14,653	0.110	$2.27	0.18	$0.012
1908[a]	1,650,000	165,844	3,428,000	35,849	19,000	.100	2.07	.21	.011

[a] Estimated.

The increase in the production for 1908 is due to the greater output from the Perseverance and Eagle River mines and the Treadwell group.

JUNEAU DISTRICT.

MINES ON DOUGLAS ISLAND.

The only mining operations in progress on Douglas Island during the year were at the Treadwell group. These mines are so well known that only a brief mention of the recent developments will be made. One of the principal features of economic interest has been the increase

[a] Bull. U. S. Geol. Survey No. 287, 1906, pp. 22-38.

in the power-producing facilities and the reduction in the cost of power. Last year oil was introduced in place of coal, and this year a considerable reduction of expense is reported because of this change of fuel. The amount of water power has been increased during the year by the completion of a new 72-foot dam across the basin at the head of Fish Creek, and another 60-foot dam at an elevation of 1,200 feet on Ready Bullion Creek is nearly completed. These storage basins will add considerably to the present water supply during the winter months. A much greater engineering problem is the development of the water power from Lake Turner on the east side of Taku Inlet, which is being undertaken by the Treadwell Mining Companies. Lake Turner is 7.9 miles long, averages half a mile in width, and in places exceeds 100 feet in depth. With the completion of a dam at the mouth of the lake an elevation of 65 feet above tide water will be obtained, and it is estimated that 10,000 horsepower can be developed throughout the year. The transmission of this electric power across Taku Inlet will require a cable span of 2½ miles, and thence it is a distance of 18 miles to Treadwell.

The Treadwell mine has been opened largely on the 1,450-foot level, which will be used as a base level for deeper exploration, and to which the Seven Hundred Foot and Mexican shafts will be extended. Below this level the shafts will be inclined to follow the dip of the ore body. The ore mined during the year was principally from the 900-foot and 1,050-foot levels, and to some extent from the 600-foot, 750-foot, and 1,250-foot levels.

On the Seven Hundred Foot claim the 100-stamp mill was reconstructed and put in operation early in February. A new shaft house was built, the shaft was extended to the 1,450-foot level, and the 1,250-foot level was partly developed. The ore mined was derived mainly from the 880-foot and 990-foot levels.

The main developments at the Mexican mine consist of the extension of the shaft which will eventually be connected with the 1,450-foot level of the Treadwell mine. Work was continued on the 1,100-foot level, and the ore extracted was principally from the 770-foot, 880-foot, and 990-foot levels.

At the Ready Bullion mine the 1,500-foot level was opened and developments were nearly completed. The 750-foot level was extended to explore the south ore body exposed on the surface. At this level it was found to be separated from the middle ore body by 12 feet of slate country rock, but its lateral dimensions have not yet been determined. The ore mined was from the 1,200-foot, 1,300-foot, and 1,500-foot levels.

The production statistics for 1908 from these mines show an output of 1,367,920 tons, yielding $2,999,420, or an average of $2.17 per ton.

GOLD CREEK MINES.

There are three large lode mines on Gold Creek—the Perseverance, Alaska-Juneau, and Ebner. These properties are all located along the same mineral zone which has been described in detail in a previous report.[a]

Considerable progress was made at the Perseverance mine this year, though operations were handicapped by a lack of sufficient power. Development work was carried on throughout the year, and the main ore body was opened at the tunnel level for a length of 1,500 feet, its width varying from 60 to 100 feet. Twenty-five feet above this level the intermediate level, from which the stopes are being started, has been extended over a length of 1,400 feet, and chutes have been driven at intervals of 20 feet to connect with the tunnel level. The 100-stamp mill on the property was started June 1 and was operated continuously until the end of October. The mine developments will be continued throughout the winter and 100 additional stamps are to be added to the mill.

At the Alaska-Juneau mine mining was renewed the last of June and continued until the middle of October. During this period 35 men were employed and the 30-stamp mill on the property was in continuous operation. The ore milled was derived principally from the open pits, and the mine developments consisted in extending a raise from the upper-pit tunnel to connect with the upper pit. The output was about the same as for 1907.

Operations at the Ebner mine were suspended throughout the year pending a sale of the property.

At the Hallam group of claims, adjoining the Ebner mine on the northwest, surface explorations were in progress during the summer, and encouraging results are reported.

Placer mining was in progress in Silverbow Basin for several weeks early in the summer, but a lack of equipment prevented extensive operations and little was accomplished.

MINES NORTH OF JUNEAU.

The principal mining operations along the mineral zone extending from Juneau to Berners Bay were at the Eagle River mine, where developments were carried on throughout the year. The ore body that is being mined is a well-defined quartz vein inclosed in the slates and locally enriched by ore shoots. This vein deposit is displaced by faults which have caused much difficulty in its exploration. The underground workings were extended on the four tunnel levels through the main fault, which includes a width of 50 to 100 feet of

[a] Bull. U. S. Geol. Survey No. 287, 1906, pp. 56-85.

crushed material, and the ore body was located. About 50 feet beyond the main fault a second displacement was encountered with about 6 inches of gouge along the fault plane, and further explorations on the first, second, and third levels opened the vein deposits, which had apparently been displaced about 70 feet to the north. Most of the ore mined was derived from the upper workings above tunnel No. 1. The 20-stamp mill was run to its full capacity during the year, except in the winter months, when only 5 stamps could be operated because of a lack of water for power purposes. This difficulty, however, has been partly eliminated by the building of a flume to a creek near Eagle Glacier, from which it is believed a sufficient water supply will be obtained to give ample power during the winter months.

To the north of Eagle River, at Yankee Basin, a crew of men was employed during the summer to develop the Dividend and adjoining claims. The crosscut tunnel on the Dividend claim is 1,170 feet in length, intersecting the lode at a point 990 feet from its mouth at a depth of 350 feet. From this tunnel a drift has been extended for 250 feet to the southeast along the ore body, and considerable ore was thus developed. On the Black Chief group the Gold Pan vein has been developed by a crosscut 90 feet long intersecting the vein at a depth of 75 feet and by a 22-foot drift along the vein. In the creek, 150 feet below this tunnel, a second vein from 2 to 5 feet wide has been partly developed. On the B. C. claim, to the south of the Black Chief, a 100-foot tunnel and 100 feet of crosscutting have been completed and a well-defined quartz vein has been developed. On the other properties within this area assessment work is said to have been done, and on some of them a small amount of development work was done.

At Echo Inlet several men were employed to explore the Gold Standard group of claims, and considerable progress was reported.

The Jualin mine, the only property in the Berners Bay area where mining was done during the year, was worked under lease by a small crew during the winter and spring months. Early in the summer, however, these operations were suspended, and the property has since been idle.

On the numerous prospects on Salmon Creek, McGinnis Creek, Montana Basin, Peterson Creek, and Windfall Creek work has been carried on principally by the owners, and only in a few places have the developments been in excess of the annual assessment requirements.

MINES SOUTH OF JUNEAU.

The mines south of Juneau have been inactive during the year, except the Crystal mine, at Port Snettisham, where work was resumed in April and 10 men were employed until November. During this period developments were extended from the upper level toward the surface of the Crystal vein, which varies from 18 inches to 5 feet in width, and considerable ore was stoped out. On the southeast end of the Daisy Bell claim the vein was stripped along the surface for 200 feet, a tramway was built to the mill, and a small amount of ore was mined. The 5-stamp mill was in operation for fifty days, and an average of 15 tons of ore a day was treated during this time.

At the Holkham Bay group of claims, on the south side of Endicott Arm, a little development work was done along the surface on the main ore body, a quartz vein, and considerable advance was made in the crosscut channel, which it is supposed will cut the vein 400 feet from its mouth.

Explorations at Limestone Inlet have been advanced on the Enterprise and Arizona groups of claims. These properties are on the north side of the inlet, at an elevation of 1,000 to 1,500 feet and from one-half to three-quarters of a mile from tide water. The ore bodies are auriferous quartz veins inclosed in a granitic rock, which intrudes the slates and greenstones bordering the shores of the inlet. On the Enterprise claim a quartz vein from 3 inches to 9 feet wide and averaging 5 feet has been exposed by surface excavations for several hundred feet. This vein strikes N. 25° E. and dips 45° NW.; its valuable content is principally free gold. A similar quartz vein, averaging 1½ feet in width, occurs on the Arizona claims, and has been developed by surface cuts for 800 feet. This vein is parallel in strike and dip to the Enterprise vein and also carries free gold. On both of these properties other quartz veins have been discovered but have not yet been developed. Galena, sphalerite, chalcopyrite, and pyrite are present in the veins in small amounts.

Small developments on some of the properties in the vicinity of Windham Bay and on the Sunny Day prospects, at the south entrance to Endicott Arm, are reported, but no extensive mining operations have been carried on in these sections.

ADMIRALTY ISLAND.

Little progress has been made in the development of the properties on Admiralty Island. On the claims of the Mansfield Gold Mining Company a few men were employed throughout the year in driving the crosscut tunnel to cut the vein at a depth of several hundred feet. This tunnel was reported to be 250 feet in length. Surface explorations are said to have revealed other valuable vein deposits on the property. Assessment work is reported to have been done on the Mammoth group, the Portage group, and the prospects at Hawkes Inlet.

SITKA MINING DISTRICT.

The principal mining interests during the last few years in the Sitka district have been in the vicinity of Klag Bay, on the west coast of Chichagof Island, at the De Groff mine and the Mills prospects. These properties are apparently on the same quartz vein, which averages about 5 feet in width and in which the ore occurs in shoots from 40 to 60 feet long. On the De Groff property two such ore shoots have been developed at three different levels by tunnels following the vein. The 4-stamp mill on the property has been operated the greater part of the year, and a considerable gold production is reported. On the Mills prospects, located above and on the northern extension of the De Groff properties, development work was advanced on the surface and in the two main drift tunnels, and ore shoots are reported to have been found within the vein. On the Hirst and Bahrt claims, at Hirst Cove, just north of Klag Bay, prospecting was done during the summer.

The mines and prospects in the vicinity of Silver Bay on Baranof Island have received little attention this year, and no important developments are to be recorded.

WRANGELL MINING DISTRICT.

The mines and prospects within the Wrangell mining district have been inactive during the last year, and except assessment work little has been accomplished. On the Portage Mountain group, at the head of Duncan Canal, a small crew of men was employed during the winter to drive a tunnel to prospect a vein at an elevation of 900 feet, and 60 feet of this work was accomplished.

On Woewodski Island no work was in progress at the Hattie and Smith camps, properties of the Olympic Mining Company. One mile above the Smith camp, on the east side of the lake, a quartz vein was discovered, on which a 40-foot drift tunnel was extended, and encouraging results were reported.

KETCHIKAN MINING DISTRICT.

Little interest has been shown in gold mines and prospects in the Ketchikan district during the year, and except the gold contained in the copper ores the production of this metal was very small.

At Dolomi, on Prince of Wales Island, developments have been confined to the sinking of a shaft on the Jessie claim to a depth of 226 feet. On the 125-foot level drifts were extended for 150 feet, and considerable ore is said to have been developed. A 25-horsepower hoist and boiler plant was installed, also a 2-drill air compressor. On the Valparaiso, Amazon, and other claims only assessment work was done.

The prospects in the vicinity of Hollis, on Twelvemile Arm, have been idle, except the Julia claim, at the mouth of Harris Creek. On this property a pump and air compressor were installed and a small amount of development work was done in the shaft. Assessment work alone is reported from the other properties adjacent to Twelvemile Arm.

At the Goldstream mine and other prospects on Gravina Island no work was done until late in the year, when the annual assessment work was performed.

No developments were in progress at the prospects on Cleveland Peninsula, except at the Old Glory group, where ore was mined and milled in the 2-stamp mill during the spring and a small yield reported.

No important mine improvements or new discoveries are reported on Revillagigedo Island, and most of the prospects were idle throughout the year.

COPPER MINES AND PROSPECTS.

GENERAL OUTLINE.

All the producing copper mines in southeastern Alaska are located on Prince of Wales Island, in the Ketchikan mining district. During 1908 only five of the ten producers of 1907 made shipments, and one prospect, the It, was developed to the producing stage. The metal production from the copper ores was less than half of that for 1907, but the grade of ore shipped was considerably higher than in previous years. In general the mines are working low-grade copper deposits, averaging from 50 to 80 pounds of copper to the ton, though, by sorting the ores, it is possible at some of the mines to increase the grade of the product. There has been practically no change since last year in the cost of producing copper from these mines, but the market value of the metal has decreased from an average of 20 cents to 13 cents a pound. The cost of mining ranges from $1 to $3.50 a ton; haulage from the mine to the wharf from 15 to 50 cents a ton; transportation from Alaska to the smelters at Tacoma or in British Columbia from $1.50 to $3 a ton, including the cost of loading and unloading. The smelters will pay approximately as follows for the ore: Total copper values less 1 per cent and less 3 cents per pound refining charges; 90 per cent of gold and silver values; 10 cents per unit bonus for iron in excess of silica and 10 cents per unit penalty for silica in excess of iron. The charges for treatment are from $1 to $3 per ton. Thus, with the price of copper at 15 cents under existing conditions a copper deposit of large tonnage on Prince of Wales Island should contain at least 3 per cent of copper and $1 to the ton in gold to defray the cost of production. However, some deposits of lower-grade ore may be sorted so as to bring the ore content above 3 per cent of copper.

Deposits containing a considerable excess in iron are more favorable than those with a siliceous gangue. Where the ore is smelted in Alaska the costs of transportation are less, but the expense for smelting is somewhat greater.

There are a large number of copper deposits on Prince of Wales Island where small masses or veins of copper ore are exposed and from which high assay values are obtained. On these the locator performs the required assessment work each year, which often amounts to very little, or even in some instances simply to a relocation. Most of the deposits lack the tonnage of ore which is the essential factor to make a mine, and the surface indications at many of the prospects are unfavorable for the development of any considerable tonnage. It is therefore advisable for the prospector, after he has satisfied himself that some of his mineral claims lack the necessary tonnage, to abandon them, even though they show some rich ore, and to lend his efforts to the development of other more favorable properties, or to the search for new and more promising ore bodies.

PRODUCTION.

The following table shows the ore tonnage and its content of copper, gold, and silver produced from the copper mines in southeastern Alaska during 1907 and 1908:

Production of copper ore in southeastern Alaska.[a]

Year.	Ore mined.	Copper.		Gold.		Silver.	
		Amount.	Value.	Amount.	Value.	Amount.	Value.
	Tons.	*Pounds.*		*Ounces.*		*Ounces.*	
1907	79,982	4,758,814	$951,761	3,384	$69,960	44,196	$29,143
1908 [b]	46,700	3,937,700	519,776	2,806	58,000	39,622	21,000

[a] Computations based on average price of copper $0.20 a pound and silver $0.67 an ounce for 1907, and copper $0.132 and silver $0.53 for 1908.
[b] The figures for 1908 are based partly on estimates.

KETCHIKAN MINING DISTRICT.

KASAAN PENINSULA.

GENERAL STATEMENT.

Kasaan Peninsula is a promontory 18 miles long and 3 to 6 miles wide on the east side of Prince of Wales Island. It is a heavily timbered, mountainous area, with dome-shaped summits reaching altitudes of 1,000 to 2,800 feet and deeply dissected by narrow valleys and gulches. The occurrence of copper on this peninsula was known to the Russians as early as 1865, but not until 1900 were actual developments undertaken. Copper production began in 1905, and the total output at the close of 1907 was approximately 7,000,000 pounds.

The average content per ton of ore mined during this period was 48 pounds of copper, 0.035 ounces of gold, and 0.27 ounces of silver, or an average total value of about $10 a ton. The copper production for 1908 is considerably less than that for 1907, as some of the principal producers were idle throughout the year.

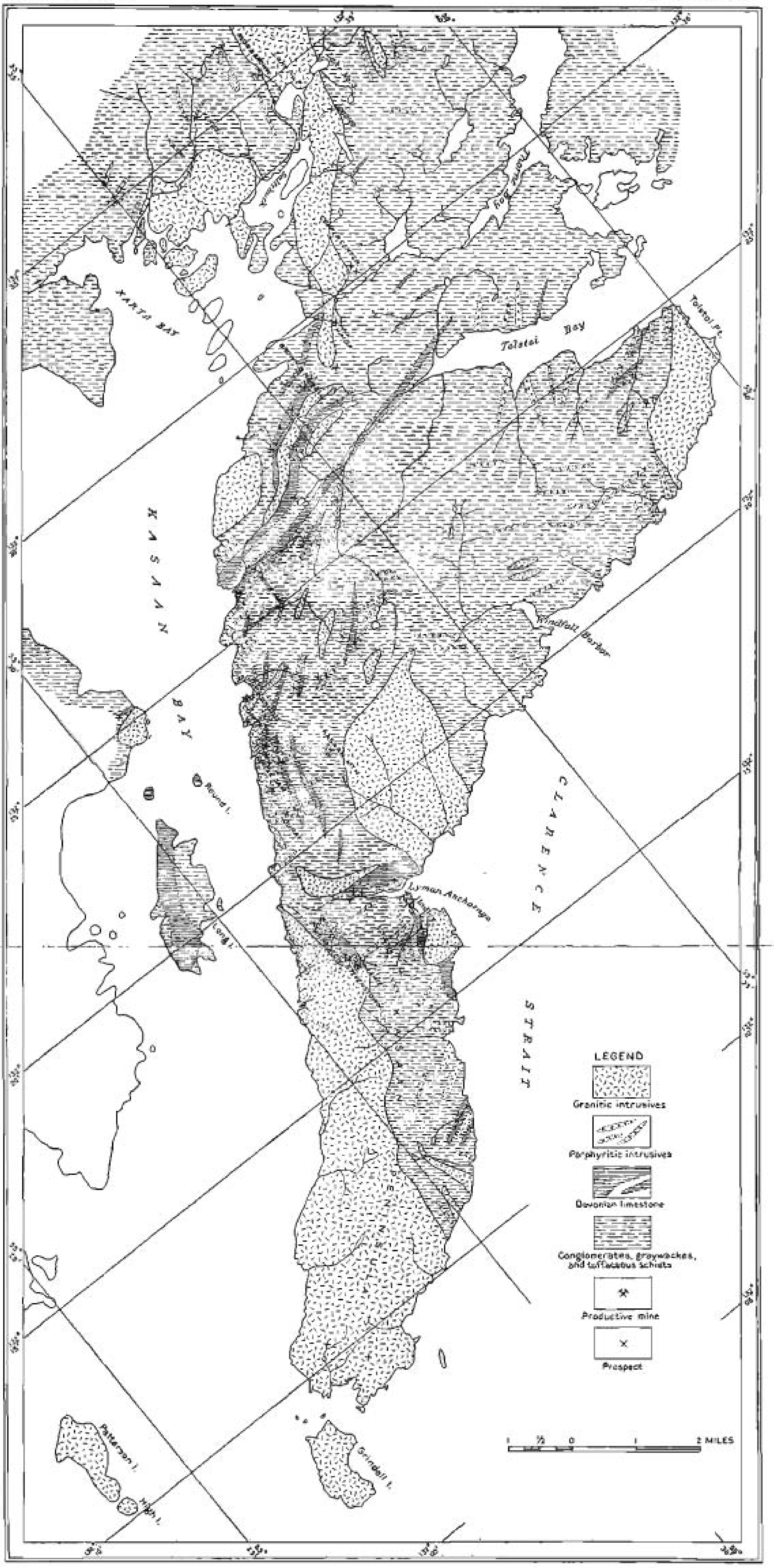
GEOLOGY.

The geologic formations exposed on Kasaan Peninsula are made up of stratified rocks, including those of sedimentary and volcanic origin, and of intrusive granite and porphyritic rocks (Pl. II). The stratified rocks are of consequence to the prospector as the inclosing rocks of the ore bodies, the occurrence of which depends on their composition; the intrusives are significant because they are referred to as the original source of the ore deposits. It is therefore important to know with which of the intrusives and intruded rocks the ore deposits are most commonly found. The accompanying sketch map (Pl. II) shows the distribution of the rocks and the location of the mines and prospects.

The stratified rocks are principally graywackes interbedded with limestones and conglomerates, all of which have been considerably metamorphosed. The tuffaceous material occurs intermixed with the sedimentary rocks in beds of considerable thickness. The graywackes, which are the most widely distributed, are fine to coarse grained rocks of clastic texture, composed largely of feldspar with amphibole crystals scattered more or less abundantly throughout. The bedded structure is lacking in many places and the rock closely resembles a massive igneous rock, though on the weathered surfaces the clastic texture may be readily recognized. The conglomerates are composed of pebbles and cobbles of graywacke, quartzite, limestone, and igneous rocks of granitic and porphyritic textures. There is both a younger and an older succession of graywackes and conglomerates, the discussion of which is left for the detailed report. Limestone beds are intercalated with the graywackes and conglomerates, but are generally crystallized to such an extent that all possible evidence of their age is obliterated. However, on Long Island, which occupies the central portion of Kasaan Bay, limestone beds carrying Devonian fossils occur, and these probably represent the same geologic horizon as the strata on the peninsula.

The structure of the stratified rocks is that of a closely folded synclinorium with a general northwest strike and northeast dip. This structure, however, is interrupted locally by the intrusive masses, and at these places the bedding planes of the stratified rocks are usually parallel with the lines of contact of the intrusives.

The intrusive rocks, which apparently make up the main mass of the peninsula, are exposed over about one-third of the surface area



GEOLOGIC MAP OF KASAAN PENINSULA, PRINCE OF WALES ISLAND.

represented on the map, the individual masses being elongated in a northwesterly direction parallel with the structure of the stratified rocks. The granitic intrusives include granodiorite, syenite, hornblende diorite, and a little granite, and probably represent several minor epochs of igneous invasion during one general period, though in some of the rocks this difference in composition may be attributed to differentiations within the igneous magma during solidification. At the contacts of these granodiorite batholiths various phenomena are presented, such as masses of slightly altered and sheared granodiorite surrounded by unaltered granodiorite, showing sharp contacts in some places, while in others the two phases merge gradually into each other. This suggests a peripheral solidification of the igneous batholith, fracturing of this outer portion, and subsequent introduction of molten rock into the interstices. Again, we find fragments of highly metamorphosed stratified rocks forming angular inclusions in the igneous mass. Some of these fragments are recognized as such only by the presence of parallel lines of biotite flakes, the other portion of the inclusion having been replaced by the intruding magma. A related feature is noticeable in the schist strata adjacent to the contact, which show an introduction of feldspar, quartz, and other pegmatitic minerals along the bedding planes. Such occurrences suggest a partial replacement of the invaded beds by igneous material.

The granodiorite and adjacent metamorphic rocks are intruded by pegmatite dikes, but these are not plentiful. In composition they are closely related to the granodiorites and were probably derived from the same underlying magma.

After the intrusion of the granitic rocks, porphyritic dikes, many of them several hundred feet wide, invaded the stratified rocks as well as the granodiorite. This invasion, like that of the granitic rocks, was accompanied by the introduction of ore deposits.

The most recent rock formations are represented by the numerous smaller basalt and diabasic dikes which crosscut all the rock formations and also the ore bodies.

ORE DEPOSITS.

The ore deposits on Kasaan Peninsula, unlike most workable copper deposits in the States, consist of original or primary ores. Four types of ore bodies, defined by their occurrence and mineral composition, are recognized, as follows:

(1) Contact-metamorphic deposits occurring in irregular masses, from 10 to 250 feet in dimensions, along the contacts of the intrusive rocks (usually with limestones) and composed essentially of chalcopyrite, magnetite, pyrrhotite, and pyrite in a gangue of amphibole, orthoclase, epidote, garnet, and calcite.

(2) Lode deposits occupying shear zones from 5 to 30 feet wide in the stratified rocks and composed of chalcopyrite, pyrite, and usually sphalerite with some quartz and calcite, the ore occurring in lenses and disseminated in the inclosing rock.

(3) Vein deposits occupying fissures from 1 foot to 6 feet wide in the limestones and locally along intrusive dikes and composed of galena, sphalerite, chalcopyrite, and tetrahedrite in a gangue of quartz, calcite, and barite.

(4) Disseminated deposits occurring as irregular masses without defined limits and composed of bornite and chalcopyrite in small masses and particles disseminated in basic diorite intrusives and associated with biotite, epidote, and calcite.

The contact-metamorphic deposits are by far the most important and have been the principal copper producers. A lode deposit has been developed at the Rush & Brown mine, and from it a considerable yield of copper has been derived. Deposits of the third and fourth classes have been prospected at several points, but have not as yet been developed into metal producers.

The copper deposits which are now being mined belong to the first class and consist of low-grade base ores containing high percentages of iron and lime. They yield, therefore, a desirable product for fluxing purposes at the smelters in British Columbia and at Tacoma.

MINE DEVELOPMENTS.

The mines on Kasaan Peninsula were inactive during the winter, and some were idle throughout the year. Early in the summer the Mamie and Stevenstown mines were consolidated under one management and a lease on the smelter was obtained. During August the smelting plant was reconstructed and improved so as to treat a larger tonnage more economically than had been done in previous years, and at the mines the underground workings were pumped out, necessary repairs made, and ore developments extended. Early in September the smelter was put in operation, and from that time until the first of November an average of 360 tons of ore was treated daily. The lack of siliceous ores necessitated the suspension of operations in November, and the smelter was to be closed during the winter of 1908–9. At the mines development work will be in progress throughout the winter in the search for and opening of new ore reserves.

The Mount Andrew property, which adjoins the Stevenstown on the northwest, was not operated during the year.

The It Mining Company, which was organized early in 1908, has been actively engaged in developing the It and adjacent prospects. The copper deposit on the It claims has been explored by a tunnel, crosscuts, and a 66-foot raise to the surface, mostly through ore, and a small body of ore has been developed, the dimensions of which have not been determined. This is a contact deposit with diorite to the southwest and limestone to the northeast, forming the hanging wall. The mineral zone is about 100 feet wide at this point, and along its northwest extension similar deposits are being explored on the Alarm and Reed claims. The ore consists of chalcopyrite, pyrrhotite, and pyrite in a gangue of garnet, epidote, and calcite. The lack of magnetite in these deposits, though that mineral dominates in most of the other deposits on the peninsula, and the presence of pyrrhotite, which is lacking in most of the other deposits, are of interest. Work was not begun on this property until May, but by the end of September a surface tramway 1 mile long, ore bunkers, and a wharf were completed. The first ore shipment was made October 5 to the Hadley smelter, and in November shipments were made to the Tyee smelter at Ladysmith, British Columbia.

The Rush & Brown mine was idle, except for the assessment work, which was accomplished during the summer. However, at the close of the year ore from the bunkers at the wharf, which had been filled in 1907, was shipped to the Tacoma smelter.

At the Goodro, Venus, Copper Center, Brown & Newell, Poor Man, Ouray, Hole in the Wall, and other prospects on Kasaan Peninsula assessment work was reported to have been done, and in some places small developments were in progress.

HETTA INLET.

GENERAL STATEMENT.

Kasaan Peninsula on the east coast and Hetta Inlet on the west coast of Prince of Wales Island constitute the two most important copper-mining areas in southeastern Alaska. The mines and prospects adjacent to Hetta Inlet are included within an area of 50 square miles, at the center of which is Copper Mountain, and during the last year the production from this area exceeded that of the mines on Kasaan Peninsula. During the summer the Alaska road commission constructed a trail from Sulzer, the principal town, to the head of Hetta Inlet, a distance of 3½ miles, thus connecting the town with the wagon road which leads across a portage to the head of Cholmondeley Sound, on the east side of Prince of Wales Island, and affording a short route for travel and mail to Ketchikan. A customs office was also established at Sulzer early in the year.

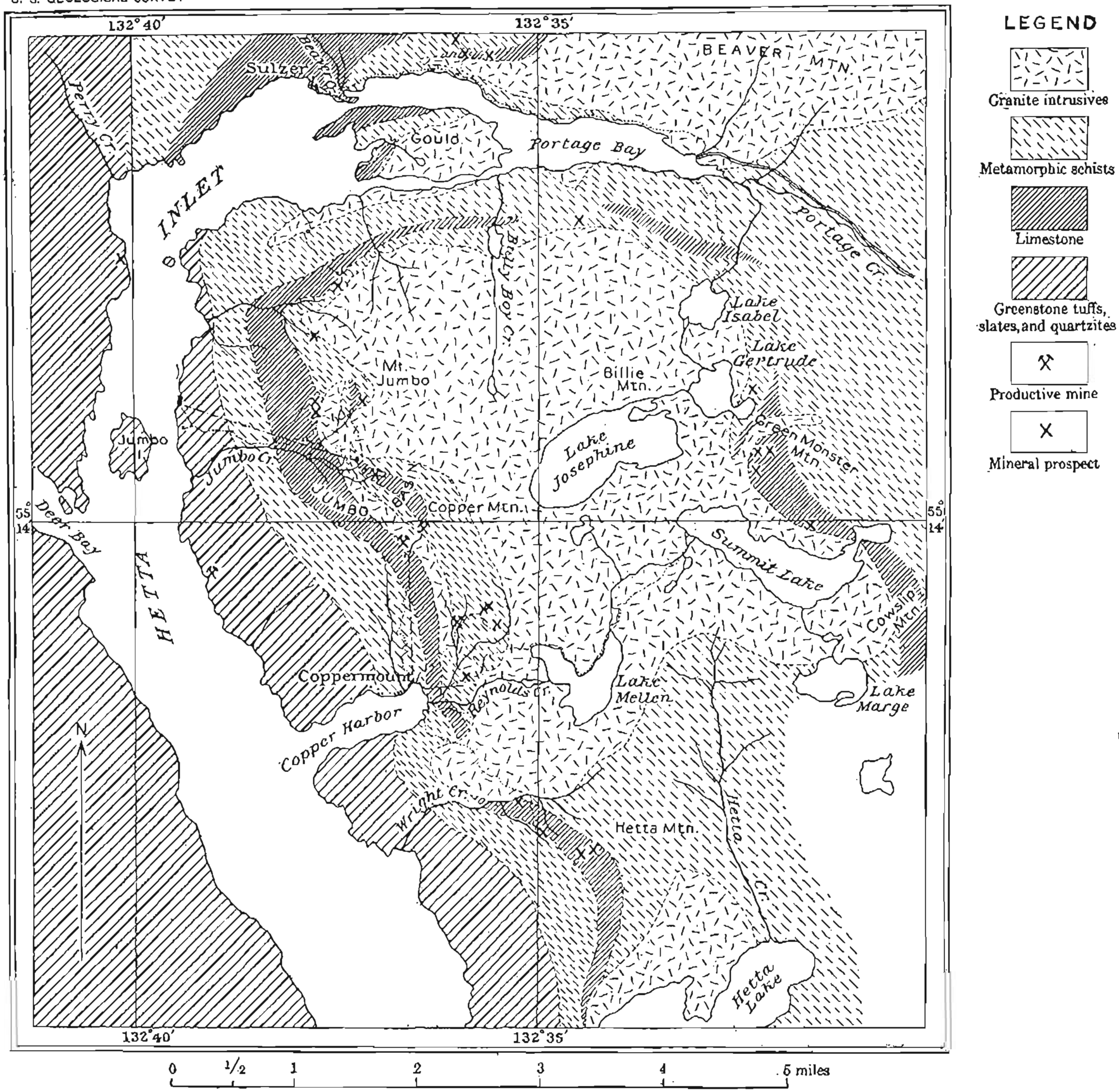
Copper Mountain, which occupies the central portion of the area, has an altitude of 3,961 feet and is the highest peak on Prince of Wales Island. The surrounding topography is abrupt and shows the characteristics of glacial erosion, such as pyramidal peaks, domed summits, amphitheaters, and scooped basins now occupied by lakes. These lakes are important as reservoirs of water for power, which has been developed for both mining and smelting purposes.

GEOLOGY.

The general geology of this area has been described in previous reports, but in view of the additional data obtained while mapping the area in detail during the last summer a restatement of the salient facts pertaining to the geology and ore deposits may be of interest. To present these more clearly a sketch map (Pl. III) is given, showing the general distribution of the rock formations and the positions of the mines and prospects. The most striking geologic feature is the irregular granitic intrusive mass which occupies the central portion of the area. From this mass spurs or dikes, from 30 to 600 feet in width, branch out into the surrounding bedded rocks. In composition this granitic rock varies from a granodiorite to a peridotite, the average rock being an albite diorite. The periphery of the intrusive mass is in places more basic or richer in femic minerals than the central portion, and these minerals, as well as the feldspars, are to some extent replaced by epidote, garnet, sulphides, and other minerals. The granite is surrounded by a succession of metamorphic schists with interstratified limestone beds, the latter being entirely marmorized. These schists are much wrinkled and sheared, and include both calcareous and siliceous varieties. Nearer the intrusive contact they are further altered to a hornstein or amphibolite, which is usually banded with parallel beds of epidosite and rarely garnetite. Locally they are commonly termed greenstones because of their compact, indurated character. These schists are impregnated with the sulphide minerals pyrite and pyrrhotite, which in places form massive bodies, though the amount of copper in them is rarely sufficient to make ore. The limestones are economically of greater importance, as they have assisted materially in the formation of the ore bodies. The principal limestone belt extends from Hetta Mountain northwestward over New York Mountain and into Jumbo Basin; another belt occurs on Green Monster and Cowslip mountains. Narrow bands of schist are interstratified in these limestones, and in turn narrow beds of limestone are interstratified in the schists. Overlying and to the west of the main limestone belt is a considerable thickness of altered siliceous schists which are conformable on the limestone and grade upward into a succession of amphibole and chlorite schists interstratified with quartzites and showing no limestone. These chlorite and amphibole schists, with interstratified quartzites and slates and a few beds of a massive greenstone, probably representing an ancient lava, constitute the slate and greenstone formation which borders the shores of Hetta Inlet.

ORE DEPOSITS.

There are two classes of ore deposits in the Copper Mountain area—contact deposits, occurring between the granite and limestone or



GEOLOGIC MAP OF COPPER MOUNTAIN REGION, PRINCE OF WALES ISLAND.

schist, and vein or shear-zone deposits, occurring along the bedding planes of the greenstone schist and quartzites.

The contact deposits, which are the most important, occur principally in Jumbo Basin, where they have been extensively mined, though smaller deposits of the same type have been prospected at many points around the contact of the granitic mass. The ore bodies consist of sulphides of copper and iron in a gangue of garnet, epidote, calcite, and some quartz. Certain deposits are associated with much magnetite; in others this mineral is lacking and pyrrhotite is present. The contact rock or gangue within which these deposits occur, like the ore bodies themselves, is sporadic in its occurrence. Locally in Jumbo Basin mineralization is developed across a width of several hundred feet, but at other places the granite and limestone lie close together, no contact minerals having been developed. The character of the deposits also depends on the adjacent country rock. Where limestone occurs the copper sulphides and gangue minerals are present in large masses and veins of ore following the original channels extend into the limestone. Where the schists constitute the contact rock, the mineralization is less concentrated and the sulphides are disseminated along the bedding planes for a considerable distance from the contact, only locally forming small masses.

The vein or shear-zone deposits occur principally in the greenstone schists and quartzites, and as a rule are parallel with the bedding planes. They consist of pyrite, chalcopyrite, and small amounts of sphalerite, and these minerals occur in massive veins from a few inches to a few feet wide and disseminated in the altered inclosing rock. Such deposits have been developed at the Corbin and Red Wing mines, which, however, have been only small copper producers.

MINE DEVELOPMENTS.

The mines and prospects of the Hetta Inlet region have been fully described in previous reports, and it remains only to discuss the latest developments. The Jumbo mine has been the principal copper producer during the year, and most of the development within the area has been done at this mine. The mine is located at an elevation between 1,500 and 2,000 feet on the north slope of Copper Mountain. An aerial tramway, 9,000 feet long, connects it with ore bunkers of 2,000 tons' capacity at the wharf. At the mine developments were extended along the main sulphide body, which is now exposed over a length of 120 feet, averaging 30 feet in width. On and above this same level a second sulphide body, separated from the main deposit by 70 feet of contact rock, was opened early in the year, and from it a large tonnage of ore has been mined. The

No. 4 level, which was started just above the upper terminal of the tramway, was extended for 320 feet, and two small ore bodies were crosscut, from which a small tonnage has been derived. This level is now being advanced to undercut the raise in No. 3 tunnel, and it will eventually serve as a passageway for all the ore mined from the workings above, thus doing away with the necessity of the auxiliary 600-foot tram. Surface explorations on the northeast side of Jumbo Basin, between the magnetite deposit and the mine, have revealed new deposits of chalcopyrite associated with magnetite, and it is planned to develop these ore bodies during the winter.

At the property of the Cuprite Copper Company, which adjoins the Jumbo claim on the east, developments were extended during the winter. Two tunnels 80 and 130 feet long were driven in the contact zone and small masses of ore were exposed. The general results were not satisfactory, and the work was stopped during the spring.

Considerable prospecting was done on Hetta Mountain during the summer, and a number of mineral claims were surveyed for patent. Other claims extending southeastward from Copper Mountain were also prospected and surveyed.

The properties of the Alaska Copper Company, including the smelting plant, and the Corbin mine, owned by the Alaska Metals Company, were idle throughout the year.

Operations at the Red Wing mine were resumed in August and small ore shipments were made. The ore body is a vein deposit inclosed in greenstone schists and quartzites which parallel the shore line. It lies close to tide water and at the lower or 100-foot level salt water was entering the mine workings in small amounts along the walls of a crosscutting diabase dike. During the summer the ore was mined from the stopes above the lower level, and careful investigations were made in regard to the practicability of extending these workings farther in depth.

On the Texas, Russian Bear, Gould, and other prospects within the area small amounts of development work were done, but no important discoveries are reported.

NIBLACK ANCHORAGE.

The Niblack mine, at the head of Niblack Anchorage, an embayment on the east coast of Prince of Wales Island, was operated from April 15 to October 30. During this period the shaft was sunk to a depth of 360 feet and developments were extended on the 300-foot level, where two ore bodies were opened. A raise was made in one of these deposits to connect with the 225-foot level, and most of the ore thus developed was mined. Several shipments to the Tacoma smelter were made during the summer.

NORTH ARM.

Developments at the Cymru mine, on Mineral Creek, three-quarters of a mile from the head of North Arm, on the east side of Prince of Wales Island, were in progress early in the spring. A vertical compartment shaft was started in the foot wall of the ore bodies, to replace the incline shaft, and surface improvements were begun and partly completed. In July, however, it was found necessary to suspend all operations.

OTHER PROSPECTS.

In the vicinity of McLean Arm, near the south end of Prince of Wales Island, prospecting for copper has been done in recent years and many claims have been staked. The Johnson & Gouley prospect is located at a point 1,500 feet in elevation and 2 miles from the beach on the south side of McLeans Arm, 4 miles from its entrance. Small masses of chalcopyrite are reported to have been found on this prospect, and have been developed by surface cuts.

Just south of McLeans Arm at Mallard Bay are the Daly-West and Thompson copper prospects, on which small amounts of development work were done during the summer. Prospecting on the north arm of Mallard Bay revealed a brecciated vein deposit carrying copper ore inclosed in greenstone schists and exposed on the beach with a westerly strike. This vein is said to have been followed to a point 1,200 feet from the beach and 150 feet in elevation, where a similar ore occurs. The property is located as the Veta group, and the developments consist of surface cuts and a short tunnel.

At Sea Otter Harbor, on the west side of Dall Island, considerable prospecting has been done on the Shellhouse claims, which extend from the beach on the south side of the bay to the top of the mountain, at an elevation of 2,400 feet. Here several bodies of chalcopyrite-pyrrhotite ore in a quartz-calcite gangue inclosed in limestone and siliceous schist have been found and prospected on the surface. The Miller claims are adjacent to the Shellhouse property, and on them similar deposits are exposed by surface cuts.

On the south end of Gravina Island, at Seal Bay, a tunnel was started late in the summer to crosscut the rock formations in the endeavor to locate ore bodies, some of which are exposed on the surface. In October this work was being rapidly advanced, and it was planned to extend the tunnel to a length of 2,000 feet. No improvements are reported from the prospects at Dall Head or Vallenar Bay.

SILVER-LEAD PROSPECTS.

At only a few localities have deposits of silver-lead ores been found in southeastern Alaska, and none of these deposits were productive during the year. The Moonshine prospect, the property of the

Alaska Galena Company, was idle except for assessment work and small developments carried on by three men employed during the year. The main 200-foot tunnel was extended, and in the fall a body of galena ore was reported to have been found in it, thus encouraging further developments. The silver-lead prospects in Groundhog and Glacier basins, at the head of Mill Creek on the mainland east of Wrangell, were idle except for the assessment work which is reported to have been done.

New discoveries are reported on a creek entering the north end of Blake Channel east of Wrangell Island. Veins of silver-lead ore were found at points 3 and 4 miles from the mouth of this creek and located as the Mount Wedar group and Mount Berg group. Most of the developments were made on the Mount Berg claim and consist of a 150-foot crosscut tunnel and surface cuts. These deposits are said to be similar to those at Glacier Basin and occur in the metamorphic schist country rock.

BUILDING STONES AND MATERIALS.

The principal building stones of southeastern Alaska are marble and granite, and the building materials are gypsum and cement rock. The distribution, quality, and market for these products were discussed in last year's report,[a] and here it is necessary only to consider the recent progress of developments. Marble is the only building stone that has been placed on the market and gypsum is the only building material that is being mined.

MARBLE.

The principal marble quarry in southeastern Alaska is located at Calder Bay, on the north end of Prince of Wales Island. At this quarry, the property of the Alaska Marble Company, developments have been carried to an average depth of 45 feet, the area of the floor being 60 by 90 feet. At this level a tunnel has been started under the hill, the plan being to excavate a large room underground. This room will be gradually enlarged and eventually the quarry operations will be protected from the weather by a roof of stone, and can thus be carried on throughout the winter. The marble at this depth is reported to be better than that near the surface, being comparable with the best grades of Italian white marble. Large shipments were made during the year to Seattle, Tacoma, and San Francisco, and a much greater production is planned for 1909.

The Ham Island marble properties, in the Wrangell mining district, were bonded early in September, and a crew of men was employed to determine the extent of the deposits on this island. The work con-

[a] Bull. U. S. Geol. Survey No. 345, 1908, pp. 116-126.

sisted of surface excavations and diamond-drill explorations. Except small blocks for local use, there was no production from this locality.

Small explorations are reported to have been made on the Marble Island and Tokeen Bay marble deposits in Davidson Inlet.

GYPSUM.

The only locality in southeastern Alaska at which gypsum is being mined is Iyoukeen Cove, on the east side of Chichagof Island. The geology and occurrence of gypsum in this vicinity were discussed in last year's progress report (Bulletin 345) and need not be taken up here. At this mine deposits of gypsum of large dimensions have been developed, though as yet their extent has not been determined. The mine workings consist of a 190-foot shaft from which two levels, at points 90 feet and 160 feet in depth, have been extended. During the year the work has consisted in opening stopes and putting in raises and chutes to facilitate the extraction of the rock. At a point 225 feet east of the shaft a raise was made from the lower level to the surface, thus forming a passageway for the men and giving better ventilation in the mine. A large tonnage was produced during the year and shipped to the plaster plant at Tacoma to be prepared for market.

CONCLUSIONS.

The metal mines in southeastern Alaska which have yielded the greatest output have been those mining the low-grade gold deposits. Their production has been gradually increased from year to year, and the possibilities are that a still greater output will be made in future years. The ore reserves are large, and the amount of ore developed is kept well in advance of that mined. The copper mines, on the other hand, are operating on relatively small ore bodies, which can be extracted in a short time, and the development of new ore reserves is a serious problem at many of the localities. It is therefore a question whether the present copper production will be largely increased in the future.

On Kasaan Peninsula and in the vicinity of Copper Mountain some of the copper mines are developing copper ores rich in magnetite, which constitute a desirable product for the smelters at Tacoma and in British Columbia, and because of their iron content are of increased value. There are in this region large bodies of magnetite ore which contain from 0.5 to 1.5 per cent of copper, but at present they can not be mined with profit as copper ore. They would, however, be of value as iron ore if there was a market for iron ore on the Pacific coast. The copper content could be readily separated from the magnetite mechanically by fine grinding and magnetic concentration, and thus the copper values could be won. Such treatment, however, would necessitate a briquetting of the ground magnetite before it could be used for reduction to pig iron. The electric process of smelting has been used on similar magnetite ores in California, and future developments may find it applicable in the Ketchikan district. At present about 2,000,000 tons of magnetite are developed on Prince of Wales Island, and a much greater tonnage is possible. These ores for the most part contain practically no phosphorus or detrimental impurities.

Other deposits of iron ore, as yet undeveloped, occur as magmatic segregations along the mainland adjacent to the Coast Range intrusive rocks. These deposits are being explored in the vicinity of Haines and other points on the mainland coast.

COPPER MINING AND PROSPECTING ON PRINCE WILLIAM SOUND.

By U. S. Grant and D. F. Higgins, Jr.

INTRODUCTION.

In 1898 two geologists of the United States Geological Survey visited Prince William Sound; one examined the extreme northwestern part of the district,[a] and the other made an examination of a considerable part of the sound and described several copper prospects.[b] In 1900 further information concerning the geology and copper deposits was obtained.[c] In 1905 a more detailed reconnaissance of the general geology and mineral resources was made, a preliminary report of which has been published.[d] In 1907 further information concerning the progress of mining and prospecting was obtained.[e] In 1908 the writers continued the work of 1905 and completed a detailed topographic and geologic map of part of Latouche Island. A report on the general geology and mineral resources of the sound is now in preparation.

Prospecting for copper on the shores of Prince William Sound dates back for some years, but it was not continuous until 1897, when the recent period of activity may be said to have begun with the staking of the claim on which is now situated the Ellamar mine. Prospecting was especially active from 1903 to 1907, but declined in 1908, after the fall in the market value of metallic copper, comparatively little development beyond the necessary assessment work being undertaken except at some properties on Knight Island, on Fidalgo Bay, and in the vicinity of Copper Mountain.

The following descriptions are confined chiefly to properties on which considerable development work has been done since the report

[a] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898 Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 265–340.

[b] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 341–423.

[c] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of the Copper River district, Alaska; a special publication of the U. S. Geol Survey, 1901, 94 pp

[d] Grant, U. S., Copper and other mineral resources of Prince William Sound: Bull. U. S. Geol. Survey No. 284, 1906, pp. 78–87.

[e] Moffit, F. H., Notes on the copper prospects of Prince William Sound: Bull. U. S. Geol. Survey No.: 345, 1908, pp. 176–178.

of 1905. There are, however, numerous prospects which are not mentioned in that report nor in the present one. In 1906 and 1907 many claims were staked at various places on the sound, especially on Knight Island. New discoveries were made on the south side of Fidalgo Bay and on and to the east of Cordova Bay, but on the latter little work was done. Only two properties—the Ellamar mine, at Ellamar, on Virgin Bay, and the Bonanza mine, on Latouche Island—are making regular shipments of ore. Each of these mines has been in operation for a few years.

A preliminary map of the mineral resources of the Prince William Sound region constitutes Plate IV of this volume.

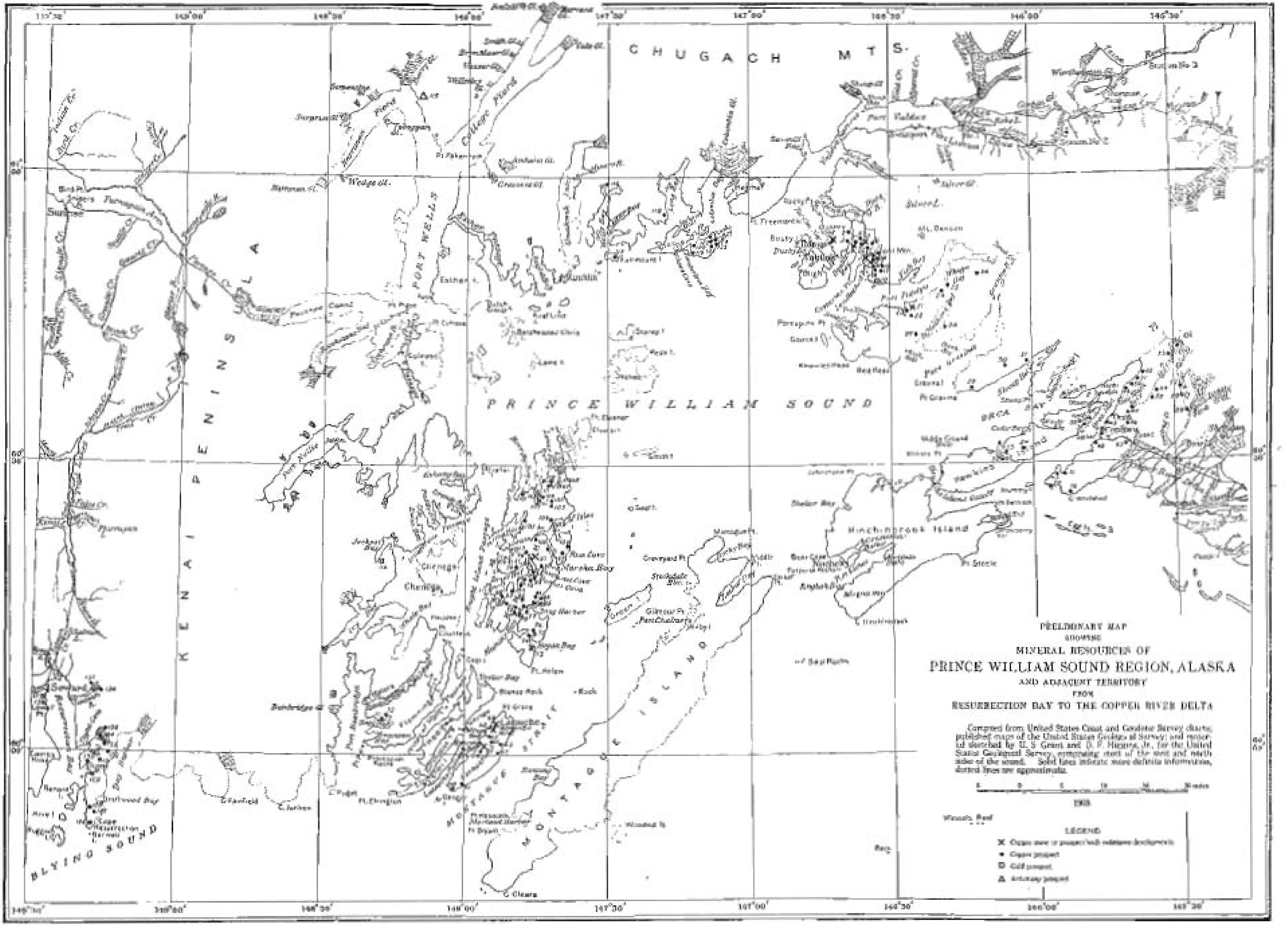
LATOUCHE ISLAND.

Bonanza mine.—This mine has continued shipping since 1903, steadily increasing its output. A dock, ore bunkers, an office, and mess and bunk houses have been constructed, and two tramways have been built from the dock to the mine, about half a mile distant. The mine is in the main a large, open hill face, from which the ore is quarried and run down to two tunnels, one 30 feet and one 120 feet below the quarry floor. The ore is then trammed from these tunnels to the dock. Aside from the open quarry the development work includes about 3,700 feet of tunnels.

Latouche Copper Mining Company.—This company's property is situated about half a mile north of the Bonanza mine. A dock, ore bunkers, mess houses, and a tramway from the dock to the tunnel, a distance of a quarter of a mile, have been built. The property has been developed by numerous shallow pits and trenches, and by a 700-foot tunnel which strikes the ore-bearing ground 200 feet below the surface. The ore is rock charged with chalcopyrite and some pyrrhotite and pyrite. Most of the ore removed has come from one stope, which is 45 by 15 feet in area and 5 to 10 feet in height. Several hundred tons of ore are reported to have been shipped in 1907, and there is some ore remaining in the bunkers.

Chicago-Latouche Mining and Power Company.—At the head of Wilson Bay this company has installed a pipe line and an electric power plant and is engaged in running a tunnel east-southeastward, with the expectation of cutting a continuation of the Bonanza ore bed to the south-southwest. In July, 1908, this tunnel had reached a length of about 1,400 feet.

Reynolds-Alaska Development Company.—On Horseshoe Bay this company has built a small town, installed a pipe line and electric power plant, and constructed over a mile of corduroy road from its dock eastward to its shaft and tunnels. The shaft, reported to be 100 feet deep, with a crosscut at its bottom to an ore body, was full of water at the time of the writer's visit. About half a mile northeast


PRELIMINARY MAP
SHOWING
MINERAL RESOURCES OF
PRINCE WILLIAM SOUND REGION, ALASKA
AND ADJACENT TERRITORY
FROM
RESURRECTION BAY TO THE COPPER RIVER DELTA
LEGEND
Copper prospect
Gold prospect
Antimony prospect
CHUGACH MTS.
PRINCE WILLIAM SOUND
KENAI PENINSULA
PORT WELLS
MONTAGUE ISLAND
MONTAGUE STRAIT
Hinchinbrook Island
ORCA BAY
BLYING SOUND
Port Valdez
Seward
Chenega

of the shaft and 400 feet above sea level 2,000 feet of tunneling has been done, most of which is on the Duchess claim. Here a body of ore has been encountered which strikes north-northeastward and dips 70° W. It is only a few inches thick where first encountered at the south-southwest, but thickens gradually toward the north for 500 feet along the strike until a thickness of 45 feet is reached; beyond this point exploration has not gone. The ore body consists of pyrite and some chalcopyrite mixed with bands of slate and graywacke. Considerable sorted ore is on the dump, and small shipments are reported to have been made from this tunnel.

Other prospects.—The above-mentioned properties are on the northwest side of Latouche Island. Other but much less extensive work has been done elsewhere, especially by the Latouche Consolidated Copper Company, which has sunk a few pits near the southeast end of the island; by the Seattle-Alaska Copper Company, which has installed a steam plant and begun the sinking of a shaft on the southeastern shore of the island, a mile and a half from its southeastern point; and by the Latouche Island Copper Mining Company, which has sunk a 60-foot shaft and run a 100-foot tunnel near the southeastern shore of the island, about 4 miles from its northeastern point.

KNIGHT ISLAND.

On Knight Island a considerable amount of development work has been done, mainly in 1906 and 1907. Much of this work was done on or near Drier Bay, on the west side of the island.

DRIER BAY.

Knights Island Consolidated Copper Company.—This company, locally known as the Hubbard-Elliott Company, has installed a wharf, offices, ore bunkers, and a steam power plant at the northeast corner of Drier Bay. Work has been done on a number of claims, but the main development has been on two tunnels called the Monarch and the Bald Eagle. At the Monarch, a mile and a half northwest of the dock and about 600 feet above sea level, about 350 feet of development work has been done. At the Bald Eagle tunnel, which is about 900 feet above sea level and three-fourths of a mile northeast of the dock, is a northwestward-facing cliff with an iron-stained surface. The rock is greenstone with irregular schistose zones that wrap around masses of nonschistose rock. The schistose zones carry chalcopyrite and pyrrhotite, and in some of them these sulphides are abundant and form ore bodies, from one of which a few hundred tons of ore have been mined. Connecting the Bald Eagle tunnel with the dock is a wire rope aerial tramway, the upper station of which was unfortunately somewhat damaged by a snow slide in the early part of

1908. Shipments of ore have been made from this tunnel, and some ore remains in the ore bunkers.

Knights Island Alaska Copper Company.—About 900 feet above sea level and half a mile northeast of Northeast Cove of Drier Bay, this company is running a tunnel to intercept a vein which outcrops on the hill 360 feet above the mouth of the tunnel. In July, 1908, the tunnel had reached a length of 300 feet, and it was thought that the vein would be reached 100 feet beyond. The vein consists of a schistose zone in the greenstone, carrying quartz, pyrrhotite, and chalcopyrite.

Twentieth Century Knight Island Copper Mining Company.—This company has staked nine claims south of Northeast Cove of Drier Bay. The property is developed by a small floating wharf, a bunk house, and two tunnels. The lower tunnel is about 250 feet above sea level and has been driven for 30 feet in greenstone and chlorite schist. A few stringers of chalcopyrite have been revealed. The upper tunnel is about 350 feet above sea level and in July, 1908, was 390 feet long and was still being extended. It follows a 6-foot shear zone containing numerous lens-shaped bodies and stringers of chalcopyrite. At 230 feet from the entrance a raise of 70 feet has been made on this shear zone. The upper tunnel is expected to cut several ore-bearing zones whose outcroppings appear on the hill above.

Knights Island Copper Mining Company.—Development work has been done by this company half a mile southeast of Barnes Cove of Drier Bay. Sidney Paige examined this prospect in 1905 and reported a lens of ore (chalcopyrite and pyrrhotite in greenstone) approximately 30 feet wide and 40 feet high.[a] A tunnel, about 100 feet below this lens, is now being run with the expectation of cutting it. Another tunnel, over 100 feet in length, has been run along a schistose zone carrying quartz, chalcopyrite, pyrrhotite, and pyrite.

Russell Ball Copper Company.—This company's prospect is located on the south side of Drier Bay, between Barnes Cove and Mallard Bay. The company has located six claims, four on Drier Bay and two over the ridge from Drier Bay toward Snug Harbor. The property on Drier Bay is developed by four openings. A wire-rope aerial tram operated by a windlass has been rigged from the upper tunnel to the shore. This tunnel is 520 feet above sea level and is 60 feet long on a vein of nearly solid chalcopyrite with a little pyrrhotite. The vein averages 8 inches in width. Good outcroppings were reported above at an altitude of about 1,000 feet, but these were covered with snow when visited in July, 1908. The other three openings are below and vary from 12 to 30 feet in length. They are intended to cut the vein mentioned above, but have not been driven far enough to strike

[a] Bull. U. S. Geol. Survey No. 284, 1906, p. 85.

it. Some ore is sacked ready for shipment, and a small amount was shipped in July, 1908.

MUMMY BAY.

Mummy Bay is on the southwest side of Knight Island. At H. J. Harvey's prospect, near the northwest corner of the bay, some strippings near the shore have exposed irregular quartz lenses carrying pyrrhotite, chalcopyrite, and pyrite. Three-fourths of a mile from the shore are a few small areas of diabase containing disseminated pyrrhotite and chalcopyrite. These have been prospected by two tunnels, each about 150 feet in length. Near the center of the north shore of the bay, at Charles Schultz's prospect, is an opening 10 feet wide and 30 feet long on a schistose zone containing chalcopyrite and a little pyrrhotite. A few tons of ore have been taken from this opening.

EAST SIDE OF KNIGHT ISLAND.

Happy Jack Copper Mining and Development Company.—This company's property is located on the south side of Hogan Bay, just at the entrance. A steam plant, an office, and mess and bunk houses have been constructed. The main work has been done on a tunnel at the shore, which in July, 1908, had reached a length of 986 feet. It is being run to intersect a vein that outcrops higher up and to the southeast and extends along a fissure, cutting across the strike of the country rocks, which are slates, graywackes, and greenstones. The vein, where examined, varies from 1 foot to 4 feet in thickness and contains quartz, chalcopyrite, and pyrrhotite. Two tunnels have been run on this vein, one 398 feet and the other 535 feet above sea level. The upper tunnel is 85 feet in length and the other, with its branches, is about 450 feet in length. A number of tons of ore are now on the dumps from these two tunnels, and some ore has been shipped.

Wilcox prospect.—This prospect is located near the head of Hogan Bay, Knight Island. It is being opened by the James Mullins Coal Company, of Cleveland, Ohio. Six claims and a fraction are staked. The property is developed by four substantial log buildings and three tunnels. The longest of the tunnels is 1,500 feet from the head of Hogan Bay, at an elevation of 315 feet. It is about 500 feet in length and has one side drift of 50 feet on which work was being done in July, 1908. A few veins and some disseminated chalcopyrite are shown. The second opening is about three-fourths of a mile up the main left-hand gulch at the head of Hogan Bay and about 1,000 feet above sea level. This tunnel is 70 feet long and is designed to crosscut leads whose outcroppings appear in the hill above. Several small veins of solid chalcopyrite were encountered. The third opening was not visited, as it was small and difficult of access.

Hogan, Hemple & Egan prospect.—This prospect is one-fourth mile west of the head of Hogan Bay and has about 130 feet of tunnel, which reveals an irregular vein of chalcopyrite with a little pyrrhotite. Other showings, on which very little work has been done, occur on the mountain side above this tunnel.

Discovery Bay.—On the north side of the entrance to Discovery Bay J. J. Bettles has a prospect on two iron-stained zones that appear at the water's edge. These zones strike north-northeastward and apparently reappear on the south side of the entrance to Delight Bay. The eastern zone is 12 feet in thickness and has on its hanging-wall side 10 to 15 inches of fairly solid ore consisting of pyrrhotite and chalcopyrite. Northeast of Snug Harbor, at the head of Discovery Bay, Graham & Harrison have a 60-foot tunnel in greenstone. Higher up, on the divide between Snug Harbor and Delight Bay, and about 1,300 feet above sea level, they report a vein from 4 to 11 feet in thickness, which has been traced for several hundred feet. The ore shown to the writers from this vein is brecciated and schistose greenstone carrying chalcopyrite and a little pyrrhotite.

Copper Bullion claims.—These claims, locally known as Rua's claims, are situated on the east side of Knight Island, and the development work consists of a tunnel, which had reached a length of 360 feet in July, 1908. This tunnel is about half a mile from the east shore of the island and a mile and a half north of the entrance to Marcia Harbor. The rock excavated in the tunnel is greenstone with a few stringers of pyrrhotite and chalcopyrite, but at the end a brecciated zone cemented by quartz and these two sulphides has been encountered. As far as the workings show, this zone is about 60 feet in width and strikes in a northeasterly direction. About 400 feet above this tunnel, at the base of a southward-facing cliff on the south side of Iron Mountain, is an exposure of ore 65 feet in width. All of this width, except about 10 feet of mixed ore and rock, is practically solid pyrrhotite with a small percentage of chalcopyrite. About 200 feet farther up the cliff the ore body appears to be 30 feet in width, and at the top of the ridge, 150 feet still higher, there is reported to be 12 feet of ore. It seems probable that the tunnel cuts this same ore body.

Bay of Isles.—Near the northwest side of the Bay of Isles is the Snowstone group of claims, and west of the head of the south arm of the bay is the Pandora group of claims. On the Snowstone group are two tunnels, 55 and 25 feet in length, a fourth of a mile from the shore and about 200 feet in elevation. On the Pandora group, half a mile from the water and about 500 feet above sea level, a schistose zone in the greenstone is exposed along a small creek. This zone is 50 feet in width and contains scattered through it a few small stringers of ore and three smaller zones, 5 to 24 inches in width, in which the ore stringers are abundant. The ore is chalcopyrite with some pyrrhotite. A tunnel here intersects three ore-bearing zones, 2 to 6 feet in width, in the larger schistose zone. A small shipment of ore has been made from this place.

NORTH END OF KNIGHT ISLAND.

Near the head of Louis Bay there are a few prospects. At one of them, controlled by the Knights Island Mining and Development Company, a small steam sawmill and electric plant have been installed at the extreme southeast corner of Louis Bay. From this plant electric drills have been worked in two tunnels 1½ miles south of the south end of this bay. One of these tunnels is 85 feet in length and cuts five schistose zones, 2 to 18 inches in width, in greenstone. These zones carry pyrite, chalcopyrite, and pyrrhotite. The main or lower tunnel was started to intersect these and several other ore-bearing schistose zones, and is 160 feet in length. This company is constructing a small sawmill to be run by water power.

HERRING BAY.

Herring Bay is the large bay at the northwest corner of Knight Island. At the head of its southeastern arm the Crown Copper Company has built two bunk and mess houses and a small floating dock. A quarter of a mile to the south is a tunnel 25 feet in length; and about a mile from the camp and on the east side of a lake is another tunnel 100 feet in length, in greenstone, which was run to intersect some veins that outcrop on the ridge to the northeast. Other prospects are situated on the same arm of Herring Bay, and also on the northeast arm. At the latter locality there is a tunnel 50 feet long in greenstone with cracks filled by quartz, pyrite, sphalerite, and chalcopyrite, which is also disseminated to a small extent in the country rock.

GALENA BAY.

Near the head of Galena Bay the Galena Bay Mining Company has built a small town, constructed a dam that gives a 52-foot head of water, and installed an electric power plant. The electric power is transmitted about 3 miles southward and used to run an air compressor at the mouth of a long tunnel. This tunnel, which is about 750 feet above sea level, is being driven to intersect a large shear zone that outcrops to the east 800 feet or so above the tunnel. In 1905 this tunnel was about 300 feet in length, and in August, 1908, it had reached a length of over 1,500 feet. It is expected that when the tunnel strikes the ore zone an aerial wire-rope tramway will be installed from the tunnel to tidewater, a distance of about 18,000 feet. The material for this tramway is now on the ground.

BOULDER BAY.

Reynolds-Alaska Development Company.—This company has twenty claims located on the east side of the head of Boulder Bay. The property is developed by a wharf, an electric plant, an air compressor, office, and bunk houses, a supply house, a superintendent's house, and about 2,100 feet of drift in the main tunnel and 200 feet of drift in a smaller opening. The main tunnel is at tide water, and is composed of a rather complicated system of crosscuts, winzes, and raises, driven through interbedded greenstones, slates, and graywackes. It is electrically lighted on the main drifts. A few veins of chalcopyrite were encountered. About 150 feet above this system is the smaller tunnel mentioned above. It is in greenstone having locally small quantities of disseminated chalcopyrite. Veins 2 to 3 inches wide also occur, and on the face a foot of ore was present. Just to the right of the main adit is a small excavation from which it was reported several tons of shipping ore were procured. Several hundred tons of ore are said to have been shipped from this property. Some of this ore came from two large bowlders, composed mainly of iron and copper sulphides, which were found on the beach at the mouth of the main tunnel.

Fielder & Hemple prospect.—The claims of this prospect lie at the head of Boulder Bay, and are practically surrounded by the property of the Reynolds-Alaska Development Company, described above. A tunnel and several small crosscuts, aggregating about 200 feet in length, have been run at an elevation of 400 feet and a quarter of a mile from the bay. Some ore is ready for shipment, most of it having been obtained within 20 feet of the surface. Two small excavations, 120 feet above the tunnel, uncover surface showings of chalcopyrite stringers in sheared greenstone.

ELLAMAR.

The Ellamar mine, formerly known as the Gladhaugh, continued shipping in 1908, but the amounts were materially decreased from the customary output. The earlier shipments were derived from a rather poorly defined ore shoot in which the chalcopyrite was more abundant than the pyrite and pyrrhotite, and the later shipments evidently came, in part at least, from outside this ore shoot. It is reported that there is still a large tonnage of this lower-grade ore in the mine. The ore body is a lens-shaped mass of these copper and iron sulphides and has been opened in the 100, 200, 300, 400, and 500 foot levels of the mine. On the 500-foot level the ore body has decreased in size to about 40 by 70 feet, and it pinches out before reaching the 600-foot level. Prospecting for other ore bodies in the strike of this ore lens is now being carried on by diamond drilling southeast of the mine.

LANDLOCKED BAY.

Standard Copper Mines Company.—This company has constructed a wharf, ore bunkers, an office, etc., on the north side of Landlocked Bay. From the wharf a wire-rope aerial tramway, 2,526 feet in length, leads up the south side of Copper Mountain. Above this tramway is another, 923 feet long, leading to the mouth of a tunnel about 2,000 feet above sea level. This tunnel is run to intercept three ore-bearing zones that outcrop on the mountain above. In August, 1908, it had reached a length of 420 feet. The lowest ore zone is intersected near the mouth of the tunnel, and from this considerable ore has been mined and most of it has been shipped. The second zone is not clearly cut by the tunnel, which at the time of visit was thought to be entering the third zone. These zones are schistose areas in the greenstone of Copper Mountain and they carry lens-shaped bodies of ore. The property has also been developed by several smaller tunnels and strippings.

Three Man Mining Company.—This company has a considerable number of claims, locally known as the Dickey claims, about the head of Landlocked Bay. Most of the development work has been done on the north side of the bay, where numerous tunnels have been run, strippings made, and several veins revealed. Much of the work has consisted of drifting along the veins or of short crosscuts that intersect the veins. The veins are in greenstone, graywacke, and slate, and consist of schistose shear zones carrying chalcopyrite and pyrrhotite. These sulphides occur to some extent in solid, more or less lens-shaped bodies within the schistose rock. The sulphide bodies, which are in places composed very largely of chalcopyrite, vary from a few inches to a few feet in thickness. Small shipments of ore have been made from these claims, and more is now ready for shipment. Most of the work, however, has been devoted to uncovering the veins, and not to getting out ore.

Hemple prospect.—This prospect is located west-northwest of the head of Landlocked Bay. A good trail has been opened to the mess house, 1,500 feet from the shore. At 400 feet above sea level is a tunnel 125 feet in length, the first 40 feet of which is in broken greenstone with numerous small veins of chalcopyrite. A second tunnel, 600 feet in elevation, is about 400 feet long and crosscuts three ore-bearing zones. Some sorted ore is on the dump. Extending 1,200 feet west from this upper tunnel is a series of fifteen to twenty small strippings and pits on a schistose zone in greenstone. Several of these openings show veinlets of ore.

FIDALGO BAY.

Whalen & Nelson prospect.—On the south side of Fidalgo Bay, 7 miles east of Fish Bay, is a smaller bay called Whalen Bay. Two miles east from its head and about 700 feet above sea level are some strippings and a small tunnel. The country rock is a hard black to greenish slate, and the ore is a hard band of nonslaty rock containing irregular stringers and disseminated grains of chalcopyrite and pyrrhotite. This band of ore is 2 to 4 feet in thickness where examined, and it is reported to have been uncovered at intervals for a considerable distance, in some places being 12 feet thick.

Fidalgo Mining Company.—The prospect owned by this company is located on the south side of Fidalgo Bay, a mile southwest of Whalen Bay. Twenty-four claims, known locally as Blakney's prospect, have been staked. A supply house at the beach, a bunk house, and a tunnel are the main developments on this property. The tunnel is 2,800 feet from the shore and 450 feet in length. It follows a well-defined shear zone. Two rather definite lens-shaped ore shoots, each about 5 by 50 feet in cross section, have been struck at 200 and 300 feet from the entrance, and many small stringers of ore, which is chiefly chalcopyrite, occur throughout the tunnel. A small crosscut beyond the second ore shoot shows a 20-inch vein of nearly solid chalcopyrite. Several small strippings have been made on the shear zone, which has been traced for about 3,000 feet. Some ore is ready for shipment.

Fidalgo Alaska Copper Company.—This company's property is on the south side of Fidalgo Bay, south of Fish Bay and half a mile east of Irish Cove. The main development work has been done near the top of a hill which rises about 1,000 feet above the sea. A large amount of stripping has been done, and several short tunnels and two longer ones have been run. The main tunnel has over 400 feet of workings. The country rock is a hard black to gray slate, with a little graywacke. The ore, which is chalcopyrite with a little pyrite, occurs in hard, fractured zones in the country rock as a cement to the fractures, as irregular stringers, as disseminated grains, and as larger replacements of the country rock. These fractured zones are irregular in size and extent; some of them have been proved not to continue far, but the extent of others is not yet shown by the developments. Altogether there is a considerable amount of ore exposed in the strippings and in the tunnels, and some ore is ready for shipment.

GOLD ON PRINCE WILLIAM SOUND.

By U. S. Grant.

Placer gold in small amounts has been found in a few of the streams flowing into Prince William Sound. Some of these localities are as follows: Solomon Gulch, on the south side of Port Valdez; Mineral Creek and Gold Creek, on the north side of Port Valdez; streams near the front of Shoup Glacier; King River, at the extreme southwest corner of Port Nellie Juan. Only a small amount of work has been done on these placers, and on none of them has the work proved really profitable.

For several years there have been reports of the finding of "float" ore, carrying considerable values in gold, on the shores of Jackpot Bay, west of Chenega Island. Recently (1908) one vein carrying ore of this character has been located on the east side of this bay near its head (the south end). The country rock at this locality is graywacke and graywacke slate, with a general north-northeasterly strike, parallel with the axis of the bay, and a dip of 40° to 60° WNW. A quarter of a mile from the shore of the bay and approximately 770 feet above sea level an opening has penetrated 8 feet into a quartz vein and runs up the cliff side for 12 feet. The vein strikes N. 52° W. and dips 67° W. It is, as here exposed, 20 to 28 inches in width and has a fairly well defined central zone which is rich in metallic sulphides—arsenopyrite, galena, and sphalerite. This central zone is 6 to 11 inches in thickness. Three samples for assay were taken across the outer parts of the vein, and three across the central sulphide zone. The first samples showed 0.5 ounce per ton of gold and 0.3 ounce of silver, or a total value of $11.89 per ton. The second set gave 2.5 ounces per ton of gold and 5.9 ounces of silver, or a total value of $54.73 per ton.[a] Though this vein is small and its extent is not known, still its gold content should encourage further search for gold-bearing veins in this vicinity.

[a] Assays by W. H. Coghill and D. F. Higgins, jr., of Northwestern University.

NOTES ON THE GEOLOGY AND MINERAL PROSPECTS IN THE VICINITY OF SEWARD, KENAI PENINSULA.

By U. S. GRANT and D. F. HIGGINS, JR.

INTRODUCTION.

Seward is situated on Kenai Peninsula at the north end of Resurrection Bay, in west longitude 149° 27′ and north latitude 60° 6′. This bay (fig. 1) lies between Prince William Sound on the east and Cook Inlet on the west, and extends farther north than any of the other bays facing the Gulf of Alaska between these two large inlets. Seward is of importance as the tide-water terminus of the Alaska Central Railway and the outfitting point for gold fields to the north.

The rocks in the vicinity of Seward have been examined by two geologists of the United States Geological Survey—W. C. Mendenhall,[a] who visited this district in 1898, and F. H. Moffit,[b] who was there in 1904. In August, 1908, the writers spent three days at Seward and in the vicinity examining copper prospects and incidentally obtaining information on the general geology.

GEOLOGY.

Previous descriptions.—Mendenhall[c] has described the Sunrise "series" as consisting of interbedded fine blue-black slates and dark-gray arkoses, which form the country rocks from Seward northward to Sunrise, on Turnagain Arm of Cook Inlet, and from Sunrise eastward to Passage Canal (or Portage Bay) and Port Wells, in the northwestern part of Prince William Sound.

Moffit[d] has described the same "series" of rocks as extending from Seward northward to Turnagain Arm, and stated that it holds a few conglomerate beds containing well-rounded pebbles chiefly of argillaceous rock and granite, with less numerous pebbles of quartzite or quartz; that the cleavage of the Sunrise "series" near Resurrec-

[a] A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 265–340.

[b] Gold fields of the Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 7–52.

[c] Op. cit., pp. 305–307

[d] Op. cit., pp. 17–18.

tion Bay is in general parallel with the bedding, which is about N. 10° E.; that several massive quartzite beds, from 4 to 6 feet thick, are conspicuous in the vicinity of the glacier east of Seward, about 2 miles from Resurrection Bay; and that the beds at this last locality lie in immense folds slightly overturned to the east.

Below are given some further descriptions of the geology (1) at Seward, (2) from Thumb Cove southward along the east shore of Resurrection Bay to a point opposite the south end of Renard Island, and (3) on Renard Island. These localities are shown on the accompanying map of Resurrection Bay (fig. 1).

Seward.—The town of Seward is beautifully situated on an alluvial fan formed by a stream that comes from the mountains to the west. The eastern mountain just north of this stream is apparently composed of easily disintegrated slates, and the pebbles in the stream bed are mainly of slate and graywacke. On the shore, and also a few rods back from the shore of Resurrection Bay for about a quarter of a mile southwest of the railway dock at Seward, are exposures of graywacke, which varies from coarse to fine in grain and has interbedded with it a small quantity of dark-gray slate. The bedding is not distinct, but apparently the strike is north and south and the dip about 65° W.

Thumb Cove and the shore to the south.—On the north side of Thumb Cove, just west of the main stream near the head of the cove, there are exposures of graywacke somewhat similar to that at Seward. The rock here is much fractured and broken and the fractures are healed by quartz veins of very fine grain, almost chalcedonic in appearance. The strike is N. 18° E. and the dip 40° W. Along the north shore of this cove, west of the above-mentioned locality, graywacke with a little slate exists in several exposures which were not closely examined. The general direction of the dip here is west-northwest, at an angle of 20° to 50°.

The country rock for a mile northeast of Thumb Cove is greenstone, chiefly in flows, which are commonly ellipsoidal [a] and in some places amygdaloidal. The ellipsoidal greenstones consist largely of more or less spherical masses which vary from a few inches to 10 feet in diameter. Here there are a few glaciers, the moraines of two of which were examined and found to contain, in addition to the common greenstone, a number of varieties of coarser-grained igneous rocks, mostly basic. At the mouth of the valley that runs north-northeastward from the northeast corner of Thumb Cove lie many bowlders of rocks similar to those in the moraines, such as medium-grained diabase with red jasper-like veinlets; medium-grained diabase with porphyritic feldspar crystals; light-colored greenstone with

[a] Clements, J. M., The Vermilion iron-bearing district of Minnesota: Mon. U. S. Geol. Survey, vol. 45, 1903, p. 144.

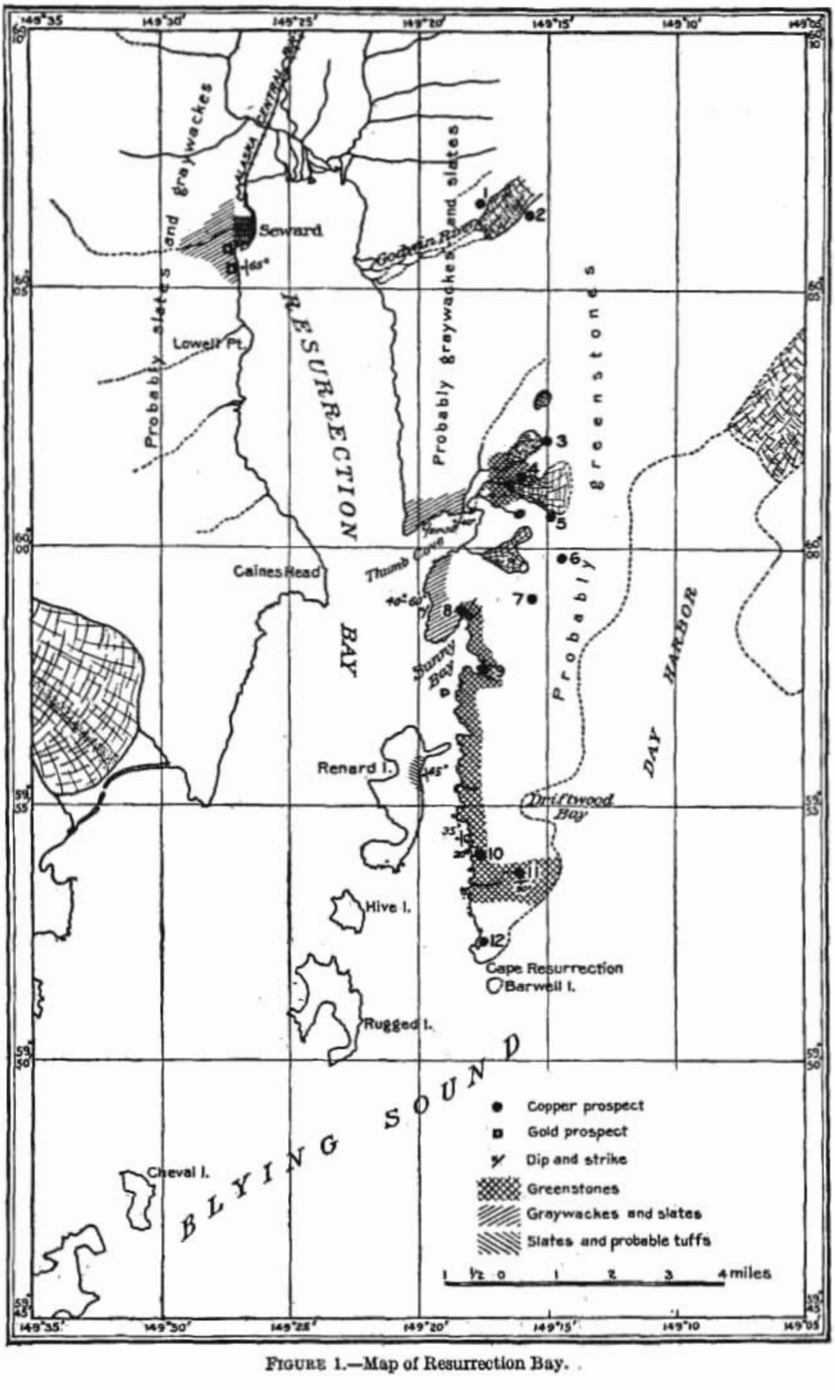


FIGURE 1.—Map of Resurrection Bay.

quartz amygdules; coarse-grained diabase with red stains; fine-grained gray granite, or aplite, in dikes in greenstone; coarse-grained diabase with large plates of augite; medium-grained diorite with veins of diorite-pegmatite. It is thus probable that the high mountains east and northeast of Thumb Cove are composed of basic igneous rocks, both extrusive and intrusive, and that the lower mountains north of the bay and west of the valley above mentioned probably consist of slate and graywacke.

Graywacke with a little slate is seen along the shore between Thumb Cove and Sunny Bay. The general dip is from 40° to 60° NNW. On the northwest side of Sunny Bay black slate, in many places highly fractured, alternates with greenstone in flows undoubtedly interbedded with the slate. Some of these flows are ellipsoidal in structure. At the extreme north end of Sunny Bay greenstone becomes the country rock, and it extends southward along the east side of Resurrection Bay as far as the present examination went—that is, to a locality opposite the south end of Renard Island; thence this rock was traced eastward across the point on the east side of this bay. This greenstone varies in character, but is in general a fine-grained, altered diabase or basalt, which as a rule occurs in flows that are commonly ellipsoidal in structure. The dip ranges from 20° W. to vertical. Cutting the greenstone are a few diabase dikes, usually less altered than the main country rock. In one locality, about an eighth of a mile north of the Iron Mask claim (prospect No. 10), is a layer of black slate about 15 feet thick interbedded with greenstone and dipping about 35° W.

Renard Island.—On the east side of Renard Island, just south of the long sand spit which projects northeastward, is an eastward-facing cliff consisting of black slate overlain by rather soft green and gray schistose rocks of at least two varieties. The rocks have a marked cleavage, which runs about parallel with the bedding; the strike is N. 7° W. and the dip is 45° W. The gray rock is fine grained, except for small crystals of feldspar, rarely of quartz, around which the matrix of the rock seems to have flowed or been sheared. This rock is possibly a water-laid tuff or perhaps a sheared trachyte or andesite. Higher up in the cliff are fine-grained green schistose rocks, which are probably sheared greenstones or tuffs. At the base of the cliff and probably coming from it are fragments of coarse-grained diabasic greenstones and coarse-grained graywackes.

Summary and conclusions.—Most of the east side of Resurrection Bay from Thumb Cove southward is occupied by basic igneous rocks, which occur chiefly in the form of flows of ellipsoidal greenstone. The same rocks, with their intrusive coarser-grained equivalents, undoubtedly make up the mountainous highland between Resurrection Bay and Day Harbor and extend northward for an unknown distance. The flows in general dip to the west and are overlain by a series of graywackes and slates, which on Renard Island contain probably water-laid tuffs or sheared extrusives. The graywackes and slates have been compressed into folds whose axes strike a little east of north, and these rocks undoubtedly make up the east shore of Resurrection Bay northward from Sunny Bay. They also probably form the western mountainous ridge which runs from Thumb Cove northward to and beyond Godwin River.

The rocks on the east side of Resurrection Bay appear to belong to one general period, which began with numerous basic lava flows, in part, at least, submarine. These were followed by clastic sediments, which were deposited on and locally interbedded with the later lava flows. With the sediments some tuffaceous material was probably deposited.

The mountains immediately west of the northern half of Resurrection Bay are probably composed of graywackes and slates, and in some of these mountains the slates are soft and easily disintegrated. The relation of the rocks on the west side of the bay to those on the east side is not clear.

The Sunrise "series," as heretofore described, does not include igneous rocks, except near the mouth of Knik River, at the head of Knik Arm of Cook Inlet, where greenstone tuffs, rhyolites, and rhyolite tuffs have been described as included in this "series."[a] The presence of conglomerates in the Sunrise "series" and the finding of a considerable terrane of surface igneous rocks in connection with the slates and graywackes on the east side of Resurrection Bay seem to indicate the possibility of the separation of the rocks in the vicinity of Resurrection Bay and northward into two unconformable groups. One of these would contain, at least locally, much contemporaneous igneous material and is extremely similar in lithology and general characteristics to the Orca "series," which is extensively developed to the east on Prince William Sound. The relation, if the separation above suggested can be made, of the igneous rocks and associated sediments to the rest of the Sunrise "series" is not clear. From analogy with the district to the east (Prince William Sound), where a "series" (Orca) containing contemporaneous igneous rocks is younger than a "series" (Valdez) of more metamorphosed sediments, it might be concluded that the same relation held in the Resurrection Bay region, but convincing evidence for such a conclusion is not at hand. At the present time the relation of the Sunrise "series" to the Valdez "series" and to the Orca "series" has not been determined.

[a] Paige, Sidney, and Knopf, Adolph, Geological reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, pp. 13-15.

The age of these rocks is likewise uncertain. The Sunrise has been assigned to the Paleozoic and to the Mesozoic, as has the Orca, which is possibly Mesozoic; the Valdez is probably Paleozoic.

COPPER PROSPECTS.

Comparatively little work has been done on the copper prospects in the vicinity of Seward, most of them having been staked recently. They are all, so far as known, located east of Resurrection Bay. In the following paragraphs they are described in order from north to south, the numbers in the descriptions referring to localities on the accompanying map (fig. 1).

Prospect No. 1.—This is just north of the glacier at the head of Godwin River and about 2,400 feet above séa level. It was staked by L. F. Shaw, John Deubruel, and G. Bouchaert, of Seward. Little work has been done here. Specimens from the prospect are nearly solid pyrrhotite with a little chalcopyrite, and there is said to be one large bowlder here, about 700 pounds in weight, of similar ore. An 8-foot vein carrying both copper and gold is also reported as occurring near this same locality.

Prospect No. 2.—This prospect, staked by W. L. Redman and Samuel Guyot, of Seward, is just south of the glacier at the head of Godwin River and about 2,700 feet above sea level. The vein here is reported to be 9 feet in width, and the specimens shown the writers are composed of porous, heavily iron-stained gossan carrying malachite, azurite, and chalcopyrite. No work has been done at this locality.

Prospects Nos. 3, 4, and 5.—At these localities are the Real Thing, Copper Chief, and Iron Cap groups of claims, staked by S. E. Likes and A. H. Frazer, of Seward. There are twenty-three claims in these groups. At the time of visit (August, 1908) the Real Thing and the Iron Cap groups were covered with snow. Each is located at the foot of a high cliff forming the edge of the gathering ground of a small glacier. It is reported that the magnetite in connection with the chalcopyrite at the Real Thing group extends along and up the cliff in a northwest-southeast direction for a horizontal distance of 500 to 600 feet. The lead has been traced three-quarters of a mile. The vein is reported to be as wide as 9 feet, having chalcopyrite on one side and magnetite on the other. Specimens presented by Mr. Likes show the magnetite to be fine, uniformly grained, massive, and blue black in color. Much of it is pure, but more commonly minute grains of chalcopyrite are scattered through it. The contact of the main part of the chalcopyrite and the magnetite is very abrupt. The specimens show veinlets of chalcopyrite 0.03 inch wide, extending for 0.3 to 0.4 inch into the magnetite. With the chalcopyrite is pyrite in irregular patches—possibly imperfect crystals—and in elongated patches that may be veinlets. The Iron Cap lead was reported to have been traced for 4,500 feet along the glacier. Magnetite is reported to occur below, giving away to chalcopyrite and pyrite farther up the cliff.

A part of the showings of the Copper Chief group of claims was seen. The lead consists of a brecciated and sheared zone, about 6 feet wide, in partly ellipsoidal greenstone. This zone strikes N. 37° W. and dips 35° S. Pyrite, chalcopyrite, hematite, and a little epidote occur distributed through the numerous quartz veinlets and through the part of the greenstone nearest the shear zone. The hematite occurs only in the quartz. The greenstone is fine grained, dense, and of a leek-green color when fresh.

Prospect No. 6.—This lies to the south-southeast of those last described, and is reached from Day Harbor. There are several claims here, staked by the Reynolds-Alaska Development Company. They are reported to carry chalcopyrite in shear zones in the greenstone.

Prospects Nos. 7 and 8.—E. F. Pitman and A. C. Gould, of Seward, have staked a group of six claims, called the Feather Bed group, running eastward from the northeast corner of Sunny Bay. At the shore a small amount of digging has been done and some pieces of float containing pyrite and a little chalcopyrite have been encountered. The chief claims of this group are about 1½ miles east of the shore and were not visited because they were reported to be covered with snow. These claims are said to contain a shear zone which holds four stringers of nearly pure chalcopyrite; the stringers vary up to 7 inches in thickness and are reported to carry 14 to 19 per cent of copper. The zone strikes a little east of north and is about vertical; it has been traced from an elevation of about 2,500 feet up to 3,500 feet.

Prospect No. 9.—This prospect, called the Peterson claim, is located at the water's edge on the east side of the north part of the south arm of Sunny Bay. The country rock is a rather fine grained, fairly fresh diabase. A tunnel, 35 feet in length, has been run along a brecciated and vertically sheeted zone, which is 5 feet in width, strikes N. 32° W., and dips 68° W. The cement of the breccia is composed of quartz, calcite, sphalerite, pyrite, epidote, and chalcopyrite. About 200 feet to the southwest of this tunnel is another, 35 feet in length, extending along a similar brecciated zone which carries less vein material. This zone is 6 feet wide, strikes N. 12° W., and is vertical.

Prospect No. 10.—This prospect, called the Iron Mask claim, is on the east shore of Resurrection Bay, opposite the south end of Renard Island, and was staked by H. E. Ellsworth, of Seward, and the Reynolds-Alaska Development Company. A small opening has been made here at high-tide level in a brecciated mass of greenstone. The breccia, as exposed, is 12 feet in thickness and has been traced for 100 feet or more along the shore. It is overlain by nonbrecciated greenstone, the junction between the two striking N. 27° W. and dipping 20° W. This appears to be the strike and dip of the flows at this locality. The rock of the breccia is a very fine-grained diabase in fragments varying from a few inches to less than a fourth of an inch in size. The material between the larger fragments is composed of the small fragments and a greenish cement. The original breccia, which is probably a flow breccia mixed with tuffaceous material, has been slightly broken and the fractures have been healed by quartz and pyrite, with a little calcite and chalcopyrite. These minerals have also penetrated and locally replaced the original cement and some of the fragments. A very little sphalerite occurs here. Assays across this 12-foot brecciated zone are reported to show 1.1 per cent of copper, and some small streaks carrying more chalcopyrite gave 7 to 8 per cent of copper.

Prospect No. 11.—This is about a mile east-southeast of No. 10, and was staked by E. F. Pitman and A. C. Gould, of Seward. There are three claims here, called the Fairview group, running eastward from the shore. A cliff a short distance from the water shows considerable iron stain, which is not accessible. The main showings are about three-quarters of a mile east from the shore, along a cliff on the south side of a mountain which rises to an elevation of about 2,500 feet. At the base of this cliff is a brecciated zone in the greenstone somewhat similar to that described above. This zone is 8 to 10 feet in thickness, strikes N. 78° E., and is vertical. Higher up and about 300 feet to the east is another similar zone (possibly the same one faulted a little to the north), from 8 to 10 feet in thickness. Fragments in the breccia are from 1 inch to 12 inches in diameter and consist of a medium to fine-grained diabase. This breccia seems to have been again fractured, the fractures filled, and the original cementing substance replaced, in part or wholly, by quartz, pyrite, marcasite, and chalcopyrite. Many pieces of the breccia are rounded and split in concentric layers when weathered. The cement is soft and much weathered and is now usually in the form of gossan, and the whole zone is much iron stained, although it has not been impregnated with these sulphides through its entire thickness. In one place there is a band 6 feet thick where the cement is fairly rich in sulphides; an assay of this material is said to have given 9.8 per cent of copper. This brecciated zone has been penetrated by a tunnel 10 feet in length, but the tunnel could not be reached at the time of the writer's examination on account of snow.

About a quarter of a mile to the northeast of this point, on the east side of the ridge, there are poor exposures of an irregular quartz vein perhaps 10 feet in width, standing vertical and running approximately east and west. No work has been done here. The rock contains much quartz and is commonly free from sulphides, but locally holds pyrite and a little chalcopyrite.

Prospect No. 12.—This is on the east shore of Resurrection Bay, about half a mile from Cape Resurrection. It was staked by W. R. Lietzke, of Seward. Specimens reported to come from this place consist of quartz containing some fragments of diabase, pyrite, and a little chalcopyrite. It is probable that this prospect is in a brecciated zone similar to those at Nos. 10 and 11 described above. Mr. Lietzke also has a prospect about a mile northeast of Cape Resurrection, near the shore.

Summary and conclusions.—The copper prospects examined are on veins in basic igneous rocks, chiefly in flows of ellipsoidal greenstone. These veins occur (1) as shear zones, (2) as brecciated zones where there has been little shearing, and (3) as brecciated zones parallel with the flows of greenstone. The first and second varieties of veins cut across the flows indiscriminately, and the third are apparently flow breccias which have been further fractured by movements due to folding. The first variety includes prospect No. 4, and probably also Nos. 3, 5, 6, and 7; the second, prospect No. 9; and the third, prospects Nos. 10 and 11, and probably also No. 12.

The copper-bearing mineral of these prospects is chiefly chalcopyrite, a sulphide of iron and copper, carrying when pure 34.5 per cent of the latter metal. The pyrite and pyrrhotite may carry very small amounts of copper. Locally, at or very near the surface, the chalcopyrite has altered to the carbonates, malachite and azurite. The copper in the veins has undoubtedly been derived from the surrounding greenstones probably at no great depth from the surface.

At the time of visit (August, 1908) little development work had been done on these copper prospects, and little ore had been revealed. At none of the prospects examined (Nos. 4, 8, 9, 10, and 11) had the existence of a good thickness and a considerable extent of merchantable ore been demonstrated. Some of the prospects could not be examined, for lack of time, and some because they were high up in the mountains and covered with snow, which lay on the ground much later than usual in the summer of 1908. The most encouraging statement concerning the copper veins on the east side of Resurrection Bay that can be made with the present information is that they occur in essentially the same manner and in the same kinds of rocks as the copper deposits to the east, on Prince William Sound, where there are two producing copper mines and some promising prospects.

From analogy with other copper veins of similar character elsewhere, there is no good reason to expect that ore bodies which may be found in the area under discussion will necessarily increase in size or in richness with depth. In fact, the opposite is more likely to be the case. Thus in developing a prospect it is good practice to follow the ore and not to run long crosscuts to intersect veins in depth. Under present conditions a copper prospect in this district, to afford encouragement for further work, should show a reasonable probability of the presence of several thousand tons of ore carrying at least 4 per cent of copper, or, if this metal is less in amount, sufficient values in gold or silver to offset the deficiency.

GOLD PROSPECTS.

Two tunnels have been run westward into the ridge along the shore, one at Seward and one a quarter of a mile south. The south tunnel is about 50 feet above the water, 60 feet long, and runs S. 73° W. along a zone of brecciated graywacke. This zone is 3 feet wide, strikes with the tunnel, dips 70° N., and is due to breaking along parallel joint planes. The rock has been cemented by quartz, containing a little pyrite, chalcopyrite, sphalerite, and pyrrhotite. The northern tunnel is 100 feet above the water and about 40 feet long, on a similar brecciated zone in graywacke. This zone strikes N. 47° W. and dips 80° N.; it shows from 6 inches to 2 feet of nearly pure quartz. Assays from each of these veins are reported to have shown small amounts of gold.

A few gold prospects are reported to occur in the valley of Falls Creek, about 25 miles north of Seward and 5 miles east of the Alaska Central Railway. Some of these claims were staked by C. E. and J. W. Stevenson, and others by F. P. Skee and John Lechner, all of Seward. Messrs. Skee and Lechner report that they have one vein on which a tunnel 100 feet in length has been run. A winze 40 feet deep has been sunk in this tunnel, and at the bottom of the winze the vein is 3 feet 10 inches wide. In the tunnel itself the vein is 2 feet wide. The vein consists of quartz, carrying free gold near the surface and probably a telluride of gold lower down. Twenty tons of ore are said to have been shipped from this vein in 1906 and 11 tons in 1907, the ore averaging $35 per ton in gold. Specimens from the vein contain considerable native gold.

Other gold-bearing quartz veins have been discovered near Moose Pass, which is about 12 miles northwest from milepost 33 on the Alaska Central Railway. Several claims have been staked at this locality and some prospecting was done on them in the summer of 1908.[a]

[a] Personal communication from W. W. Atwood.

MINERAL RESOURCES OF SOUTHWESTERN ALASKA.

By W. W. Atwood.

INTRODUCTION.

It is proposed to summarize briefly[a] in this paper the mineral resources of Alaska Peninsula and the adjacent islands—the region usually termed southwestern Alaska. (See Pl. V.) As the lignitic coal fields which border Cook Inlet form a part of the same general province, they also will be briefly considered.

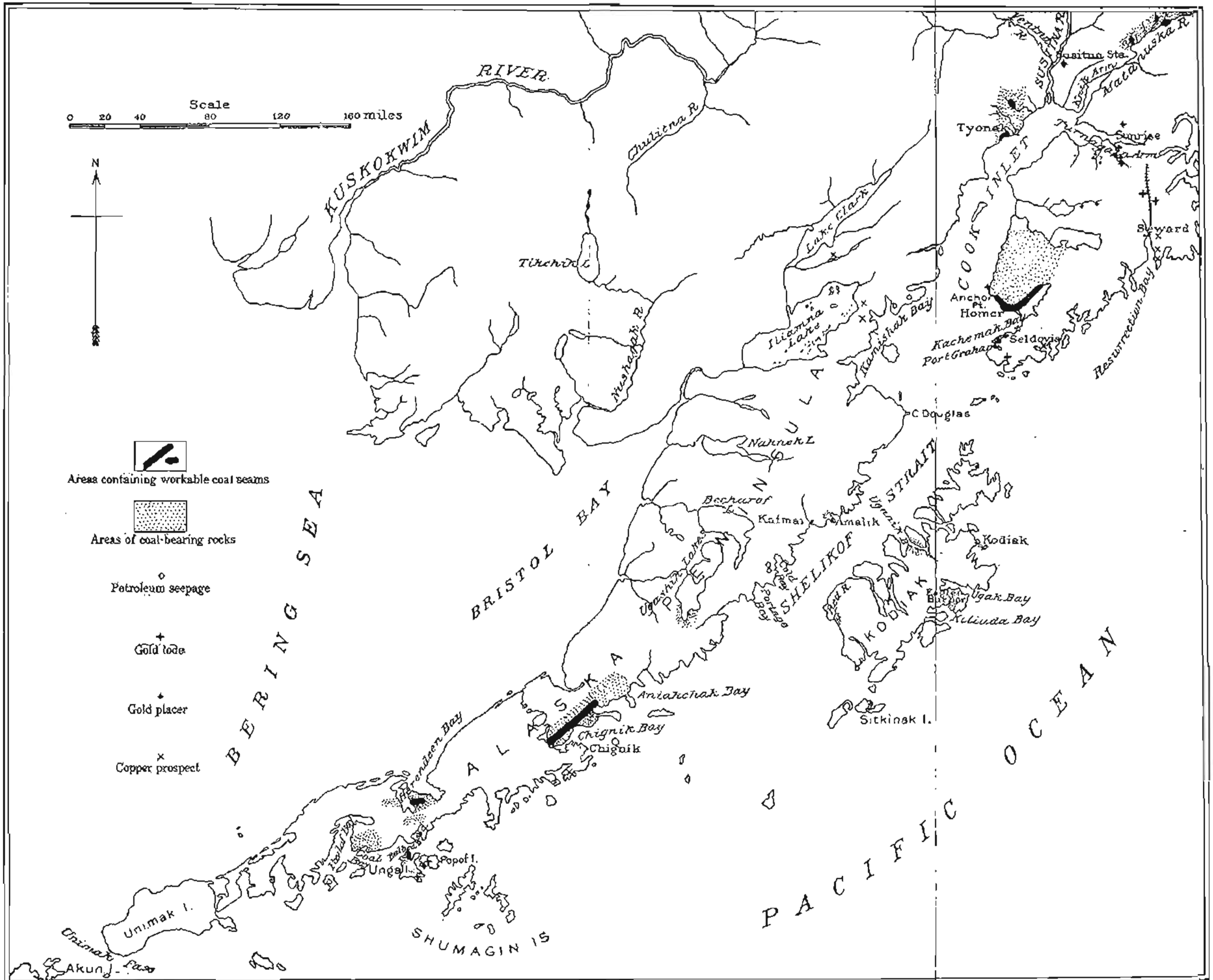
Most of the data to be presented were collected during the months of June to September, 1908, much of this time, however, being spent in examining the Unga, Herendeen Bay, and Chignik Bay coal fields. A part of the results of a study made in 1906 of the Cook Inlet coals is also incorporated. Free use has been made of the work of previous investigators in this field, to whose reports reference will be made. In this study H. M. Eakin rendered efficient aid, both in the field and in the office.

TOPOGRAPHY.

Cook Inlet occupies a broad synclinal depression bordered on the east by a low escarpment from which a gravel-floored plateau slopes up to the western margin of the Kenai Mountains. These mountains stand 5,000 to 6,000 feet above the sea and give rise to several small glaciers. The southwestern extension of the Kenai Mountains is found in the highlands of Kodiak and Afognak islands, which rise to elevations of about 3,000 feet.

West of Cook Inlet there is another escarpment marking the seaward face of an inland gravel-floored plateau, which slopes up toward rugged unexplored mountains that form a southern extension of the Alaska Range. From the West Foreland of Cook Inlet to the latitude of Cape Douglas the Chigmit Mountains, 3,000 to 3,500 feet in altitude, parallel the coast and are broken by several broad gaps. The Aleutian Range begins at Cape Douglas and stretches to the southwest, forming the axis of Alaska Peninsula and, in its submerged portions, the Aleutian Islands. These mountains vary greatly in alti-

[a] A more complete report is in preparation.



MAP OF SOUTHWESTERN ALASKA, SHOWING DISTRIBUTION OF KNOWN MINERAL DEPOSITS.

tude, in some places being only 2,000 to 3,000 feet high and in others rising to 5,000 to 6,000 feet above the sea. They include several active volcanoes exceeding 10,000 feet in altitude. Northwest of the Aleutian Range there is a belt of lowlands which extends from the base of the mountains to Bering Sea.

The coast line of southwestern Alaska exhibits extreme irregularity along the Pacific and great simplicity along the western shore of Cook Inlet and the shores of Bering Sea. The Pacific seaboard is marked by numerous indentations and wave-cut cliffs and affords many harbors. The northwest margin of Alaska Peninsula, on the other hand, has an even coast line bordered by numerous sand bars and sand reefs, with many tidal lagoons.

CLIMATE.

This province lies in about the same latitude as the British Isles, and except in the northern part does not suffer from severe climatic conditions. The rainfall varies from about 100 inches annually in the western portion of Alaska Peninsula to about 16 inches along the shores of Cook Inlet. At Coal Harbor (Unga Island) the average annual rainfall is 48 inches. During the summer rain falls at frequent intervals, but does not usually interfere with out-of-door work.

The mean winter temperature on Alaska Peninsula and Kodiak Island is about 30°, but in the northern portion of Cook Inlet it is about 12°. Ice forms in the upper portion of the inlet, preventing navigation from early in November until May. During the summer most of the snow disappears from the Kodiak group of islands and from the lowlands of Cook Inlet and Alaska Peninsula. The mean temperature from May to October, inclusive, varies from 49.3° in the Cook Inlet region to 49.1° at Kodiak and 45.5° at points farther west.

VEGETATION.

The lowlands bordering Cook Inlet and the lower slopes of the adjacent mountains are clothed with forests of spruce and hemlock. These trees range up to 16 inches in diameter. The alluvial lands are overgrown with grasses and forms of marsh vegetation. Southwestward from Cook Inlet, on the islands of Afognak and Kodiak, the trees become smaller and less numerous, and west of Kodiak and on Alaska Peninsula there are no trees. The largest forms of plant life on Alaska Peninsula, except near the head of Bristol Bay, are stunted alders that in places reach 15 feet in height, but more commonly are but 6 to 8 feet. Willow bushes border the rivers and the more marshy places in the lowlands. The vegetation in this western portion of the peninsula consists chiefly of mosses and grasses. The grasses are exceedingly luxuriant and by the end of the season are 5 feet or more in height.

TRANSPORTATION.

Seward, Kodiak, and Seldovia may be reached by steamer from Seattle. At Seldovia connections may be made for other Cook Inlet ports, and at Seward for all points to the west, including Iliamna and Cold bays, Afognak, Kodiak, Chignik, Unga, Sand Point, Balboa Bay, Coal Harbor, Unalaska, and, from June to September inclusive, Nushagak. Small schooners or launches may be engaged at several of the above ports, and the local boatmen may be trusted to take parties to intermediate and less-frequented parts.

Inland travel is not more difficult in this region than in most mountainous districts. After the zone of alder bushes and tall grasses has

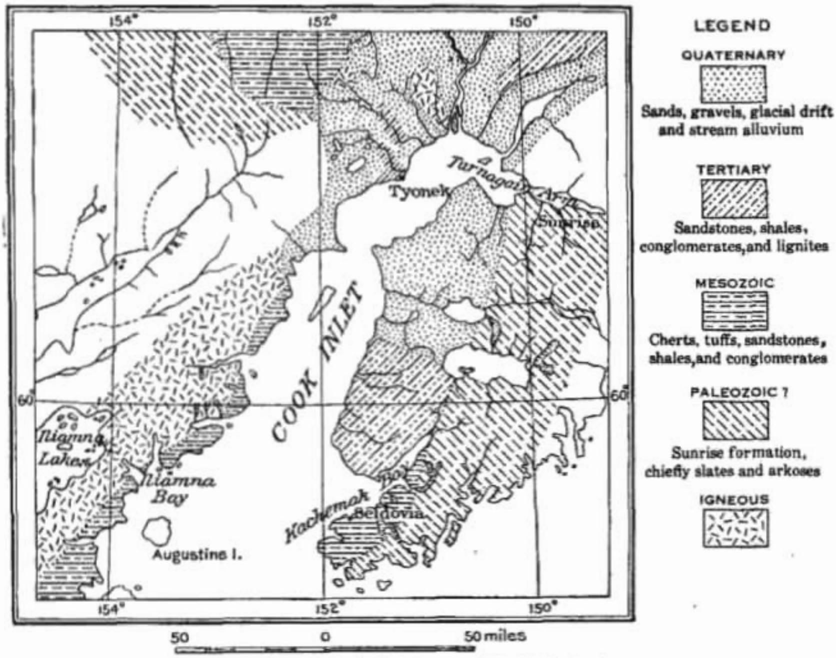


FIGURE 2.—Geologic sketch map of Cook Inlet region.

been passed the climbing is comparatively easy. In portions of the area pack horses could be used to advantage during the summer.

GEOLOGY.

KENAI PENINSULA.

The general geologic features of Kenai Peninsula (see fig. 2), as determined by Moffit,[a] are as follows:

A monotonous succession of slates and arkoses, together with scattered beds of conglomerate or quartzite, are believed to be the oldest

[a] Moffit, F. H., Mineral resources of Kenai Peninsula, Alaska: Bull. U. S. Geol. Survey No. 277, 1906,, pp. 16-28.

rocks. Some granitic intrusives are found cutting these rocks, which are probably of Paleozoic age and were termed the Sunrise "series" by Mendenhall.[a] This series probably dominates throughout the Kenai Mountains. A succession of closely folded cherts and green diabases cut by acidic porphyries occur south of Kachemak Bay and are provisionally referred to the Triassic. Their relation to the Sunrise formation is not known. In the same general region are some gently folded tuffs and agglomerates which are of Lower Jurassic age. Resting unconformably upon these rocks are the lignite-bearing sandstones and shales of the Kenai formation, only slightly disturbed. These Kenai beds are present at Port Graham, Kachemak Bay, and thence stretch northward along the eastern shore of Cook Inlet. In addition to the consolidated rocks there are extensive deposits of Quaternary silts, sands, and gravels, as well as glacial bowlders and till.

The geologic conditions in the islands southwest of Kenai Peninsula are probably similar to those in the peninsula. Kodiak, the largest of these islands, is known to contain considerable thicknesses of slate that are probably either of Triassic or of Paleozoic age, and coal-bearing rocks, probably of late Eocene age, are known to outcrop at several places on the islands. (See Pl. V.)

ALASKA PENINSULA.

The geologic conditions on the west shores of Cook Inlet ana Shelikof Strait have been studied by Stanton and Martin.[b]

> The Alaska Peninsula contains a coarse crystalline core of granite or of similar rocks, flanked on the eastern side by Mesozoic sediments and on the western side by late Tertiary or post-Tertiary beds. The Mesozoic beds are overlain in places by early Tertiary formations. Both the Mesozoic and the Tertiary beds are cut by andesite and basalt. The intrusion and volcanic overflow have continued from late Jurassic time until the present, the region containing several active volcanoes.
>
> * * * * * * *
>
> The general relations of the formations may be epitomized in the following section:
>
> *Tertiary.*—Kenai formation. Shales, sandstones, and conglomerates, with several beds of coal. The entire formation nonmarine and characterized by a large flora. Thickness, 2,000± feet.
>
> Unconformity.
>
> *Upper Cretaceous.*—Lithologically similar to the Kenai, but including some marine shales and sandstones, with an Upper Cretaceous fauna. Thickness, 1,000± feet.
>
> Unconformity.
>
> *Lower Cretaceous* (not seen within the area studied). Shales and sandstones, with *Aucella crassicollis*.
>
> Unconformity (?).

[a] Mendenhall, W. C., Reconnaissance from Resurrection Bay to the Tanana River, Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 305.

[b] Stanton, T. W., and Martin, G. C., The Mesozoic section on Cook Inlet and Alaska Peninsula: Bull. Geol. Soc. America, vol. 16, 1905, pp. 393, 410.

Upper Jurassic.—Naknek formation. Conglomerate, arkose, sandstone, and shale, with interstratified andesite flows. Thickness, about 5,000 feet.

Middle Jurassic.—Enochkin formation. Shales and sandstones, with some conglomerate beds. Thickness, 1,500 to 2,000 feet.

Unconformity. (Possibly conformable on Lower Jurassic when that is present.)

Lower Jurassic.—Tuffs and sandstones. Thickness, 1,000± feet.

Unconformity.

Upper Triassic.—Thin-bedded cherts, limestones, and shales, usually much folded and contorted and with many intrusive masses. Thickness, 2,000± feet.

Base not seen.

From Chignik Bay westward to Pavlof Bay, in the district examined by the present writer during the summer of 1908, the general structure of the peninsula is anticlinal. For nearly 200 miles the central mountain belt is made up of a great series of sedimentary beds. In the Chignik area the main fold is composed of Upper Jurassic and Upper Cretaceous rocks. No Lower Cretaceous has as yet been identified in this region. Bordering the main anticlinal fold there are gently folded strata including sediments of Upper Cretaceous and Eocene age. Post-Eocene intrusions of granite and Recent basaltic flows are associated with the sedimentary formations south of the main fold at Chignik Bay.

At Balboa Bay and northward across the peninsula to Herendeen Bay the structure is well exposed. There the central fold includes some Upper Cretaceous beds and a great thickness of Eocene sediments, with possibly some sediments of Oligocene age. Laccolithic intrusions and faulting have modified the main anticlinal fold so that there are domical structures in the midst of the fold and crystalline rocks are exposed at several places. Intrusive sheets appearing as sills and dikes are also common in this portion of the range.

To the north and south of the central fold in the Herendeen and Balboa Bay district there are minor anticlines and synclines. On the north or Herendeen Bay side these minor folds are composed of sediments that range in age from Upper Jurassic to Miocene. On the south side the sediments are of Eocene and Miocene age.

The middle and western portions of Alaska Peninsula have been and continue to be a region of active volcanism. Vast quantities of lava have been poured out at various places, and fragmental materials from the volcanoes blanket large parts of the area.

The islands near Alaska Peninsula, so far as they were examined, are composed chiefly of igneous rocks. Small areas of sedimentary formations appear on certain of these islands, but the wide range of stratified deposits exposed in the peninsula have not yet been recognized on the islands. Recent volcanic material mantles a large portion of Unga and the neighboring islands of the Shumagin group. The following table gives the geologic column as exposed in the western portion of Alaska Peninsula:

Geologic sequence in western part of Alaska Peninsula.

Age.	Geographic distribution.	Lithologic character.	Thickness (feet).	Remarks.
Recent	Stream valleys	Sands, muds, and gravels.		
Pleistocene	Lowlands and along valleys.	Unconsolidated clays, sands, gravels, and glacial drift.		
Post-Miocene	Unga Island, Popof Island, Balboa Bay, Port Moller, and Chignik Bay.	Tuffs, agglomerates, breccias, and flows.		Many volcanic deposits still show cone structure.
Miocene	Unga and Popof islands, Balboa and Herendeen bays, and Port Moller.	Loosely cemented clays, sands, gravels, and conglomerates. Some beds furnish abundant marine fossils.		These deposits usually occur in very small areas.
Eocene	Chignik Bay, Unga Island, center of Alaska Peninsula, and Herendeen Bay region.	Shales, sandstones, grits, and conglomerates. Locally carries lignite.	Up to 5,000	Carries workable lignite bed at Coal Harbor. Occupies a very large part of Alaska Peninsula in Herendeen Bay region.
Upper Cretaceous	Chignik and Herendeen bays.	Conglomerate, sandstone, and shales, with coal seams.	600+	Contains valuable coal beds at Chignik and Herendeen bays.
Lower Cretaceous	Herendeen Bay	Shale, sandstone, and calcareous sandstone.	1,800+	
Upper Jurassic	Chignik and Herendeen bays.	Sandstones, conglomerates, and arkose.	1,000+	

The Upper Jurassic sediments are exposed along the shores of Chignik Bay, Chignik Lagoon, and Chignik Lakes. They also outcrop in the central portion of the mountain area northwest of Chignik Bay and west of Hook Bay. In the Herendeen Bay region Upper Jurassic strata are exposed south of Mine Harbor at Crow Point, in the base of Pinnacle Mountain, and on the west shore of Herendeen Bay. These sediments consist of dense, fine-grained sandstones of bluish color, conglomerates, shales, and arkose. They are the oldest sedimentary rocks exposed in either the Chignik or the Herendeen Bay districts. In the Chignik area they are associated with the central part of the main anticlinal fold of the peninsula. In the Herendeen Bay district these rocks outcrop north of the main axis in minor folds exposed along the shores of Herendeen Bay. The Chignik localities have yielded several collections of invertebrate fossils whose age has been determined by T. W. Stanton.

The Upper Jurassic beds in Pinnacle Mountain, Herendeen Bay, are overlain by Cretaceous rocks and both have been folded, truncated, and in part covered by volcanic material, which issued from the summit of Pinnacle Mountain. The exposures on the west shore of Herendeen Bay are near the beach and consist chiefly of fine-grained blue sandstones. The fossil material procured from these localities has been examined by Mr. Stanton, who reports that within the Upper Jurassic of Herendeen Bay two horizons are represented. At the upper horizon are forms related to *Aucella pallasi*. The beds at this horizon are best exposed in Crow Point. At the lower horizon are forms related to *Aucella bronni*. The beds at this horizon are typically exposed near the base of Pinnacle Mountain.

Among the collections procured from the Chignik Bay region there are no fossils of Lower Cretaceous age. In parts of this region, at least, the Upper Cretaceous beds unconformably overlie the Upper Jurassic, and it may be that there is no Lower Cretaceous in the region. In the Herendeen Bay district the Lower Cretaceous appears in three belts extending through the Herendeen Bay coal field, coming to the surface on the flanks of the folds. The fossil material procured from these formations indicates that there are two horizons within the Lower Cretaceous. At the upper horizon are forms related to *Aucella crassicollis*, and at the lower are forms related to *Aucella piochii*. One of the collections contains some forms related to those of the upper horizon and others related to those of the lower horizon. The sediments of this period consist of sandstones, shales, and conglomerates.

Upper Cretaceous sediments are exposed in the mountains northwest of Chignik Bay and west of Chignik Lake. They are also present in the Herendeen Bay district. They are exposed in the central portion of the main anticline below a great laccolithic intrusion and in the syncline at the south margin of the Herendeen Bay coal field. They also appear on the flanks of the adjoining anticline to the north, on the south side of Pinnacle Mountain, and in the hills west of Herendeen Bay. The Upper Cretaceous sediments consist of sandstones, shales, conglomerates, a little limestone, seams of bituminous coal, and some lignite. Upper Cretaceous fossils were procured by Paige[a] from the coal measures in the Herendeen Bay field and by the present writer from the several other localities abovementioned in this district and in the region of Chignik Bay.

Eocene, Miocene, and post-Miocene formations are exposed in this portion of the peninsula. The Eocene strata include at least 5,000 feet of sandstones, shales, conglomerates, and seams of lignite, and form the central portion of the Aleutian Range in the Balboa-Herendeen Bay district. They extend westward at least as far as Pavlof Bay and eastward to the Chignik Bay region. Several collections of fossil shells and plants have been procured from these beds. The shells are those of marine invertebrates and have been determined by W. H. Dall to be of upper Eocene age. Mr. Dall reports that some of the material from these strata may be upper Eocene or Oligocene. The plants, as determined by F. H. Knowlton, are all of Kenai age. They were procured from beds that are interstratified with those from which the shells were obtained. Kenai plants from Alaska have been determined by Mr. Knowlton to be of upper Eocene age and the harmony

[a] Paige, Sidney, The Herendeen Bay coal field: Bull. U. S. Geol. Survey No. 284, 1906, p. 103.

between the age determinations of the plants and animals is exceedingly satisfactory. The nature of the Eocene deposits indicates that the area of sedimentation was several times just below sea level, probably near to shore, and at other times above sea level, receiving wash from higher lands, or overgrown by dense growths of vegetation.

Miocene sediments appear in Unga and Popof islands and at several places on the north and south sides of Alaska Peninsula. They consist of sandstones, shales, and conglomerates that represent offshore, shallow-water deposition. An abundance of fossil material was procured and has been identified by Mr. Dall. At Coal Harbor, Unga Island, the Miocene strata conformably overlie the Kenai formation (upper Eocene), but at other localities the Miocene sediments appear to rest unconformably upon different formations and to have been restricted to local basins. They are but little disturbed.

One collection of fossil plants, from the Herendeen Bay district but from a lithologic unit that occupies a very small area, seems to indicate post-Miocene age. The most extensive post-Miocene formations consist of volcanic tuffs and basic lava flows. They are widespread on the mainland in the vicinity of the Balboa-Herendeen Bay district, and cover many square miles in the islands to the south and in the region about Chignik Bay.

Much of the volcanic material just described may be of Pleistocene or even post-Pleistocene age, and there is little doubt that some of it is. Glacial drift mantles the lowlands on the north side of the Alaska Peninsula and is irregularly distributed in the mountain valleys.

Since Pleistocene time the land has risen, relative to sea level, and the terraces bordering the coast are covered with Recent alluvium. In the valley bottoms and at the heads of bays there are other alluvial deposits of post-Pleistocene age.

DISTRIBUTION OF KNOWN MINERAL DEPOSITS.

GENERAL OUTLINE.

The known mineral wealth of southwestern Alaska consists of coal, petroleum, gold, and copper. The distribution of these deposits is shown on the accompanying map (Pl. V). The important coal fields are located in Matanuska Valley, on the shores of Cook Inlet, near Chignik Bay, and near Herendeen Bay. Less important deposits of coal and lignite have been found at various places in Alaska Peninsula and neighboring islands.

The oil seepages occur in the vicinity of Cold Bay and on the west shore of Cook Inlet.

Placer gold has been found in paying quantities in the creek placers of the Sunrise district of Cook Inlet and in the beach placers on Popof and other islands. Some placer gold occurs also on the north shore of Kachemak Bay near Anchor Point, and in the lower part of the valley of Cooper Creek near Lake Kenai. Some development work has been done on gold-bearing ledges about 25 miles north of Seward, near the line of the Alaska Central Railway; at Moose Pass, south of the head of Turnagain Arm; and at several points in Kodiak Island. A gold-bearing quartz ledge has been located on Dry Island, north of Kodiak. Several locations for gold have been made on Popof Island, and on Unga Island lode mining has been conducted successfully for a number of years.

Copper claims have been located on the east shore of Resurrection Bay opposite Seward and southward to Cape Resurrection. In the vicinity of Lake Clark and Lake Iliamna some copper has been found, but as yet little work has been done in this district. On the west shore of Prospect Bay, a small reentrant a few miles west of Chignik Bay, there are evidences of copper, and on the east shore of Balboa Bay there is an abandoned copper prospect. In this report only the coals of Cook Inlet and the coals and other mineral deposits of Alaska Peninsula and Unga and Popof islands will be described.

COAL.

COOK INLET.

INTRODUCTION.

Coal is exposed on the shores of Cook Inlet at Port Graham, in the vicinity of Homer, and near Tyonek. Port Graham is an indentation in the east shore of Cook Inlet about 8 miles southwest of Seldovia. The extent of coal-bearing rocks at this place is somewhat less than 1 square mile. The Homer field includes the land bordering Kachemak Bay and northward to Cape Kasilof. (See fig. 2.) There are at least 1,000 square miles in this field. The coal near Tyonek is exposed along the beach, beginning at a point about 3 miles south of the town and extending southward for nearly 4 miles, and in several of the valleys north of Tyonek at least as far as Beluga River. This field contains about 150 square miles.

Each of these coal fields is in a lowland area. A sea cliff forms the shore line, and the upland surface has a rolling topography, with low hills and shallow depressions characteristic of areas mantled by glacial drift. At Port Graham the coal is on the north side of the bay, just within the entrance. It is limited at the east and west by masses of igneous rocks that form bold headlands at the margin of a small bay. From Cape Kasilof southward to Anchor Point and thence eastward for several miles beyond the Homer Split the shores of Cook Inlet and Kachemak Bay are bordered by a cliff that ranges in height from 50 to 400 feet, in which the coal beds occur. (See fig. 2.) Near Tyonek a sea cliff forms the shore line where the coal measures outcrop, but along the shore to the north there is low alluvial land, which extends inland to the margin of the coal belt.

GEOLOGY.

The geology of the Cook Inlet coal fields is relatively simple. The coal measures rest unconformably upon the pre-Jurassic diabase and cherts and Lower Jurassic tuffs, sandstones, and calcareous beds. The coal-bearing formations are slightly deformed and are overlain unconformably by Pleistocene deposits and later alluvium. Fossil plants have been procured from various localities in this field, and they have all been grouped with the Kenai. The type areas of the Kenai formation are at Port Graham and on the shores of Kachemak Bay. The age of the Kenai plants was at first thought to be Miocene, but later they were assigned to the upper Eocene. Marine invertebrate shells of upper Eocene age have been found in close association with Kenai plants in Alaska Peninsula, and there can be little doubt that the coal-bearing beds bordering Cook Inlet are upper Eocene also.

The Kenai formation consists of sand, sandstone, clay, shales, conglomerate, and seams of lignite. Much of the material is but loosely cemented. Several sections of the coal measures are given in Plate VI and figure 5.

The north-south section through the Homer field (fig. 3) shows the structural relations of the coal measures in that portion of the region. The distribution of outcrops along the beach at Tyonek is shown in figure 4.

COAL NEAR TYONEK.

The coal exposed near Tyonek is a tough woody lignite. Huge trunks of trees, now partly changed to lignite, are exposed at several places and suggest by their arrangement

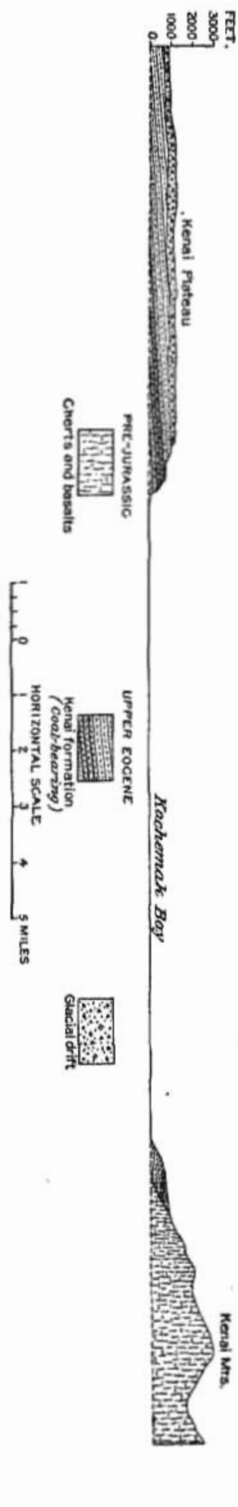


FIGURE 3.—Diagrammatic structure section across Homer coal field.

the drifting of logs into a big swamp or pond, or a group of fallen trees in a forest. A measured section in the coal-bearing series is given in figure 5. The entire series appears to be conformable and represents conditions of sedimentation similar to those existing to-day in the large deltas. The sediments indicate frequent changes in the conditions of deposition. They are such as are handled by streams of low grade and consist of sands, clays, gravels, and fragments of wood, showing a marked absence of coarse material. Most of this material is unconsolidated, or but partly cemented. Fossil leaves procured from this series have been determined by F. H. Knowlton to be of Kenai age.

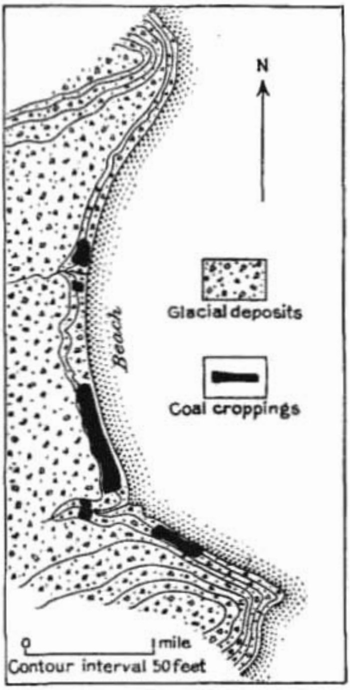


FIGURE 4.—Map showing distribution of coal croppings along the Tyonek beach, Cook Inlet.

Many of the seams of lignite have been on fire, and the clays associated with them have been burnt to a brilliant red color. Certain seams are known to have been burning for at least ten years. Near the base of the measured section (fig. 5) there is a bed of conglomerate in which the matrix is sand and the pebbles lignite. The lignite pebbles are very well rounded, and when broken the fresh fracture faces are exceedingly brilliant. They break with a conchoidal fracture. The streak from these pebbles is dark brown or black, and the material appears to be of much better grade than that outcropping as seams in this vicinity. It is difficult to believe that this great number of lignite pebbles may be accounted for as drift wood along a beach, and an alternative hypothesis is that they were derived from a lower coal-bearing series, or possibly from some seam in the lower portion of this series. This hypothesis would imply that there was a distinct unconformity in the series, and that the lower portion of it became exposed, in portions of the field at least, while sedimentation was continuing in adjoining areas. A similar conglomerate horizon was found near Beluga River and also in the section along the north shore of Kachemak Bay.

Figure 4 shows in detail the distribution of the outcrops, together with some data on the position of the beds. At the northernmost outcrop the section on page 120 is exposed.

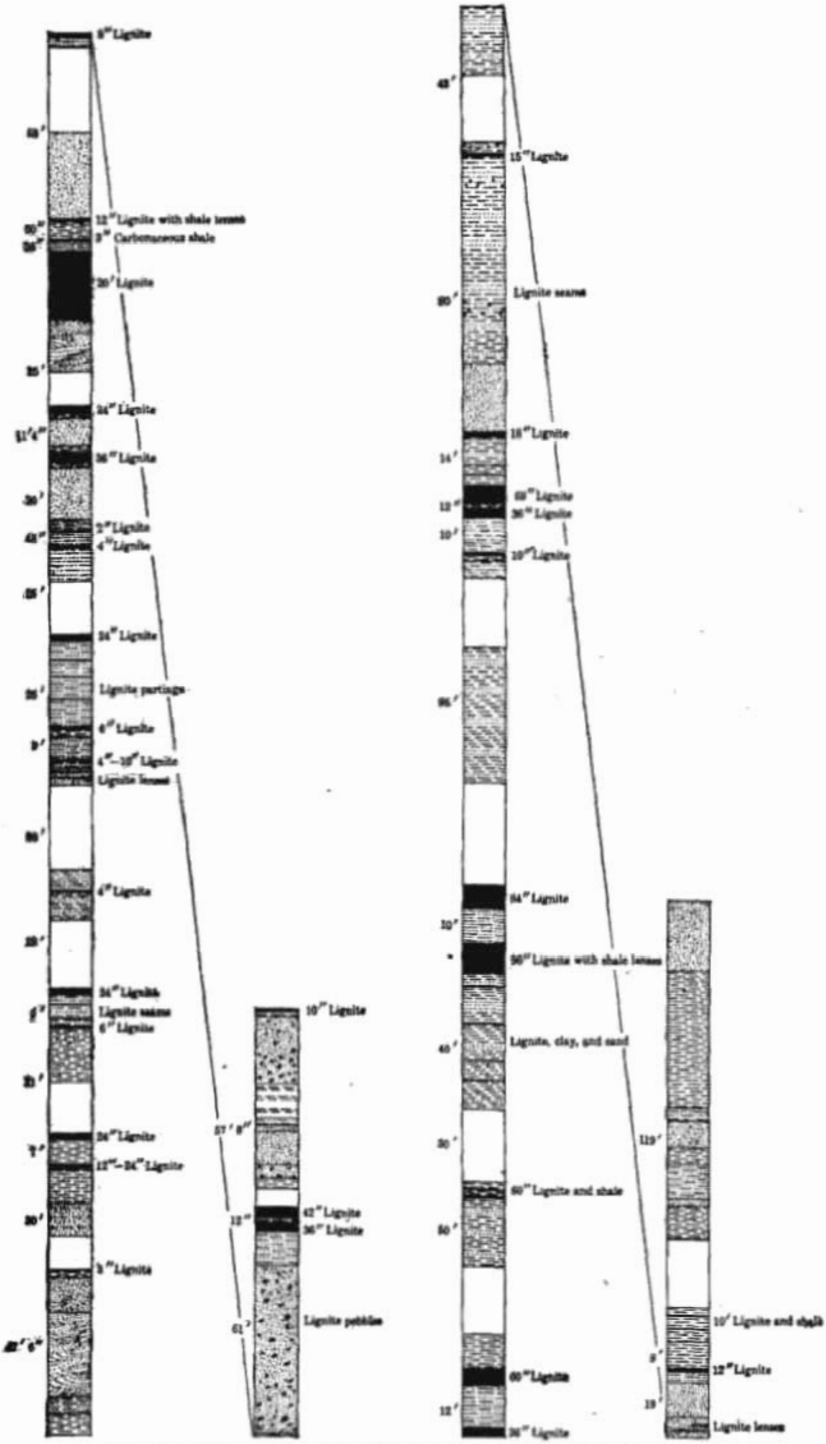


FIGURE 5.—Columnar sections of the Tertiary coal measures near Tyonek.

Section at northernmost coal outcrop near Tyonek.

	Ft.	in.
Glacial drift	10–15	
Blue clay	5	
Lignite	10	4
Blue clay	1	6
Lignite	16	6

The lower or larger seam was sampled and the analysis is given in the table on page 126. There are at least 36 seams of lignite, large and small, exposed along the beach. Several of them are from 8 to 10 feet thick, but most of them vary from 3 to 4 feet.

Each year 400 to 500 tons of low-grade lignite are taken from the Tyonek beach. This material is used for domestic purposes and as fuel on local steamboats.

Northwest of Tyonek, in the area where Beluga River crosses the coal field, the beds in general continue to dip to the northeast, and in following the valley upstream the entire section may be examined. (See Pl. V.) From these exposures it is evident that the lignite seams in the upper portion of the section are of much poorer grade than those near the base. The strike varies from N. 17° E. to N. 22° W., and the average dip is about 55°. The sediments are of the same character as those exposed along the beach south of Tyonek, consisting of loose sands, sandstones, clays, shales, conglomerates, and seams of lignite. Near the base of the section there are two seams of lignite 10 and 12 feet thick, which are more brittle and harder and appear to be of much better grade than any exposed elsewhere in the field. They outcrop 10 miles above the mouth of the Beluga, measured along the stream, and about 2 miles above a belt of dangerous rapids. The analysis of a sample taken from the larger of these seams is given on page 126.

Near the base of the section and not far from the western margin of the coal field there has been some minor folding and faulting, and heavy beds of conglomerate are exposed. These conglomerates are separable into three beds. The lowest is at least 200 feet thick and consists of fine gravel and cobblestones, grading up to 6 inches in diameter. All of this material is well worn by water. The pebbles consist of quartz, granites, basalt, schist, lignite, and various fine-grained igneous rocks. The general color of the conglomerate is dark brown. The intermediate conglomerate consists of similar material and is separated from the heavy conglomerates above and below by thin beds of sandy shale. The uppermost bed of conglomerate consists of sands and gravels, the larger pebbles of which grade up to 2 inches in diameter. White quartz pebbles are exceedingly abundant, and as the sand is of a grayish color the outcrops of this conglomerate, on account of their general light-gray color, are very conspicuous. Associated with the quartz are pebbles of schists, granites, basalts, greenstones, and various other igneous rocks. The thickness of this conglomerate is about 300 feet.

Below the conglomerate series there is a great thickness of shales and sands, in which lignite seams occur. A few fragments of dicotyledonous leaves were procured from this locality, but the material was not such as could be identified.

The heavy conglomerates outcropping along Beluga River, together with the contrast between the poor lignite above and the better lignites below, suggest a subdivision in the coal-bearing series. The fact that these conglomerates, as well as that exposed along the Tyonek beach and on the north shore of Kachemak Bay, contain lignite pebbles seems to indicate that there was at least a somewhat widespread change in the general conditions of deposition in the midst of the period. The examination along Beluga River was made without the help of an accurate map, and no unconformity was determined, but the exposures suggest that structural unconformity may exist there.

Some coal has been taken from the seams outcropping on the banks of the Beluga and carried downstream in small boats, but the difficulty of handling the boats in the narrow portions of the river and at the rapids makes this work dangerous.

COAL ON KACHEMAK BAY.

The coal measures outcrop at intervals along the north shore of Kachemak Bay, from the vicinity of Anchor Point to the head of the bay. The remaining space is filled in with glacial drift, which occupies the valleys of the preglacial surface and mantles the entire area of the coal fields. (See fig. 2.)

About 1½ miles southeast of Anchor Point seams of lignite appear in the beach at extreme low tide. These seams vary from 12 to 20 inches in thickness, strike about N. 50° E., and dip from 10° to 15° SE. The lignite is bright and clean and breaks with a cubical fracture, but lignite in such thin seams is not of much economic value. Southeastward to Troublesome Gulch several more thin seams of high-grade lignite outcrop. The strike remains about the same as that farther west, but the dip is toward the north, or into the bluff. This change in the direction of the dip indicates a gentle fold in the strata. Between Troublesome Gulch and the mouth of Diamond Creek a low anticlinal fold appears along the beach. About 1½ miles east of Troublesome Gulch a lignite seam with the following section outcrops:

Section of lignite near Troublesome Gulch.

	Ft.	In.
Coarse sand.		
Lignite	2	
Carbonaceous shale		3
Lignite	1	9
Clay.		

The analysis of a sample from this seam is given in the table on page 126. Three-fourths of a mile west of Diamond Creek a seam of lignite 3½ feet thick was sampled and the analysis of this sample also is given in the table. The section here is as follows:

Section of lignite near Diamond Creek.

	Ft.	in.
Carbonaceous shale	1	3
Lignite		3
Carbonaceous shale		5
Lignite	1	
Shale		2
Lignite	2	7
Clay.		

The next important outcrops are at Bluff Point, near the old coal mines of the Cook Inlet Coal Fields Company. This part of the field and the area extending eastward to the head of the bay have been examined by Stone,[a] to whose report the reader is referred for details. In this part of the field 2,000 to 3,000 feet of coal-bearing rocks are exposed; these include an aggregate of over 60 feet of workable coal beds, the thickest bed of which is about 7 feet. Detailed sections of the coal-bearing strata are presented in Plate VI and figures 6 and 7.

Though some mining has been done at Kachemak Bay for many years, the entire production probably does not exceed a few thousand tons. During the summer of 1906 the coal lands northwest of Homer were surveyed for patents in 160-acre claims. This work included all the land bordering the shore from the mine camp, near tunnel No. 1, westward to a locality within 2 or 3 miles of Anchor Point, and inland throughout this coastal belt for about 3 miles. In 1907 patent surveys were continued in this field and one shaft was sunk on the McDougal property, a recently staked claim, to a depth of 141 feet 6 inches. The following record from the surface downward is reported at this shaft:

Record of shaft on McDougal property, Kachemak Bay.

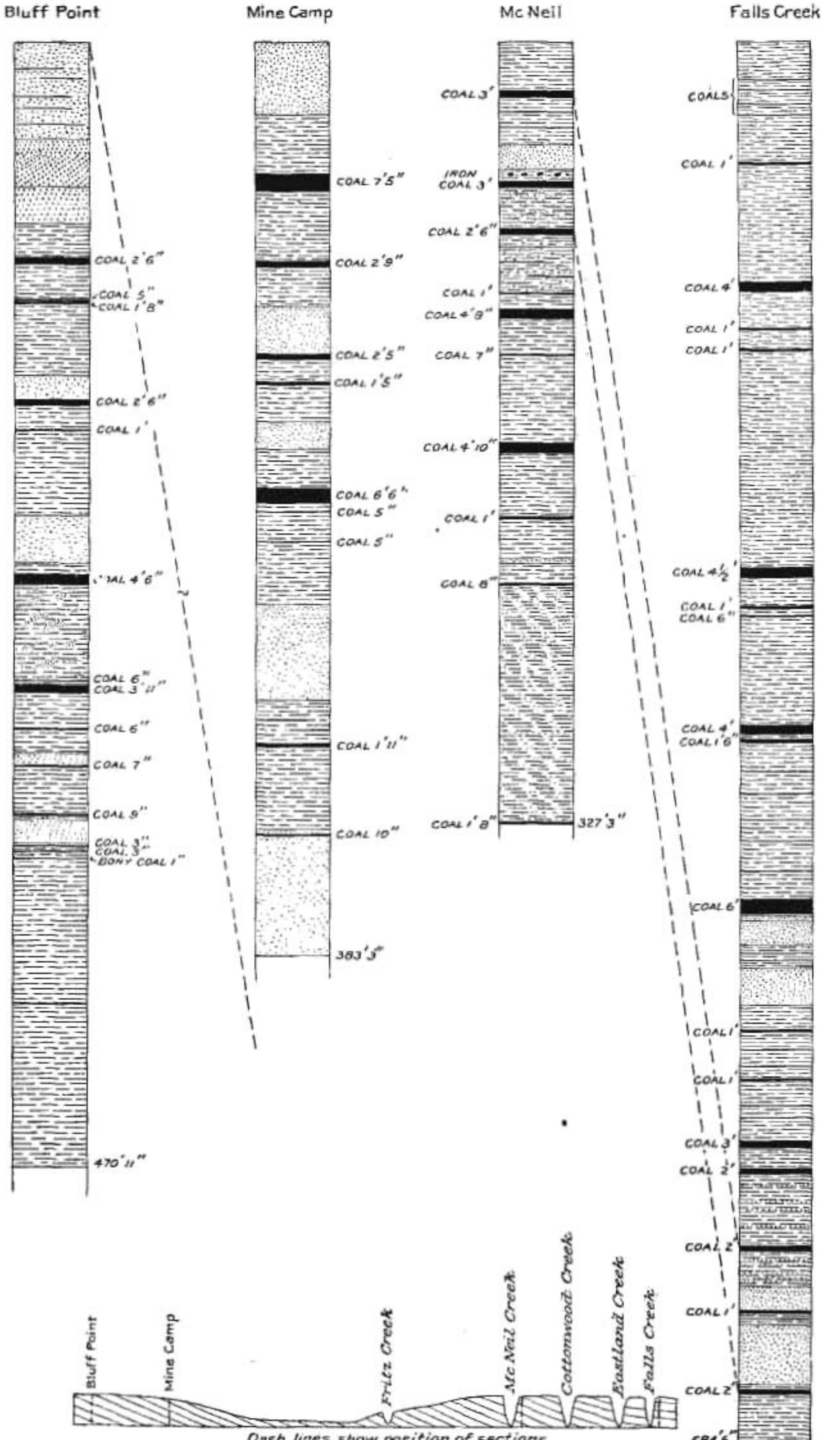
	Ft.	in.
Drift, probably glacial material and recent alluvium	85	
Sandstone	45	
Soapstone	5	
Coal	6	6

No very definite report of progress in this field has been received for the season of 1908, but there does not seem to have been much activity.

COAL AT PORT GRAHAM.

At Port Graham, a few miles south of Kachemak Bay, there is a small area of sandstones, clay shales, and lignitic coal beds, which are

[a] Stone, R. W., Coal fields of the Kachemak Bay region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 60-66.



COLUMNAR SECTIONS OF THE TERTIARY COAL MEASURES, KACHEMAK BAY.

of Kenai age.[a] There are probably several coal beds, but only two were accessible at the time of Stone's visit in 1904. One showed a thickness of 8 to 9 feet of coal, including some bone. This coal is black, brilliant, and clear.

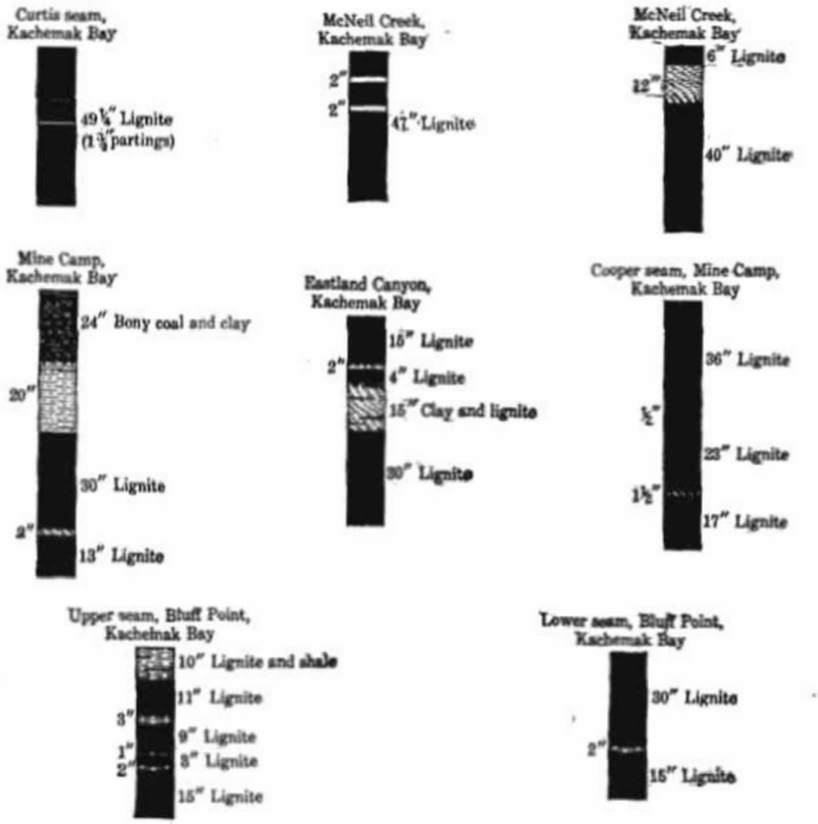


FIGURE 7.—Sections of coal seams at Kachemak Bay.

Mining was carried on by the Russians at Port Graham from 1855 to 1867, and since that time there has been some production, amounting lately to 1,000 to 2,000 tons annually. This lignite is used for domestic purposes and on local steamboats.

COMPOSITION OF COOK INLET COALS.

The following analyses will give a fair idea of the character and fuel value of the coals of the Cook Inlet region, which must all be classed as lignites. The samples taken in the field were sealed in air-tight

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[a] Stone, R. W., op. cit., pp. 66-68.

cans and sent to the laboratory. The results of the proximate analyses of the coals as collected have been recalculated to give the analyses on the air-dried basis. The samples were obtained at the following localities:

4458. North shore of Port Graham.

4457. North shore of Kachemak Bay, 3 miles east of Homer Spit.

4429. North shore of Kachemak Bay, 1 mile west of Homer Spit; 6-foot bed.

4426. North shore of Kachemak Bay, three-fourths of a mile west of Diamond Creek, several miles southeast of Anchor Point.

4432. North shore of Kachemak Bay, 1½ miles east of Troublesome Gulch, several miles southeast of Anchor Point.

4425. Loose lignite pebbles from a conglomerate on west shore of Cook Inlet, about 4 miles south of village of Tyonek.

4465. Near south end of Tyonek beach, west shore of Cook Inlet, about 4 miles southwest of village of Tyonek.

4464. West shore of Cook Inlet, first outcrop south of Tyonek, about 3 miles from village.

4434. Northwest of Tyonek, 10 miles up Beluga River, above canyon and rapids.

4456. Northwest of Tyonek, 10½ miles up Beluga River, above canyon and rapids.

Analyses of Cook Inlet coals.

[Analyses by F. M. Stanton, U. S. Geological Survey.]

SAMPLES AS RECEIVED.

Laboratory No.	Proximate analysis.					Ultimate analysis.					Calorific value.	
	Loss on air drying.	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
4458	8.20	19.96	38.73	32.46	8.85	0.52	5.81	49.53	0.92	34.37	4,885	8,793
4457	7.00	18.12	42.77	23.61	15.50	.43	5.51	44.77	.88	32.91	4,386	7,895
4429	9.40	18.59	36.13	34.92	10.36	.34	5.81	49.08	1.14	33.27	4,749	8,548
4426	19.40	28.06	33.51	32.81	5.02	.19	6.45	45.61	.85	41.28	4,340	7,812
4432	7.60	19.96	35.88	29.18	14.90	.41	5.82	44.55	.97	33.28	4,474	8,053
4425	20.80	27.60	31.47	37.18	3.75	.40	6.54	47.98	.86	40.47	4,636	8,348
4465	13.00	22.31	40.50	27.97	9.22	.30	6.20	44.23	.83	39.22	4,325	7,785
4464	9.60	20.68	41.80	29.12	8.40	.32	6.12	45.70	.77	38.69	4,440	7,992
4434	8.60	10.45	34.36	38.81	16.38	.22	5.49	44.72	.79	32.40	4,428	7,990
4456	6.40	17.44	38.25	28.69	15.42	1.63	5.61	45.25	1.16	30.94	4,581	8,246

AIR-DRIED SAMPLES (CALCULATED FROM TABLE ABOVE).

Laboratory No.	Proximate analysis.			Ultimate analysis.						Calorific value.		Classification ratios.		
	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.	Fuel ratio.	Carbon-hydrogen ratio.	Carbon-oxygen ratio.
4458	12.81	42.19	35.36	9.64	0.57	5.34	53.95	1.00	29.50	5,321	9,578	0.84	10.10	1.82
4457	11.95	45.99	25.39	16.67	.48	5.09	48.14	.95	28.69	4,716	8,489	.55	9.45	1.67
4429	10.14	39.88	38.54	11.43	.38	5.26	54.17	1.26	27.49	5,241	9,434	.97	10.29	1.97
4426	10.74	41.57	40.71	6.97	.24	5.33	56.59	1.05	29.81	5,384	9,692	.98	10.61	1.83
4432	13.46	38.79	31.55	16.21	.44	5.39	48.16	1.05	28.75	4,836	8,706	.81	8.93	1.67
4425	8.60	39.72	46.94	4.73	.50	5.34	60.59	1.08	27.75	5,856	10,540	1.18	11.34	2.18
4465	10.70	46.78	32.15	10.62	.34	5.47	50.84	.95	31.79	4,971	8,948	.69	9.29	1.59
4464	12.26	46.24	32.20	9.29	.35	5.60	50.55	.85	33.52	4,911	8,840	.69	9.02	1.50
4434	11.87	37.59	32.61	17.92	.24	4.96	48.92	.88	27.08	4,843	8,752	.87	9.86	1.80
4456	11.79	40.86	30.86	16.47	1.74	5.23	48.34	1.22	26.07	4,894	8,809	.75	9.24	1.85

REPORTED OCCURRENCES OF COAL ON KODIAK ISLAND AND ALASKA PENINSULA.

There are a number of localities on Kodiak Island and Alaska Peninsula where lignitic coal beds have been found, some of which may have future commercial importance for local use. (See Pl. V.) Dall[a] reports three occurrences of Kenai strata carrying coal beds—on the east side of Kodiak Island, at Uyak Bay, Eagle Harbor, and at Kiliuda Bay. He also states that coal occurs at the mouth of Red River, near the westernmost point of Kodiak Island, and at two localities on Uganik Island, and a 10-foot bed of lignite is reported on Sitkinak Island. On Alaska Peninsula, besides the Chignik Bay and Herendeen Bay fields, which will be described below, the reported occurrences of coal are as follows: Near Amalik Harbor Dall[b] noted an 18-inch bed occurring in a sandstone and conglomerate series 250 feet thick. Stone[c] described a section in this same region made up of sandstones and fine conglomerates, with some shales, in which occurs a 5-foot bed of coal. There are also less well authenticated accounts[d] of the occurrence of coal at Ugashik Lake and Aniakchak Bay.

CHIGNIK BAY.

INTRODUCTION.

Chignik Bay lies on the Pacific side of Alaska Peninsula, in longitude 158° west and latitude 56° 20′ north. (See Pl. V.) The coal belt, which includes at least two workable beds, stretches from Chignik River on the southwest to the northeast beyond the head of Hook Bay, paralleling the western shore of Chignik Bay for a distance of at least 30 miles. (See fig. 8.)

On the south shore of Chignik Bay there is a small reentrant known as Anchorage Bay, an excellent harbor, where the town of Chignik is located. A small steamer from Seward calls at this port once each month. To the west are Chignik Lagoon and Mallard Duck Bay, nearly cut off from the larger body of water by a sand and gravel spit. At the entrance is a sand bar which makes the inner harbor unavailable for boats drawing more than 12 feet of water. An irregular channel leads through the lagoon to the mouth of Chignik River, but the larger portion of the lagoon is dry at low tide. There is a water route up Chignik River to a chain of lakes in the central part of the peninsula, and thence after a short portage small boats may descend to Bering Sea. Boats drawing more than

[a] Dall, W. H., Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 800.
[b] Op. cit., p. 798.
[c] Stone, R. W., Coal in southwestern Alaska: Bull. U. S. Geol. Survey No. 259, 1905, p. 161.
[d] Stone, R. W., op. cit., pp. 162-163.

2 feet of water can not safely navigate the Chignik. At high tide small launches drawing barges can ascend the river as far as the coal mine.

Hook Bay lies near the north entrance to Chignik Bay. It is bordered in part by alluvial lands and in part by rugged cliffs. On the south side of Hook Bay there are sheltered waters and an excellent harbor.

The area underlain by coal west of Chignik Bay is on the southeast slope of the main mountain belt of the peninsula. The summits

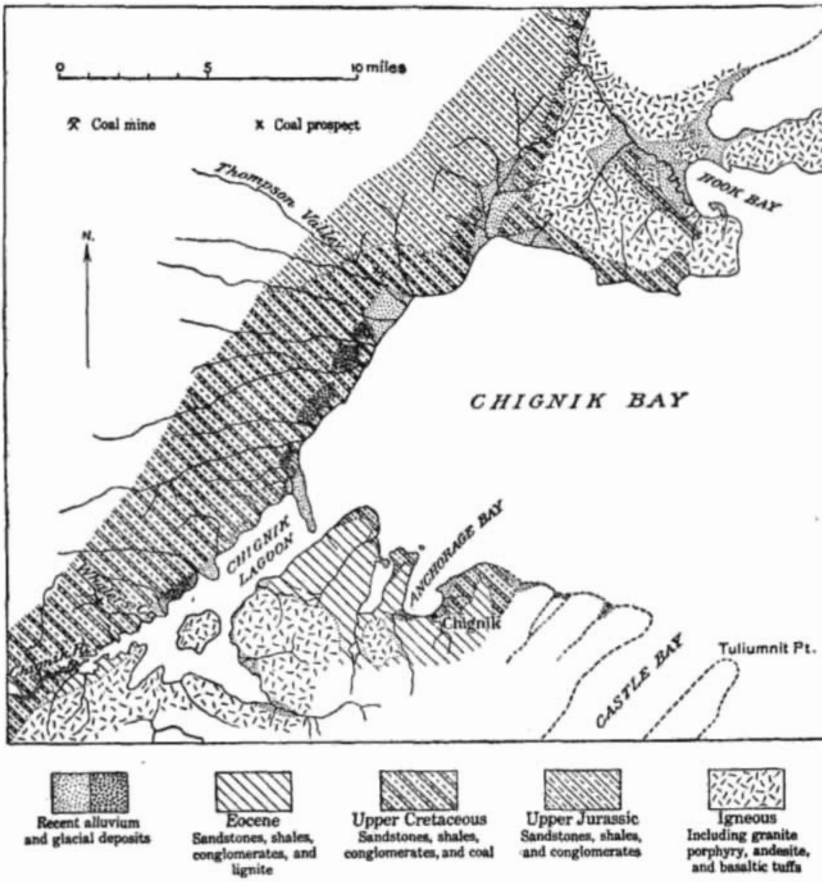

FIGURE 8.—Geologic map of Chignik Bay coal field.

reach elevations of about 2,500 feet and the broad anticlinal structure gives long, gentle slopes to the mountains. A series of nearly parallel valleys, of open U-shaped forms, cross from the summit region to the margin of Chignik Lagoon and Chignik Bay. In these valleys and on the intervalley areas, above the heavy covering of grasses and mosses, the formations are well exposed.

The winter snows do not leave the lower lands until April or May. During the summer there is considerable rain and much cloudy weather, and by the latter part of September fresh snows begin to appear on the mountains. The climatic conditions from April to October are not, however, such as to interfere with out-of-door work.

The Alaska Packers Association has a cannery in this region, on the south shore of Chignik Lagoon, and the Northwestern Fisheries Company one at Anchorage Bay.

GEOLOGY.

The central mountain area consists of a great series of sedimentary rocks (fig. 8). These beds apparently continue far to the northeast and southwest and they border the southern shore of Chignik Bay to Castle Cape. South of a line passing through Chignik Lagoon and west of Anchorage Bay there is a great mass of igneous rocks, chiefly andesites and basalts. Basaltic dikes are common in the area bordering these igneous rocks. South of Anchorage Bay there is a huge granite boss and apparently associated with it are great granite sills. Several such sills are well exposed on the north shore of Anchorage Bay. In the vicinity of Hook Bay there are other masses of granite and large areas that are mantled with volcanic tuffs and basic lava flows. Only in the extreme northeastern and southwestern parts of the coal belt do igneous rocks come into close contact with the coal, and there the coal does not appear to have been affected by the igneous activities.

The sedimentary series is known to include both Upper Jurassic and Upper Cretaceous formations, together with others that are probably of Eocene age. The absence of Lower Cretaceous fossils in the collections procured in this region is surprising, inasmuch as that horizon is well represented at Herendeen Bay, about 100 miles to the west. A description of the sedimentary formations of this portion of the peninsula is given on pages 112–115.

The structure of the central part of the peninsula is that of a broad anticline, the axis of which extends at least as far southwest as Pavlof Bay, thence stretches northeast through the Balboa-Herendeen bays region, northwest of Chignik Bay and through Chignik Lake, thus following the crest line of the Aleutian Range. Eastward from Chignik Lagoon and along the south shore of Chignik Bay the sedimentary strata are gently folded and somewhat faulted. Toward the upper limit of the sedimentary rocks more and more intruded sheets of lava appear, and the last of the sediments is succeeded by vast flows of lava. In the vicinity of Hook Bay there have been two or three centers of volcanic eruption. Great quantities of fragmental material were erupted, lavas were outpoured, and large blocks of sedimentary formations were disturbed.

THE COAL.

Coal beds have been opened at four localities in the Chignik Bay field, all in sedimentary rocks of Upper Cretaceous age. (See fig. 8.) Outcrops of coal are also known in other localities in the region, and some of these are included in the Eocene beds. The developed coals are at Chignik River, Whalers Creek, Thompson River, and northwest of Hook Bay. Some detailed sections of these coals are given

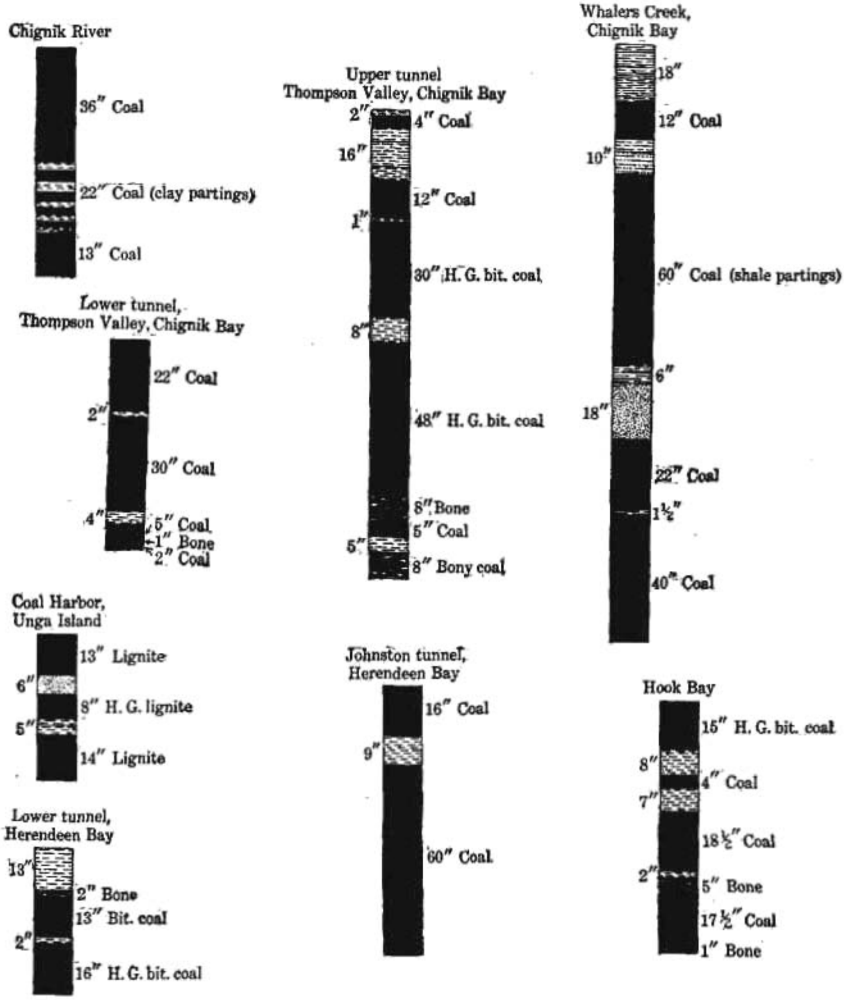

FIGURE 9.—Sections of coal seams in the Chignik Bay and Herendeen Bay fields and at Coal Harbor.

in figure 9, and an account of each locality will be given in the following paragraphs.

Chignik River.—Coal was discovered in the bluff of Chignik River in 1885,[a] but active mining was not undertaken until 1893. Since

[a] Dall, W. H., Coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 802.

that time the Alaska Packers Association has operated its mines to procure fuel for the cannery on Chignik Lagoon and for the steamers engaged in the fisheries. The coal bed that has been worked outcrops on the river bluff 3 miles above the head of Chignik Lagoon, and has been traced inland for a little more than half a mile. At this locality it strikes N. 2° E. and dips 24° E.

Two 6-foot drifts about 40 feet apart have been carried in on the coal bed. The upper drift is about 250 feet long and has been widened to 40 feet in the clear at places; it has a single crosscut to the lower drift. The upper drift is now abandoned, and work is being done only in the lower drift, which runs in nearly straight for 500 feet. At the face of the drift there is a roll in the floor which cuts out the greater part of the coal. Rooms have been opened on the upper side of the drift as far as the roll, which runs diagonally to the tunnel. In the first room, which is about 150 feet from the entrance, the roll is 75 yards from the drift, in the second room about 50 yards, and in the third room but 20 yards. The coal is carried from the rooms to the drift in chutes and taken out in tram cars, from which it is dumped directly on the barge. A section of the bed measured in the drift is as follows:

Section of Chignik River coal bed.

	Ft.	in.
Dry bone, with thin coal streaks		3–9
Coal		6
Coal and dirt		8
Coal	1	
Bony coal (gob)	1	5
Coal	1	4
	5	2

The roof of the bed, which is shale with thin layers of coal, is very even and is overlain by sandstone. The floor, however, is not so regular, and the roll or swelling in it reduces the thickness of the bed at the end of the drift from 5 feet to 9 inches. It is possible that the roll, which is known to be rather long, may be narrow, and that a short tunnel driven through it would discover the full thickness of the coal bed on the other side.

The coal is solid and bright and comes out in good-sized pieces. When used under a boiler it has to be stoked very frequently to keep it burning freely. Properly handled it is a fairly satisfactory steaming coal, although it makes a large amount of ash and the fires have to be cleaned often. An analysis of this coal is given on page 146.

The Chignik River mine is worked throughout the year by two men without machinery, the coal being undercut by hand and shot down. Coal outcrops at several other places on the north bank of Chignik River east of the coal mine, but these beds have not yet been worked, and at the surface do not appear to be of as good grade as that at the mine.

Whalers Creek.—Whalers Creek is a small stream entering Chignik Lagoon from the north a short distance below the mouth of Chignik River. Coal is exposed for 600 feet along the northernmost of the three main branches of the creek. This exposure is along the strike of the coal measures, which outcrop at the coal mine on Chignik River. The strike of the coal is N. 5° E., and the dip is 22° E. The section of the coal is as follows:

Section of Whalers Creek coal bed.

	Ft.	in.
Shaly sandstone roof.		
1. Coaly shale		10
2. Shale		8
3. Coal	1	
4. Coaly shale		4
5. Sandy shale		7
6. Coal with slate partings	5	
7. Coaly shale		6
8. Sandstone	1	6
9. Coal	1	10
10. Shaly coal		1½
11. Coal	3	4
Sandy shale floor.		

A slope has been driven for 130 feet and the coal is reported to hold its thickness uniformly except at two places, where there are slight rolls. The slope follows the lower part of the bed, including Nos. 8 to 11 in the above section. The coal bed including Nos. 9 to 11 was sampled in the usual way and analyzed with the result given on page 146.

The coal is bright, black, and blocky, being much the same as that mined at Chignik River, but at this locality the section of the coal is better in that the partings are thin. About 500 feet downstream from the mine opening there is a nearly vertical fault, which probably cuts off the coal bed. On the upstream side, about 40 feet from the opening, there is a vertical fault, which throws the coal down 6 feet. At 115 feet upstream from the mine another fault which cuts off the coal has been reported. This upper portion of the valley was filled with snow when the region was visited by the writer.

Although faults have disturbed the coal somewhat, there appears nevertheless to be a very considerable body of good coal available. The location of this coal is favorable for shipment on small boats down Chignik Lagoon, or by a railway that might be built across Chignik River a short distance above the mouth, and thence across a lowland area to the head of Dorenoi Bay, where excellent harbor facilities are reported. The distance from Whalers Creek to the head of Dorenoi Bay by the proposed railway route is about 10 miles.

Coal has been reported to outcrop at several places high on the mountain slopes northeast of the outcrops of coal in Whalers Creek.

The localities pointed out in the field by prospectors are along the general strike of the coal measures, and presumably contain the same beds that are exposed elsewhere in the field.

Thompson Valley.—Thompson Valley lies northwest of the northern portion of Chignik Bay, and is a broad, open, flat-bottomed valley, heading among the high mountains at least 10 miles from the beach. Coal is exposed on the northeastern slope 1¾ miles from the beach and 300 feet above the valley floor. The strike of the beds is N. 61° E., and the dip is 21° NW. Two workable coal beds are exposed for at least a mile and their extent is probably much greater. Where the tributary streams to Thompson Valley cross these coals there are falls or cascades in their courses. The detailed measurements of these beds are given below:

Sections of coal beds in Thompson Valley.

LOWER BED.

	Ft.	in.
Sandy shale roof.		
1. Coal	1	8
2. Shale parting		2
3. Coal	2	6
4. Coaly shale		4
5. Coal		5
6. Bone		1
7. Coal		2
Sandstone floor.		

UPPER BED.

	Ft.	in.
Cross-bedded sandstone roof.		
1. Clay		2
2. Coal		4
3. Coaly shale		4
4. Shale		8
5. Coaly shale		4
6. Coal		12
7. Clay parting		1
8. Coal	2	6
9. Coaly shale		8
10. Coal	4	
11. Bone		8
12. Coal		5
13. Shale		5
14. Bony coal		8

A short tunnel has been driven into the upper bed. A sample was taken from beds numbered 6, 8, and 10 in the foregoing section of the upper coal, and the analysis is given on page 146.

There is a large body of good coal available at this locality. The conditions for mining are favorable, and the space at the base of the bluff is ample for mine buildings and mine bunkers. The chief difficulty in the way of exploiting this coal is in making arrangements for shipping. The beach at the mouth of Thompson Valley is exposed to the severe storms from the Pacific Ocean. A railway from the valley to Chignik Lagoon could be easily built, for the route would be over a lowland area and not more than 9 miles in length. The conditions in Chignik Lagoon, however, are not favorable for loading large ocean-going vessels; hence it would probably be necessary to continue the railway along the northwest shore of the lagoon and then by the same route as that from Whalers Creek to the head of Dorenoi Bay, already described.

Hook Bay.—Hook Bay is in the northern part of the field examined. The coal in this vicinity occurs near the headwaters of the right-hand branch of the stream entering Hook Bay from the west and in the foothills of the main mountain range. Here the general strike of the beds is N. 11° E., and the dip is 34° E. The section of the coal is as follows:

Section of the Hook Bay coal bed.

	Ft.	in.
Firm sandstone roof.		
1. High-grade bituminous coal	1	3
2. Clay		8
3. Coal		4
4. Clay		7
5. Coal	1	6½
6. Clay parting		2
7. Bony coal		5
8. Coal	1	5½
9. Bone		1
Shale floor.		

Above this bed is an 8-foot bed of sandstone overlain by a thin layer of coal. Below the main bed of coal lies 4 feet of shaly sandstone, underlain by a 3-foot bed of coal, in the middle of which there is a 6-inch parting of shale. The claims have been prospected at a number of places, and one tunnel has been driven in on the main seam for a distance of 40 feet. The exposures in this tunnel show the coal to be uniform in thickness and quality.

In sampling this bed a cut was made across Nos. 5 to 8 inclusive in the above section. The analysis is given on page 146.

The strike, so far as the beds could be examined, is uniform and appears to continue without notable break for at least half a mile to the northeast. The tunnel opening is 50 feet above the stream bottom, where there is space for mine buildings. At present there is a wagon road from Hook Bay to the coal croppings, along a stream bottom where the general gradient and space would be favorable to railway construction. Hook Bay is an excellent small harbor, and is bordered by favorable sites for wharves and bunkers. The distance from the harbor to the coal is about 8 miles. At present four claims are staked out in this field, and development work is being done under the auspices of the Alaska Peninsula Mining and Trading Company.

HERENDEEN BAY.

INTRODUCTION.

Herendeen Bay, the western arm of Port Moller, is on the northwest side of the Alaska Peninsula at about 160° west longitude and 55° 30′ north latitude. (See Pl. V.) The head of the bay is near the central portion of the peninsula, and is only 8 miles from the head of Balboa Bay, a reentrant on the Pacific side. The portage

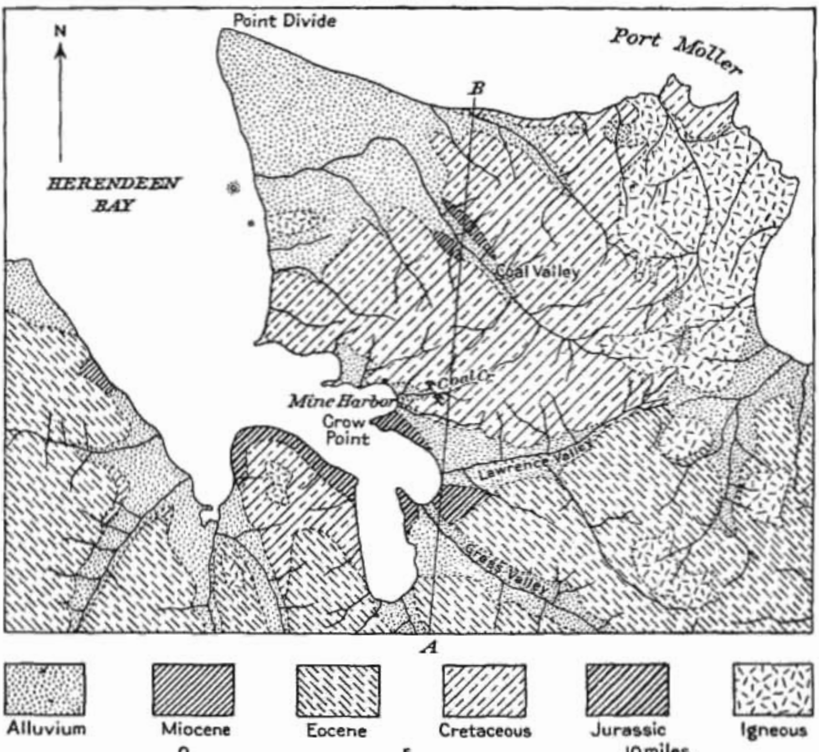

FIGURE 10.—Geologic map of Herendeen Bay coal field. *A-B*, line of section, figure 11.

from one of these bays to the other is made by an excellent trail over a pass not more than 500 feet above sea level, which connects two broad, flat-bottomed valleys.

The coal which has been opened and is now being developed is found in a small peninsula between Herendeen Bay and the main or eastern arm of Port Moller. (See fig. 10.) Within that area the coal-bearing formations occupy at least 40 square miles, and coal is exposed at various localities. Some beds of lignite outcrop on the western shore of Herendeen Bay and are reported to extend several miles to the west. In the central portion of the Alaska Peninsula, in the mountain slopes east of the trail to Balboa Bay, other beds of lignite outcrop.

Within the coal field the topography is that of gently rounded hills and low mountains. The highest points are a little over 2,400 feet in altitude, but the portions above 2,000 feet constitute but a small part of the area. The largest valley is that of Coal Creek, which is located in the central portion of the field. This valley is a broad, open, flat-bottomed trough leading northward through the coal field and westward to Herendeen Bay. The smaller valleys drain westward into Herendeen Bay and eastward into Port Moller. They are somewhat rugged, and travel is easier on the intervalley ridges than through the gorges.

Throughout the summer season, from June to October, the mean temperature is about 46° F. During the winter months, from October to May, the mean monthly temperature ranges from 13° F. to 39° F. The annual precipitation during 1903, when records were kept at the Herendeen Bay mine camp, was 46.22 inches. In the summer the number of clear days ranges from five to ten a month. During the three years from 1902 to 1904, inclusive, there were twenty-seven days when the minimum temperature was below zero and four days when the maximum temperature was below zero. Mine Harbor was frozen in the years from 1902 to 1906, inclusive, during the following periods: December 18, 1902, to May 6, 1903; December 29, 1903, to May 26, 1904; January 3, 1905, to May 25, 1905; January 15, 1906, to March 17, 1906.

In 1908 Herendeen Bay could be reached by way of Bering Sea by private means of transportation from Unalaska or Nushagak. The more common route is by regular steamer to Balboa Bay and thence by trail across the peninsula to the head of Herendeen Bay.

GEOLOGY.

This coal field is located in the minor folds northwest of the main anticlinal arch of Alaska Peninsula. The sedimentary formations exposed range in age from Upper Jurassic through Lower and Upper Cretaceous to Eocene. (See fig. 10.) Pleistocene deposits mantle a small part of the area, and in the valley bottoms and along the shores there are alluvial deposits of post-Pleistocene age. The description of the geology of the western portion of Alaska Peninsula, given on pages 114 to 115, is based chiefly on work done in the vicinity of Herendeen Bay. A few details may be added here.

In the western part of the field, where the coal locations have been made, the formations have not been modified by volcanic intrusions or extrusions, but at the eastern margin of the field there are numerous dikes, vast quantities of volcanic tuffs, and extensive lava flows. Four volcanic centers, from which lava flows and fragmental material issued, are situated near the eastern margin of the field. At the northern margin and along Herendeen Bay there are volcanic tuffs, but they are not so associated with the coal as to be significant. The northwestern portion of the small peninsula in which the coal is located is mantled in part by glacial material and in part by recent alluvium.

The central part of the field has a synclinal structure, with the axis plunging westward. To the north of this fold there is a broad anticline. Several small faults were noted within the coal field, and at the southern margin there is a fault contact indicating a throw of no less than 1,000 feet. These faults may be detected by the shifted outcrops (see fig. 10) exposed in the higher portions of the field, where there is little or no vegetation. In the mine tunnels may be recognized numerous minor faults of the same general nature as the major faults detected on the surface. Figure 11 shows the general structural conditions along a nearly north-south line through the coal field.

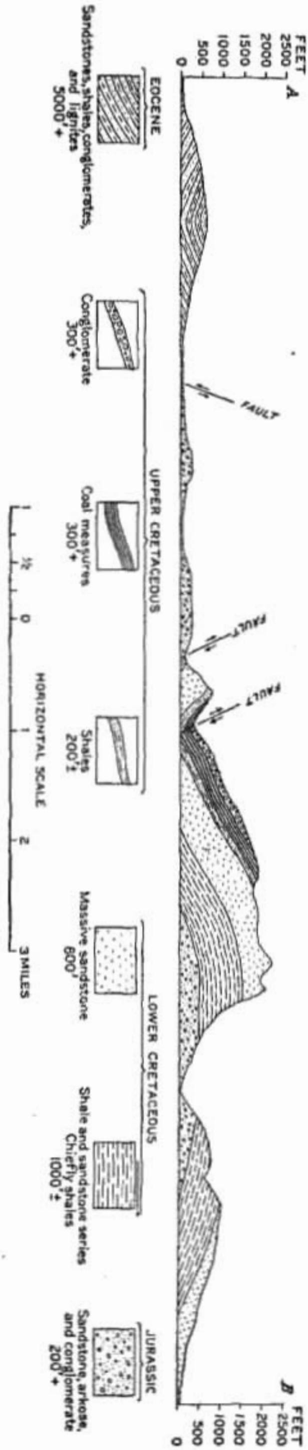

FIGURE 11.—Structure section across Herendeen Bay coal field along line *A–B*, figure 10.

THE COAL.

The presence of coal in the Herendeen Bay region has been known for a number of years. Several attempts have been made toward its development, but little has yet been mined. The first exploitation of the field was undertaken in 1880 by a corporation under the name of the Alaska Mining and Development Company. Two drifts were run, one about 200 feet, the other about 300 feet in length, on a coal bed of 4 feet average thickness. The coal was brought to the water front by a steam motor on a small tramway, and several hundred tons were taken out in 1890, of which the U. S. S. *Albatross* used between 200 and 300 tons.[a] At that time there was no immediate market for the coal, as the Western States and Territories were fully supplied from the Washington and Vancouver mines. The field was therefore abandoned and no further work was done until 1898, when C. A. Johnson relocated the coal land and started what is known as the Johnson tunnel. In 1902 the property passed into the hands of a company that did very little work, and in 1904 this company forfeited all its rights. The present claimants made surveys of the field and did some careful prospecting, which included a small amount of core-drill work. This work has been done under the supervision of Philbrick & Foster, as agents for the present claimants.

Within the coal field the best-known outcrops are near the head of Coal Valley and in the valley of Mine Creek. Coal is exposed also near the head of the next valley east of Coal Valley and at several places about the margin of the volcanic tuffs a little farther east. Outcrops of coal have been reported in tributaries to Lawrence Creek. The main coal measures outcrop about 5 miles north of Mine Harbor, on the east shore of Herendeen Bay. This locality is known as Coal Bluff. On the north coast of the coal-bearing peninsula and 9 miles east of Point Divide there are two beds of lignite, and on the west shore of Herendeen Bay nearly opposite Coal Bluff several others are exposed. Columnar sections of these coals are given in figure 9.

The following section in the coal measures was obtained on the south slope of the Mine Creek valley:

Section in the coal measures, Mine Creek valley, Herendeen Bay.

	Ft.	In.
Conglomerate	300	
Coarse sandstone, cross-bedded, with huge sandstone concretions weathering brown from abundance of limonite	50	
Sandy shale	20	
Coal seam, medium grade	3	
Firm cross-bedded sandstone, fossil leaves	3	
Shale	5	
Coal, bituminous		10
Shale	2	6
Shaly coal		6
Shale, with sandstone cones	3	
Coal, bituminous	1	
Shales	4	

[a] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 805.

	Ft.	In.
Coal, bituminous	1	2
Shaly sandstone, with sandstone cones	4	
Coal, bituminous		10
Shales	4	
Coaly shales	1	6
Shales	3	
Carbonaceous shales	1	
Shales	2	
Coal, bituminous	1	
Shales	2	
Coaly shales, with shale partings	2	3
Coal, with bony partings and shaly bed	7	
Shales	1	8
Shaly coal	1	2
Shale	2	6
Coal, bituminous	1	1
Shales	3	
Coal, bituminous	2	
Shales	3	6
Coal, bituminous	1	2
Shales		6
Coal, bituminous	1	5
Shales, with sandstone cones	4	
Coal, bituminous	1	8
Shales and sandstone interbedded	15	
Coal, bituminous		8
Shales	5	
Shaly sandstone	2	
Shales	50	
Coal	1	2
Shales	6	
Coaly shale		4
Shales	7	
Coal, bituminous	1	
Shales	3	
Coal, bituminous	1	
Shales, with sandstone cones	40	
Coarse cross-bedded sandstone and conglomerate	15	
Shales and sandstones.		

Dip, 30° N.; strike, N. 91° E.

On the left fork of Mine Creek Paige[a] measured the following section:

Section of coal beds on left fork of Mine Creek.

	Ft.	In.
Coal, crushed	7	
Shale	9	
Coal, bony	1	
Shale and sandstone	6	6
Coal, crushed		8
Coal, fairly solid (partly obscured by slide)	10	

[a] Paige, Sidney, Bull. U. S. Geol. Survey No. 284, 1906, p. 107.

	Ft.	in.
Shale, carbonaceous	3	4
Covered by slide	20	
Coal with bone (details not observed)	12	
Shale and coal	4	
Coal	2	8
Shale	6	
Coal	3	
Remainder hidden by slide.		

The detailed section of the coal exposed in the lower tunnel on Mine Creek is as follows:

Section of lower tunnel coal bed, Mine Creek, Herendeen Bay.

	Ft.	in.
Shale roof.		
1. Shaly coal	1	1
2. Bone		2
3. Coal, bituminous	1	1
4. Shaly coal		2
5. Coal, high-grade bituminous	1	4
Firm sandstone floor.		

Strike, N. 91° E.; dip, 30° N.

A section of the coal at the Johnson tunnel, which is on the south slope of the Mine Creek valley about 870 feet above sea level, is as follows:

Section of the Johnson tunnel coal bed, Mine Creek, Herendeen Bay.

	Ft.	in.
Shale roof.		
1. Coal	1	4
2. Clay		9
3. Coal, high-grade bituminous	5	
Clay floor.		

Strike, N. 101° E.; dip, 34° NE.

Samples of coal were taken from each of the above beds, and the analyses appear on page 146. No work had been done in the lower tunnel during the ten months preceding the examination, but the sample was procured by crosscutting near the farther end of the tunnel, where work had been done most recently. Material from beds 1 to 5 in the above section was included in this sample. The Johnson tunnel also had been closed for fully ten months, but a sample was procured from bed No. 3 in the above section by first cleaning the face of the seam and then making a crosscut.

The Johnson tunnel is about 100 feet long. The coal continues for about 75 feet, becomes much broken, and finally disappears. Some prospecting has been done to find the continuation of this bed, but it has not yet been located. In drifting it has been necessary to use timber to support the roof. The coal which has recently been mined here has been entirely for local consumption and has amounted to but a few tons each year.

The lower tunnel, near the stream bed and at an elevation of 275 feet above sea level, has been driven for 150 feet along the strike of the coal. At this place the roof is firm, and no timbering was necessary beyond the entrance. During 1907 about 20 tons was taken from this drift for use in drilling and for domestic purposes. The walls of the drift indicate that there has been some minor faulting at various places, the movement ranging from a few inches up to a foot. This is typical of the distributive faulting associated with the larger movements in the field and is of the same general character.

Three drill holes have been put down in the lowlands near the mouth of Mine Creek. The deepest reached a depth of 350 feet and some coal was found. The other holes were sunk 150 feet and 28 feet. The work was unfortunately delayed by the loss of tools. As yet no coal of minable thickness has been found by drilling.

In the portion of the field where work has thus far been done the mining conditions are not especially difficult. The coal beds dip at angles varying from 25° to 35° and they are well exposed in the valley bluffs. The faulting that has disturbed the formations has not been on a large scale, and when the structure is worked out in detail there should not be much difficulty in locating the coals in the different fault blocks. From the lower drift coal may be easily taken to tide water. At present a good horse trail reaches the mouth of this tunnel, and it would not be difficult to construct a wagon road or a railroad to that point. The Johnson tunnel, at an elevation of 870 feet, is less favorably located for transporting the coal. The horse trail, which reaches the lower tunnel, continues to this higher opening, but the ascent is in part difficult. Coal has, however, been packed out on horses over this trail. The construction of a road to this opening would be expensive, but the coal might easily be handled by tramways to more accessible places in the valley.

The coal exposed at Coal Bluff has the appearance at the surface of being of as high a grade as that outcropping at several other places. The coal exposed near the headwaters of Coal Creek, in certain of the tributaries from the west and in the continuation of the coal belt in which the Johnson tunnel is located, but in the opposite side of the syncline, appears to be of good grade, and in this part of the field faulting has not so greatly disturbed the formations. During the writer's visit this part of the field contained so much snow that the coals could not be satisfactorily examined.

The absence of forests will make it necessary, in the development of the field, to ship in timber. If these coals are mined on a large scale, they should be carried by railway to Balboa Bay for shipment. The route from Mine Harbor to Balboa Bay is about 16 miles long and an easy one for railway construction. Mine Harbor is well protected and is sufficiently deep for commercial purposes, but during several months of each year the upper part of Herendeen Bay is locked in ice. During the summer months coal could be shipped by way of Herendeen Bay to Bering Sea, and thus to the Alaskan ports farther north. If coal is mined from the head of Coal Valley, the problem of taking it to tide water on the Pacific side of the peninsula is a little more difficult. A railroad could be constructed along Coal Valley and connected with Mine Harbor by a route which would add about 15 miles to the direct route, or double the haul to the Pacific. At Balboa Bay there is an excellent harbor and good bunker sites are available.

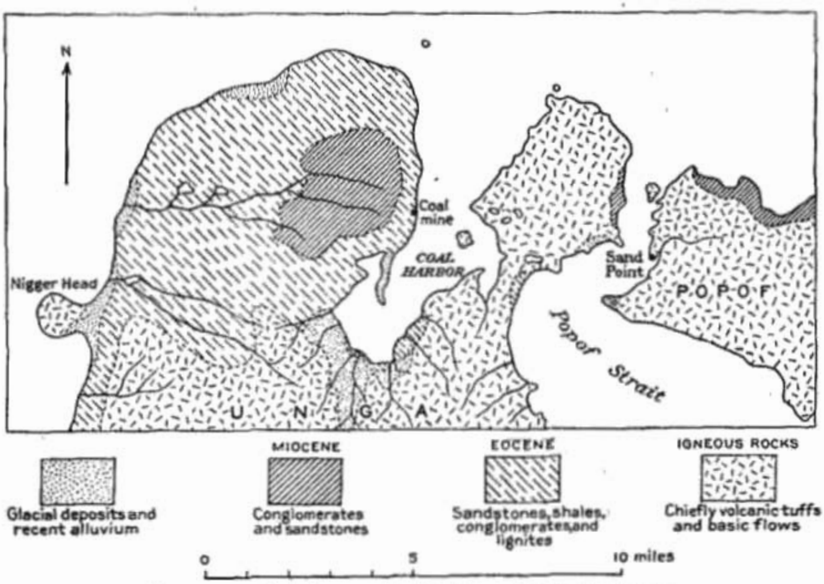

FIGURE 12.—Geologic map of Coal Harbor coal field, Unga Island.

COAL HARBOR.

INTRODUCTION.

Unga is the largest and westernmost island of the Shumagin group, which lies southeast of Balboa Bay (Pl. V). Coal-bearing strata outcrop on the west shore of Coal Harbor, at the north end of the island. These coal measures appear to underlie the northwestern portion of the island and to include about 40 square miles. (See fig. 12.)

At the eastern margin of this coal field the upland surface is a little more than 600 feet above the sea; it declines gradually to the west, reaching sea level at the western shore of the island. The entire field is therefore in a lowland area. The streams flow to the west over the gentle slopes of the upland surface and through shallow valleys. Bordering the field at the east is a steep bluff, 600 feet high, which becomes lower to the north and south and inconspicuous at the northwestern and western margins of the field. The topography of the upland surface is varied somewhat by a mantle of glacial drift, in which there are numerous small depressions containing lakes or swamps.

Unga Island enjoys a milder and more equable climate than the mainland to the north. Practically all of the winter snow disappears during the summer, and the number of clear days exceeds that for the mainland.

The northern portion of the island is overgrown by grasses and shrubs. A few patches of alder bushes are scattered on the valley slopes, but there are no trees on the island.

GEOLOGY.

The distribution of the formations in and near the coal field is given in figure 12. The coal-bearing rocks are of upper Eocene age and are overlain conformably by Miocene conglomerates. The Eocene sediments consist of sands, sandstones, clays, shales, conglomerates, and seams of lignite, and much of the material is but poorly cemented. A section was measured a short distance north of the coal mine on the west shore of Coal Harbor. The base of the section is 50 feet above mean tide level. This section is given graphically in columnar form in figure 13. The upper 200 feet represent Dall's Unga

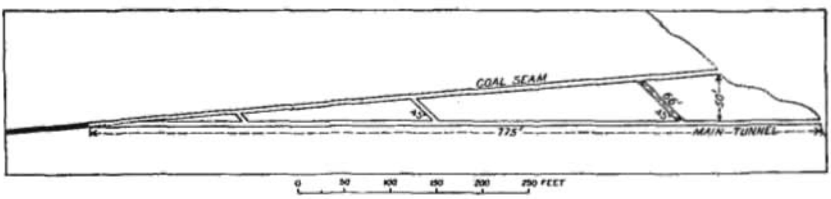

FIGURE 13.—Vertical section at Coal Harbor mine, Unga Island.

conglomerates, determined by him to be of Miocene age. These beds rest conformably upon the lower coal-bearing series, which are of upper Eocene age and have been correlated with the Kenai formation. The base of the Eocene is not exposed. The coal-bearing beds are nearly horizontal, the dip being to the west at about 9°.

Miocene beds outcrop on the northeast coast of Unga Island and on the north shore of Popof Island. Fossils procured from these localities have been reported by Dall to represent an upper Miocene horizon.

The igneous rocks in the north end of Unga Island (fig. 12) consist of granites, basalts, and volcanic tuffs. In the northeastern portion of the island basalts and tuffs overlie the Miocene beds unconformably. Coarsely crystalline rocks occur also south of the coal field, in the central portion of the island.

Glacial deposits are present in the mountain valleys south of Coal Harbor and on lowlands at the northwestern shore of the island. Along the coast line and in valley bottoms there are recent alluvial deposits, and near the north and northeast shores lie small areas of sand dunes.

THE COAL.

Previous to 1882 there had been no mining in this field except that by Russians, who are reported to have taken some coal from outcrops near the beach. From 1882 to 1884 a company was engaged in mining at this locality and is reported to have kept twenty men at work throughout that period and to have supplied with fuel small steamers engaged in seal hunting. Some of the coal was used for domestic purposes, and two cargoes, amounting to about 700 tons, are reported to have been sent to San Francisco in 1883. The property is now under the control of the Tide Water Consolidated Company. Several drifts have been opened and one mine put into operation on a shipping basis. (See fig. 13.) Bunkers have been built about 100 feet from the shore, and a steel conveyor connects them with the mine. The developed coal bed outcrops about 200 feet above tide water. The detailed measurements of the upper part of the coal bed as now exposed in the mine are as follows:

Section of coal bed in Coal Harbor mine.

	Ft.	In.
Firm, coarse grit and conglomerate roof.		
Lignite	1	1
Loose sand		6
Lignite		8
Coaly shale		2
Clay		3
Lignite		10
Lignite		4
	3	10

Strike, N. 12° W.; dip, 8° W.

The bed was sampled in the usual way, the sand and shale, which could be readily separated in mining, being excluded. The analysis of this sample is given on page 146.

There are no special difficulties associated with the mining or shipment of this lignite, and if mined with sufficient care to keep it clean it may be able to compete with the somewhat better coals that are being shipped to this part of Alaska. It will at least continue to be of value to the natives and to the few white people living on Unga and the neighboring islands.

COMPOSITION OF CHIGNIK BAY, HERENDEEN BAY, AND UNGA ISLAND COALS.

The following table gives the results of the proximate analyses of some of the coals from the Chignik Bay, Herendeen Bay, and Unga Island fields. The samples were sealed in air-tight cans as soon as collected and then sent to the laboratory. The analyses of the coal as received have been recalculated to obtain the analyses on the air-dried basis. The samples were obtained at the following localities:

6952. Coal bed on west side of main stream, 7 miles northwest of Hook Bay, east side of Chignik Bay, Alaska Peninsula.

6956. Chignik Bay, Thompson Valley, three-fourths mile above mouth of stream.

6955. Chignik Lagoon, Whalers Creek, three-fourths mile above mouth.

6953. Chignik River, north side, 2 miles below Chignik Lake.

6957. Herendeen Bay, Mine Creek, three-fourths mile above mouth.

6951. Herendeen Bay, Mine Creek, 1¼ miles above mouth.

6954. Unga Island, Coal Harbor, 1¼ miles west-northwest of Gull Island.

Analyses of Chignik Bay, Herendeen Bay, and Unga Island coals.

[Analyses by F. M. Stanton, U. S. Geological Survey.]

SAMPLES AS RECEIVED.

Laboratory No.	Proximate analyses.					Ultimate analyses.					Calorific value.	
	Loss on air drying.	Total moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
6952	4.00	5.07	27.24	42.42	25.27	2.26	4.53	55.76	0.50	8.38	5,618	10,112
6956	6.50	10.77	30.37	43.99	14.87	.70	4.98	56.27	.61	23.57	5,356	9,641
6955	2.50	5.02	34.28	45.45	15.25	1.75	4.87	62.04	.56	15.53	6,245	11,241
6953	5.20	7.06	31.48	39.68	21.78	1.30	4.83	55.14	.61	16.34	5,470	9,846
6957	4.60	7.48	32.13	48.77	11.62	.31	5.11	63.49	.91	18.56	6,256	11,261
6951	6.30	8.01	33.53	51.35	7.11	.41	5.41	60.44	.80	10.83	6,547	11,785
6954	12.50	23.27	25.42	25.13	26.18	.53	5.27	34.76	.52	32.74	3,227	5,809

AIR-DRIED SAMPLES (CALCULATED FROM TABLE ABOVE).

Laboratory No.	Proximate analyses.				Ultimate analyses.					Calorific value.	
	Moisture.	Volatile combustible.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
6952	1.11	28.38	44.19	26.32	2.35	4.26	58.08	0.61	8.38	5,852	10,533
6956	4.57	32.48	47.05	15.90	.75	4.56	60.11	.65	19.03	5,728	10,310
6955	2.58	35.16	46.62	15.64	1.79	4.71	63.63	.57	13.66	6,405	11,529
6953	1.96	33.21	41.86	22.97	1.37	4.48	58.17	.64	12.37	5,770	10,386
6957	3.02	33.68	51.12	12.18	.32	4.82	66.55	.95	15.18	6,558	11,804
6951	2.86	35.41	54.22	7.51	.43	5.09	70.16	.84	15.97	6,913	12,343
6954	12.31	29.05	28.72	29.92	.60	4.44	39.73	.59	24.72	3,688	6,638

COAL AND PAVLOF BAYS.

Coal and Pavlof bays are indentations on the south coast of Alaska Peninsula, about 50 miles west of Unga Island. The main anticlinal axis of the peninsula continues southwestward from the Balboa-Herendeen Bay region to the eastern shore of Pavlof Bay. The fold is here composed chiefly of the upper Eocene beds, which have yielded fossils of invertebrates and some plant remains. On the north shore of Coal Bay and on the east shore of Pavlof Bay there are thin beds of coal which have been worked for the local markets. The bed at Coal Bay is from 15 to 18 inches thick. On the shores of Pavlof Bay there are two beds of lignite, each of which is less than 12 inches thick.

PETROLEUM.

Petroleum is known to occur at two localities in southwestern Alaska—in the Enochkin Bay district and in the vicinity of Cold Bay. These fields were not visited by the writer, but both have been examined by Martin,[a] and the following account is abstracted from his reports. The map (fig. 14) published by Martin, chiefly from data furnished by A. G. Maddren, is here reproduced.

The Enochkin Bay oil seepages and so-called "gas springs" are in an area of shales and sandstones of Jurassic age, which are thrown up into a long anticline. This dominant structure parallels the coast, bending from an east-west strike at the south end of the fold to a northeast-southwest strike at the north end. Several wells were driven at this locality between 1898 and 1904, the deepest being about 1,000 feet deep, but no flow of oil was obtained.

At Cold Bay there are many large seepages and several wells were drilled in 1903 and 1905, but yielded no flow of oil. Here the rocks are chiefly Jurassic shales and sandstones and the structure is similar to that at Enochkin Bay.

GOLD.

INTRODUCTION.

The gold placers of the Sunrise district have been described by Moffit,[b] and the recent mining developments are summarized elsewhere in this volume (p. 52). The gold deposits of Kodiak Island were not studied by the writer, but a brief account of this district is given on page 30. U. S. Grant describes the gold prospects in the vicinity of Seward on page 107.

During the summer of 1906 a few miners were at work on the Anchor Point beach placers, using rockers or small sluice boxes, and

[a] Martin, G. C., Petroleum of Pacific coast of Alaska: Bull. U. S. Geol. Survey No. 250, 1905, pp. 37-59 Notes on the petroleum fields of Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 133-138.

[b] Moffit, F. H., Gold fields of Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 1-52.

they reported that they were making "fair wages." The gold which they obtained was very fine and the deposit exceedingly shallow,

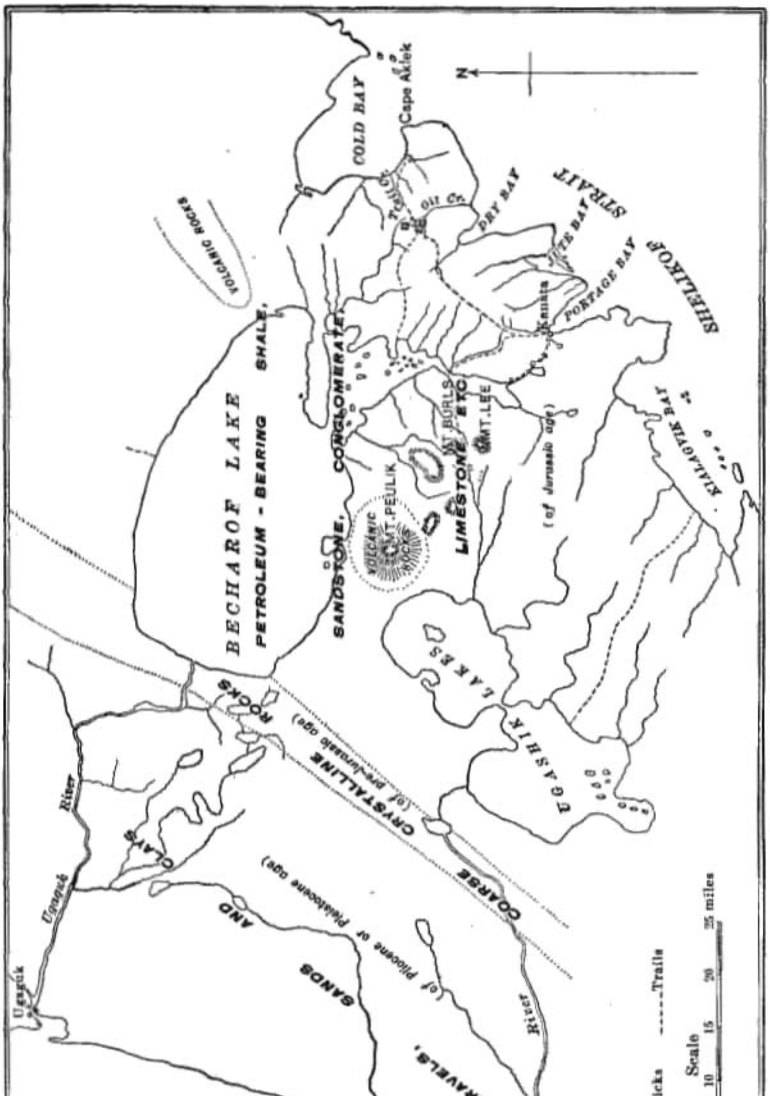

FIGURE 14.—Sketch map of Cold Bay petroleum field.

making it necessary to move frequently to different parts of the beach.

POPOF ISLAND.

Placer gold was discovered by Louis Herman in the beach about 1½ miles south of Sand Point post-office on Popof Island in the summer of 1904. (See Pl. V.) During 1904 and 1905 active work was in progress, and it is reported that gold amounting in value to about $12,000 was taken from these beach placers. The productive belt is about three-fourths of a mile long. From twenty to forty men were at work during the summer of 1904 with rockers, washing the coarse sand and gravel. All the gold that was found was below mid-tide, and most of it around large bowlders at about the level of low tide. Little work has been done on this beach since 1905. In 1908 but one man was engaged in rewashing the sand and gravel from time to time, and he is reported to have found it unsuccessful and finally to have abandoned operations.

During 1908 most of the interest on this island was centered on four lode claims that were staked on the hills immediately adjoining the beach placers. No distinct quartz ledges have been located on the claims of Louis Herman and G. C. Duchen, but the rock there exposed contains some free gold. Specimens in which free gold is plainly visible may be found in the surface zone of oxidation and weathering. This zone varies from 5 to 10 feet in thickness. Several samples were taken from the weathered material and when crushed and panned they yielded some free gold. The owners of this property have had several samples assayed and reported values up to $20 a ton. On the Louis Herman property a short tunnel has been driven and four shafts sunk below the zone of surface weathering. Ore samples were taken from three openings on this property, and though they vary greatly in their content of gold one sample was exceedingly rich. The rock in which this gold occurs is an andesite similar to that in Unga Island where the Apollo mine is located. The unweathered rock appears as a light-gray lava, containing an abundance of small pyrite crystals. In an adjoining claim one small quartz ledge has been discovered and some development work has been done.

UNGA ISLAND.

Gold-bearing ledges have been found at a number of places in Unga Island. (See Pl. V.) In the southeastern portion of the island, about 1 mile from the head of Delarof Harbor and 4 miles from the town of Unga, are located the Apollo and Sitka mines. A third mine has been opened on the Shumagin group of claims near the head of Baranof or Squaw Harbor. Several locations for gold lodes have been made on the ridge south of the Apollo mine, in the valley west of the Shumagin mine, and at points about 2 miles south of Coal Harbor.

Apollo Consolidated mine.—This mine was on a productive basis from 1891 to 1904, and was reopened during the summer of 1908, when 40 of the 60 stamps in the mill were put into operation and ore that had already been mined was run through the mill. The occurrence at this locality has been described by Becker[a] and by Martin, who visited it in 1904, gathering some additional data.[b]

The deposit as described by Becker is a reticulated vein or zone of fracture, in a country rock of andesite and dacite. The ores include free gold, pyrite, galena, zinc blende, copper pyrite, and native copper. The ore is free milling, a large part of the gold being carried in the native state. The gangue minerals are quartz and subordinate amounts of calcite and orthoclase. The ore body strikes N. 20° E. It is from 5 to 40 feet wide and forms a shoot that pitches northward. At the south end of the workings the shoot comes to the surface at an elevation of 600 feet, and at the north end it narrows and becomes of low grade at a depth of about 800 feet. Several attempts have been made to reach the ore body at lower levels by shaft and tunnel, and long crosscut tunnels have been driven in prospecting the adjoining areas. The ore body was exceedingly rich in places, carrying up to $50 a ton. The average for the main ore body was perhaps about $8. The main shoot has now been worked out. Some ore has been taken from minor zones of fracture in the crosscut tunnels, but this material has not been found in sufficient quantities to justify a continuation of the work. The country rock has been mineralized to a certain extent on either side of the main ore body.

Becker concluded that the country rock is Miocene or post-Miocene from its lithologic similarity to andesite, which is supposed to overlie the Miocene at the north end of the island. He would accordingly make the mineral veins of very recent Tertiary or post-Tertiary age. The present writer believes the post-Miocene andesites at the north end of Unga Island to be distinct in age from the country rock in which the gold ledges occur. The younger andesites cover a portion of the south end of the island and irregularly overlie the gold-bearing formation. The age of the rock in which the gold-bearing ledges occur is not definitely known, but it is believed by the writer to be Mesozoic, or older.

Sitka mine.—This mine is located across the valley from and north of the Apollo mine. The ore body is associated with a shear zone which strikes at right angles to the Apollo ore body. The rock in which this ore occurs is of the same general type as that at the Apollo mine. The ores consist of free gold, galena, zinc blende, and pyrite. The gangue minerals are quartz and subordinate amounts of calcite.

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[a] Becker, G. F., Reconnaissance of the gold fields of southern Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 12, 83-85.

[b] Martin, G. C., Gold deposits of the Shumagin Islands: Bull. U. S. Geol. Survey No. 259, 1905, pp. 100-101.

The ore is of low grade and has never yet paid for the working. During the past summer some of the material in the dump was run through the mill and the superintendent believes that the ore could now be mined and milled at a profit. This mine is connected by a tramway with the Apollo plant, so that the ore may be handled at the Apollo mill.

Shumagin mine.—Three claims have been staked out along two ledges which strike N. 60° E. and outcrop in a low ridge one-half mile southwest of the head of Baranof Harbor. The southern ledge is about 50 feet thick, but the ore has not proved sufficiently rich to encourage mining. The other ledge varies in width from 2 to 3 feet and is reported to carry values between $4 and $5 to the ton and nowhere to run below $2. These quartz ledges are in shear zones and are interrupted by many horses of country rock. The present workings consist of a lower tunnel, which has been driven 363 feet, passing through the wider quartz ledge and within a short distance of the second ledge. At the end of this tunnel a crosscut 75 feet long has been made. The upper tunnel is 79 feet long and at the end there is a crosscut running 116 feet to the east and 53 feet to the west along the ore body. The two tunnels are separated in elevation by 150 feet.

UNALASKA ISLAND.

The island of Unalaska is off the western extremity of Alaska Peninsula, near one of the most frequented routes from the Pacific Ocean to Bering Sea. It is important chiefly on account of its splendid natural harbor, on which are located two coaling and trade stations, Dutch Harbor and Unalaska. Several years ago an unsuccessful attempt was made to develop and mine some gold-bearing quartz veins near the village of Unalaska. A 3-stamp mill and a couple of tramways to connect the mill with the mine were erected, but these are now in a state of ruin. Quartz veins of economic value are reported by prospectors on several of the islands farther west.

The following notes are quoted from a report on this district made in 1905 by Collier.[a]

> The hard rocks of the islands are volcanic and consist of interbedded tuffs and flow that are cut by numerous dikes. The most common rocks are dark-gray andesites.[b] * * *
>
> South of Dutch Harbor for several miles the rocks are cut by a system of nearly vertical joint planes which extend approximately east and west. Mineralization has occurred along these joints, and in some instances quartz veins have been formed. Several such quartz veins are exposed in the bluff west of Unalaska, where they have been prospected by short tunnels. The best example, however, is found at the gold mine located 1½ miles south of Unalaska and about a quarter of a mile from the shore of Captains Bay, where a number of small veins of this kind are contained in compact

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[a] Collier, A. J., Auriferous quartz veins on Unalaska Island: Bull. U. S. Geol. Survey No. 259, 1905, pp. 102-103.

[b] Emerson, B. K., Harriman Alaska Expedition, vol. 6, Geology, 1904, p. 29.

gray andesite. The largest of these forms the main ore body of the mine and has been opened for about 200 feet. It has a maximum width of 6 or 7 feet, but thins out in both directions from the widest part and at the ends of the tunnels is not over 1 or 2 feet wide. The samples obtained here consist of kaolin and cellular quartz, heavily stained with iron in the form of limonite. Samples obtained on the dump and around the mill indicate that a considerable portion of the ore originally contained unweathered pyrite and sulphide minerals. A sample taken by the writer from the face of the drift at the principal ore body was assayed by E. E. Burlingame & Co., of Denver, who reported 0.02 ounce of gold to the ton and a trace of silver. It is reported that before the mill was built assays promised very high values, which were not realized from the ore when milled.

COPPER.

INTRODUCTION.

There are no copper mines in southwestern Alaska, but several locations have been made for copper in the Turnagain Arm district, in the vicinity of Seward, in the region of Lake Clark and Lake Iliamna west of Cook Inlet, at Prospect Bay, and on the east shore of Balboa Bay. Reference to the copper in the Turnagain Arm district may be found in Moffit's report on the mineral resources of the Kenai Peninsula.[a] The Lake Clark and Lake Iliamna region was not visited by the writer, but the occurrence of copper ores is reported by mining men who examined this district during the summer of 1908.

PROSPECT BAY.

Prospect Bay is a few miles west of Chignik Bay, on the south shore of Alaska Peninsula. (See Pl. V.) The copper property here has attracted some attention, and various reports regarding it have appeared in Alaskan and Pacific coast papers. The ore body is located at the west shore near the head of Prospect Bay, and fortunately near an excellent little harbor behind a sand and gravel hook. The zone that is staked is about 50 feet wide and consists of crushed rocks in which there are numerous small cavities containing minerals in the crystalline form. The minerals include pyrite, galena, sphalerite, chalcopyrite, and quartz. The crystalline development is in places of the geode type. The country rock to the southwest is coarsely crystalline and of a granitic type. The contact to the northeast is not well exposed. When visited during the early part of the past season, no large body of high-grade ore had been developed, as currently reported. Hand specimens which are fairly rich in copper minerals may be procured from the fracture cavities.

BALBOA BAY.

On the east shore of Balboa Bay, in the midst of the andesitic lava, there is a shear zone in which some copper occurs. There are several prospects in this vicinity and one short tunnel was driven some years ago, but has now been entirely abandoned.

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[a] Moffit, F. H., Bull. U. S. Geol. Survey No. 277, 1906, p. 48.

MINING IN THE KOTSINA-CHITINA, CHISTOCHINA, AND VALDEZ CREEK REGIONS.

By Fred H. Moffit.

KOTSINA-CHITINA REGION.[a]

INTRODUCTION.

The notes here given do not present a full account of progress in the Kotsina-Chitina region in 1908, for some of the important copper prospects receive no mention. No property is omitted intentionally, however, and where claims or work are not mentioned it is because an opportunity for collecting the facts did not present itself.

This region has been recently described in some detail,[b] and these notes are intended to be merely a report of progress since the material for that description was collected.

Copper prospecting in the Chitina Valley was seriously hindered by the low price of copper and the financial depression of 1907–8. It was difficult to raise money for prospecting or for development, so that some claim owners made no attempt to do more than the assessment work necessary to hold their ground. This condition was noticeable in the early part of the year, for it was said in Valdez that the quantity of provisions and other freight carried in over the snow in the months from January to March was considerably less than usual. On the other hand, considerable effective development work has been carried on that seems likely to be of more value in showing the possibilities of the region and the nature of its ores than most of the work done in previous years. Such work has probably been stimulated in part by the fact that construction work on the Copper River Railroad is being pushed and that better transportation facilities are to be expected in the near future.

COPPER PROSPECTS.

BONANZA MINE.

A force of men was employed by the Kennicott Mines Company during the year 1908 in preparing the Bonanza mine for shipping ore. In the early part of the year provisions and equipment were started from

[a] Dan Creek, Chititu Creek, and the Bonanza mine were visited by members of the Geological Survey in the early part of September, 1908. The notes on other streams of the Kotsina-Chitina area were obtained from prospectors seen in Valdez later in the month.

[b] Moffit, F. H., and Maddren, A. G., The mineral resources of the Kotsina and Chitina valleys, Copper River region: Bull. U. S. Geol. Survey No. 345, 1907, pp. 127–175.

Valdez, but owing to the early opening of Chitina River a part of this freight did not reach its destination and was left near McCarthy's cabin, about 7 or 8 miles above the Chitina's mouth. This misfortune did not interfere with work, however, for most of the equipment left behind will not be needed till the work is further advanced. Construction of an aerial tramway from the camp on National Creek to the mine was begun and about half of the necessary towers were erected. A sawmill, a bunk house, and a blacksmith shop were built and a tunnel was started to cut the ore body about 40 or 45 feet below the bottom of the winze in the old tunnel, or about 75 feet below the old tunnel itself. This tunnel had been driven 137 feet in September, and it was expected that 90 feet more would be required in order to reach the winze. The wagon road leading to the mine was widened and graded, so that supplies can now be sledded almost to the mine. Furthermore, construction work on a short piece of railroad from the camp and ore bunkers to Chitina River was started. This road will extend from the mouth of National Creek to a point not far from the junction of Lakina and Chitina rivers, and will make it possible to ship ore and supplies before the Copper River Railroad is completed, as one or two steamboats in addition to the *Chitina* will be placed on Copper River by the spring of 1909 and will form a connection between the lower part of the railroad at Abercrombie Rapids and the upper part at Lakina River.

M'CARTHY CREEK.

The shear zone in which the copper ores of the Bonanza mine are deposited has been traced by prospectors northeastward across the ridge to its McCarthy Creek side, where it is intersected by other shear zones. The vicinity of these intersections is in places marked by the deposition of copper minerals, and the ground has been staked for copper. The occurrence of copper minerals differs here from that at the Bonanza mine in that deposition has taken place well up in the Chitistone limestone instead of near its base. Igneous intrusions are present in the limestone also and give another point of difference from the occurrence at the Bonanza mine.

The largest exposure of ore known on this "extension of the Bonanza lode," as it is called, was found on the Marvelous claim. It consists of two bodies of chalcocite about 6 feet apart, with surface exposures approximately 5 by 8 feet and 4 by 7 feet, joined by stringers. A tunnel was started 100 feet below the outcrop on the east side of the shear zone to cut the ore at depth. A second tunnel 100 feet below the first was also started, but the work was discontinued. On the Hero claim chalcocite in small amount is found near a porphyry dike, but whether there is a genetic relation between the two is not known.

The Houghton Alaska Exploration Company has, besides other property, twelve lode claims on or near the "Bonanza fault" and a 160-acre placer claim on McCarthy Creek. These claims have been surveyed for patent, and patent proceedings are pending. Two of the claims are on the Bonanza fault. Others lie on cross faults intersecting the main fault at a large angle. A tunnel was started on a claim known as Slide No. 3 on the east side of the Bonanza fault, and is being driven in a nearly westerly direction to intersect the fault. At the close of the season (1908) 113 feet of tunnel was completed. An incline raise on a gouge seam was started in the tunnel and continued for 12 feet. It is believed by the operators that this tunnel will have to be continued for about 1,000 feet before striking the Bonanza fault zone. Besides work on the claims, a trail was built from the camp on McCarthy Creek to the tunnel, and sufficient work was done on the placer claim to satisfy the $500 patent requirement. The claims on the "Bonanza fault extension" lie at elevations ranging from 3,000 to 3,500 feet above McCarthy Creek, and consequently could be mined to that depth by an adit tunnel if ore is found in sufficient quantity. Under present conditions the cost of mining is great, and it is not intended to undertake any considerable development work until the railroad has cheapened transportation rates.

There was also some prospecting on the lower part of McCarthy Creek, but it was not learned just what work was done or what success was met.

NUGGET CREEK.

Two tunnels were projected on the Valdez claim in the summer of 1908. One, a little more than a quarter of a mile northeast of the old Valdez tunnel, on a fault plane believed to be the same as that exposed in the old tunnel, showed a well-marked plane of movement but did not disclose any considerable amount of copper minerals. The second tunnel was southwest of the old tunnel and lower down on the hill slope. It had been advanced 100 feet northwestward to strike the Valdez fault, but was not completed. The tunnel was driven in amygdaloidal greenstone, and the rock in places was found to be mineralized. It was believed that the ore body of the Valdez tunnel would be encountered within a few feet.

ELLIOTT CREEK.

The most important work of development on Elliott Creek was that done on the Elizabeth claim. It consisted of an extension of the main adit and the driving of drifts, which now have a total length of about 475 feet. A winze also was started in one of the drifts. Two calcite veins, one carrying iron and copper sulphides, were cut in the adit tunnel and probably represent the Elizabeth vein exposed at the surface.

KOTSINA RIVER.

Work was carried on in the Kotsina River valley by a number of companies, but information concerning the development of all the properties is not at hand. The most extensive operations were those of the Great Northern Development Company, which continued the work begun in the previous year. The four tunnels on Kotsina River west of Ames Creek were extended, as were also those on Ames Creek itself. No considerable bodies of ore are reported to have been cut, however. Work was continued at Iron Mountain, west of Strelna Creek, where the company has two tunnels with a total length of not less than 635 feet, in the larger of which there is a raise of 159 feet. At Copper Mountain, on Clear Creek, the company has done a little work on a vein of chalcopyrite 2 feet wide in mineralized country rock.

PLACER MINING.

Placer mining in the Chitina Valley is still confined to Dan Creek and Chititu Creek. Prospecting on Young Creek has shown the presence of gold in the gravels, but not in sufficient quantity to be of commercial value, at least with the present cost of mining.

The Dan Creek Mining Company, which holds the creek claims below the canyon of Dan Creek, employed the summer in preparing ground for the installation of a hydraulic plant and in prospecting its claims. The improvements on the property include a bobsled road 16 feet wide and 5,800 feet long, from the site of the proposed sawmill to Nizina River, and a wagon road 8,500 feet long, from the sawmill to the canyon. All the rock and gravel cuts were made 12 feet wide, and a bridge 14 feet wide, with a span of 30 feet, was constructed over Dan Creek. A site was cleared away on Boulder Creek for a power plant which will use the water of that stream for generating electric current to run the sawmill and for other purposes.

Ground and timber were also prepared for a dam above the canyon of Dan Creek to furnish water for hydraulic mining. About 50,000 feet of logs were cut for mining purposes. Besides this 11 shafts, with a total depth of 188 feet, were sunk to determine the amount and gold tenor of the gravels on certain claims.

Operations on Chititu Creek were in continuation of those of the previous year. Two hydraulic plants were in operation, but neither one completed a full season's run, for trouble was experienced in procuring labor and work was suspended probably two weeks earlier than the weather required. In consequence the output of Chititu Creek was smaller than the amount which other conditions justified the operators in expecting. The two hydraulic plants are now in good condition, and there is every reason to believe that the summer of 1909 will see a marked increase in the production of the stream.

CHISTOCHINA RIVER REGION.

The Chistochina region is situated in the southern foothills of the Alaska Range. It includes the streams tributary to the head of Chistochina River and adjacent to the glacier of the same name, and lies 35 miles north of Copper River, or 225 miles by trail from Valdez. Its early history and the occurrence of the gold have been described by Mendenhall,[a] and little can be added to his description. The country rock is slate, and the gold occurs in gravels consisting principally of slate but containing also a small proportion of the porphyritic and diabasic intrusives that cut the slate, as well as granite cobbles from some foreign source. The streams that have been productive during the last summer (1908) are Slate Creek, Miller Gulch, Middle Fork, Eagle Creek, and Chisna River. It is estimated that about 100 men have been engaged in work during the season, and that the production of the streams enumerated above is $68,000. Development on Chisna River and Daisy Creek has consisted of prospecting and ditch construction, but the regular pick and shovel work was done on the other streams. It was found that some of the bench gravels of Daisy Creek are frozen and that steam points will be required in winning the gold from them. A thawer and an hydraulic plant for exploiting ground on both Daisy Creek and Chisna River will be installed in 1909.

VALDEZ CREEK.[b]

Valdez Creek is one of the small headwater tributaries of Susitna River. (See fig. 15.) It rises in the foothills of the Alaska Range and flows in a general southwesterly direction for about 12 miles. It is approximately 160 miles north-northwest of Valdez, or 120 miles directly south of Fairbanks. It lies in a region difficult of access and consequently not well known.

Although the creek is a tributary of SusitnaRiver, the trails most frequently used for reaching it approach the stream from the Copper River valley. Two trails are in use. One leaves Copper River at the mouth of Gulkana River and follows that stream to the head of its western fork. Crossing the divide to the Susitna drainage basin, it descends McLaren Creek to Susitna River and then turns northward, going up the river to the mouth of Valdez Creek. This trail traverses a broad, flat area, swampy and dotted with lakes so that traveling is difficult at many places. The second trail follows the southern foothills of the Alaska Range westward to Valdez Creek from Paxton's road house, between Gulkana and Summit lakes on the Valdez-Fair-

[a] Mendenhall, W. C., Geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41, 1905, p. 107.

[b] The notes here given were obtained from prospectors who came out from Valdez Creek to the coast in September, 1908.

banks trail. This trail was used during last summer (1908), and is said to offer many advantages over the more southern one. Food and mining equipment for Valdez Creek have usually been taken in over the southern trail in winter, but in 1908 contracts were made for the delivery of freight by boat at the head of navigation on Susitna River, whence it was to be taken overland to Valdez Creek with horses. The trip from Valdez Creek to the mouth of Indian River was made in the fall of 1908 in eleven days with horses, the distance being

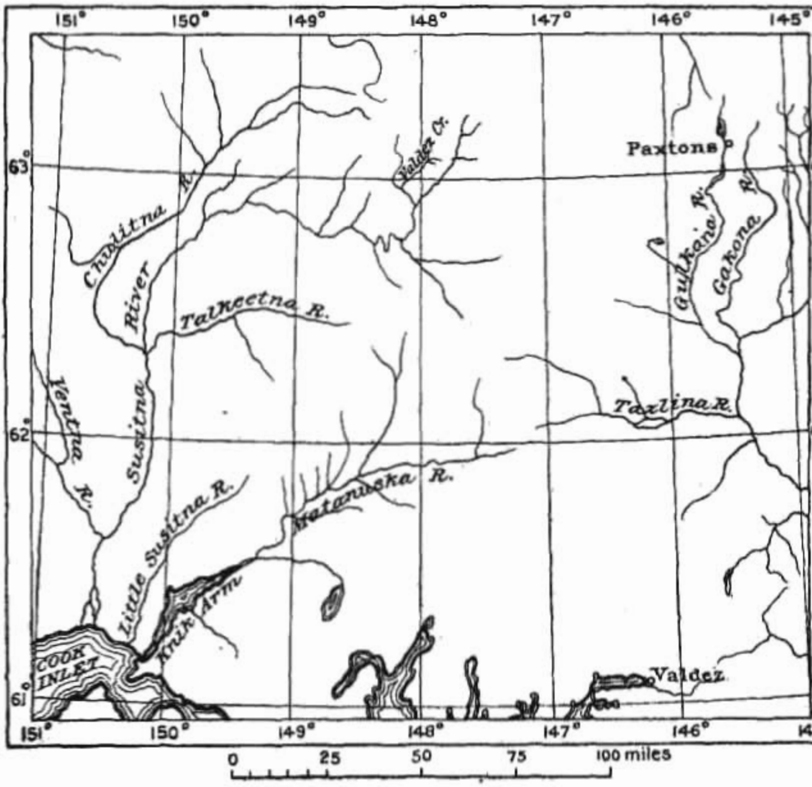


FIGURE 15.—Sketch map showing location of Valdez Creek.

approximately 90 miles. Eldridge has stated[a] that Susitna River is probably navigable for light-draft stern-wheel steamers for a distance of 130 miles above its mouth, which would be to a point near the mouth of Indian River. In July, 1898, the little steamer *Duchany*, drawing about 2 feet of water, ascended the Susitna to a point within 12 miles of Indian River. It is believed, however, that this would not be possible later in the summer. A light steamer drawing 2 feet of water could probably reach the Talkeetna, 87 miles from Cook

[a] Eldridge, G. H., A reconnaissance in the Sushitna Basin and adjacent territory, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1898, p. 10.

Inlet, at nearly all stages of open water, but it could traverse the remaining 35 miles to Indian River only on high water. When once established, this more direct route will doubtless result in a great saving of both money and time.

The excessive cost of freighting supplies into the region has hindered the development of mining and has prevented prospecting to a great degree. The average cost of supplies under present conditions is not far from 50 cents a pound, and the price paid for labor is $1 an hour without board.

The present importance of Valdez Creek lies in its gold placers, discovered in 1903. It is estimated that these placers have produced between $175,000 and $200,000. Mining is practically restricted to two localities on the creek—Lucky Gulch and the vicinity of Discovery claim at the mouth of Willow Creek. The productive area is a small

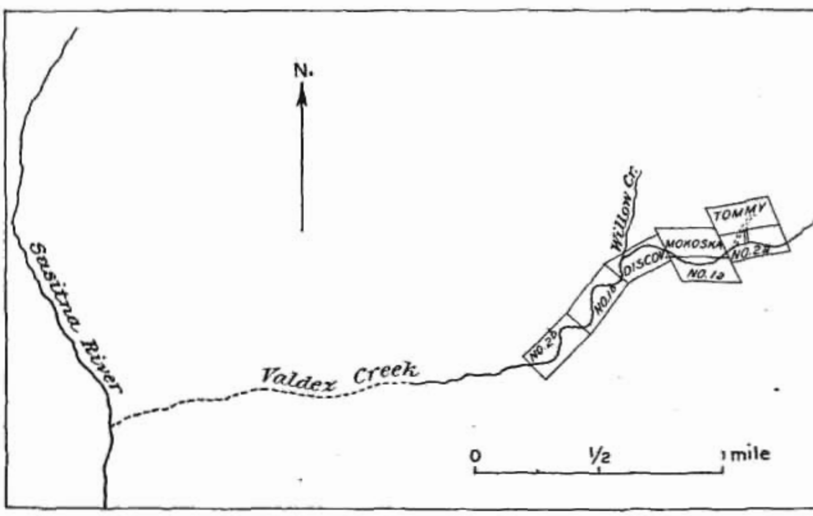


FIGURE 16.—Sketch map of Discovery and neighboring claims on Valdez Creek.

one, and though a large number of claims have been staked, only a few have contributed to the estimated output given above. Figure 16 shows the relation of the better-known claims.

Valdez Creek has cut its present channel through deep gravels and has intrenched itself in the underlying schist bed rock. On claim "No. 2 above" the bench bordering the creek has a height of 170 feet. The lower 60 feet is rock, leaving a thickness of 110 feet of gravel.

Gold is found in the creek gravels and in the bench gravels. A considerable portion of that in the creek is probably derived from the benches and is therefore a product of secondary concentration. Gold is not distributed in paying quantity throughout the bench gravels, nor uniformly over the bed rock, but occurs in a well-defined pay streak—an old channel occupied by the stream before its present rock-walled channel was cut. The two channels intersect each other on claim "No. 2 above," the old channel being 60 feet above the present one. The portion of the pay streak or old channel on claim "No. 2 above" is mined directly from the face of the bench, but the values of the Tommy claim are recovered through a tunnel starting from the bench face and crossing low-grade or barren ground of "No. 2 above." The entrances to these workings are of course 60 feet above the creek. Gold is found in paying quantities in the lower 5 feet of gravel and in the upper 2 feet of the schist bench on which the gravel rests. The average width of the pay streak is 40 feet, and it has been exploited for a distance of about 400 feet from the face of the bench.

A hydraulic plant was installed on Valdez Creek below Willow Creek in 1908, but until that time most of the work of washing the gravels had been done by hand methods. This plant includes a pipe line with two giants and an elevator. For the most part Valdez Creek affords good dumping ground for tailings, but unfortunately an elevator is required at the locality where this plant is in operation.

The gravels of Lucky Gulch are shallow, averaging about 4½ feet in depth. There is much coarse gold in the product of this gulch, nuggets ranging from $5 to $50 being frequently obtained. The largest yet discovered had a value of $970. Lucky Gulch is reported to yield about $40 a day to the man.

The total number of men engaged in mining on Valdez Creek during the summer of 1908 is estimated to be about 120, of whom 20 expected to remain on the creek during the winter. With better facilities for carrying in supplies, the number of men employed by the operators will doubtless be increased.

MINERAL RESOURCES OF THE NABESNA-WHITE RIVER DISTRICT.[a]

By FRED H. MOFFIT and ADOLPH KNOPF.

INTRODUCTION.

The district of which this paper treats lies on the northeast side of the Wrangell Mountains and includes the headwaters of Copper, Tanana, and White rivers. Nearly all of the area is within the rectangle formed by parallels 61° 40′ and 62° 40′ north latitude and meridians 141° and 143° 20′ west longitude. Like the district south of the Wrangell Mountains, it has attracted the attention of prospectors and miners through reports of wonderful copper deposits. These reports have originated partly in stories told by Indians and partly in accounts of ornaments and implements found in their possession by the early explorers.

The region is difficult to reach, and supplies are not easily obtained, yet the search for valuable minerals has been carried on by a few men since shortly after the discovery of gold in the Klondike, and it was to aid in the development of the mineral resources that the surveys of 1908 and of previous years were undertaken.

The work on which this paper is based was a continuation and extension of the work begun by F. C. Schrader and D. C. Witherspoon, of the United States Geological Survey, in 1902, and Mr. Schrader's field notes and maps have been used freely in the field and office studies. During the course of the summer all the better-known prospects on the northeast side of the Wrangell Mountains and in the Alaskan portion of the White River valley were visited, and the geologic and topographic mapping begun by Schrader and Witherspoon was extended down White River to the international boundary. In this work the writers were assisted by S. R. Capps, whose time was given chiefly to topographic mapping, but who also helped in geologic work during the earlier part of the season.

The party consisted of seven men and was equipped with a pack train of eleven horses and the usual camp outfit. Supplies for the

[a] This paper is a preliminary statement of the results of a geologic and topographic reconnaissance survey made in 1908, concerning which a more comprehensive report is in preparation.

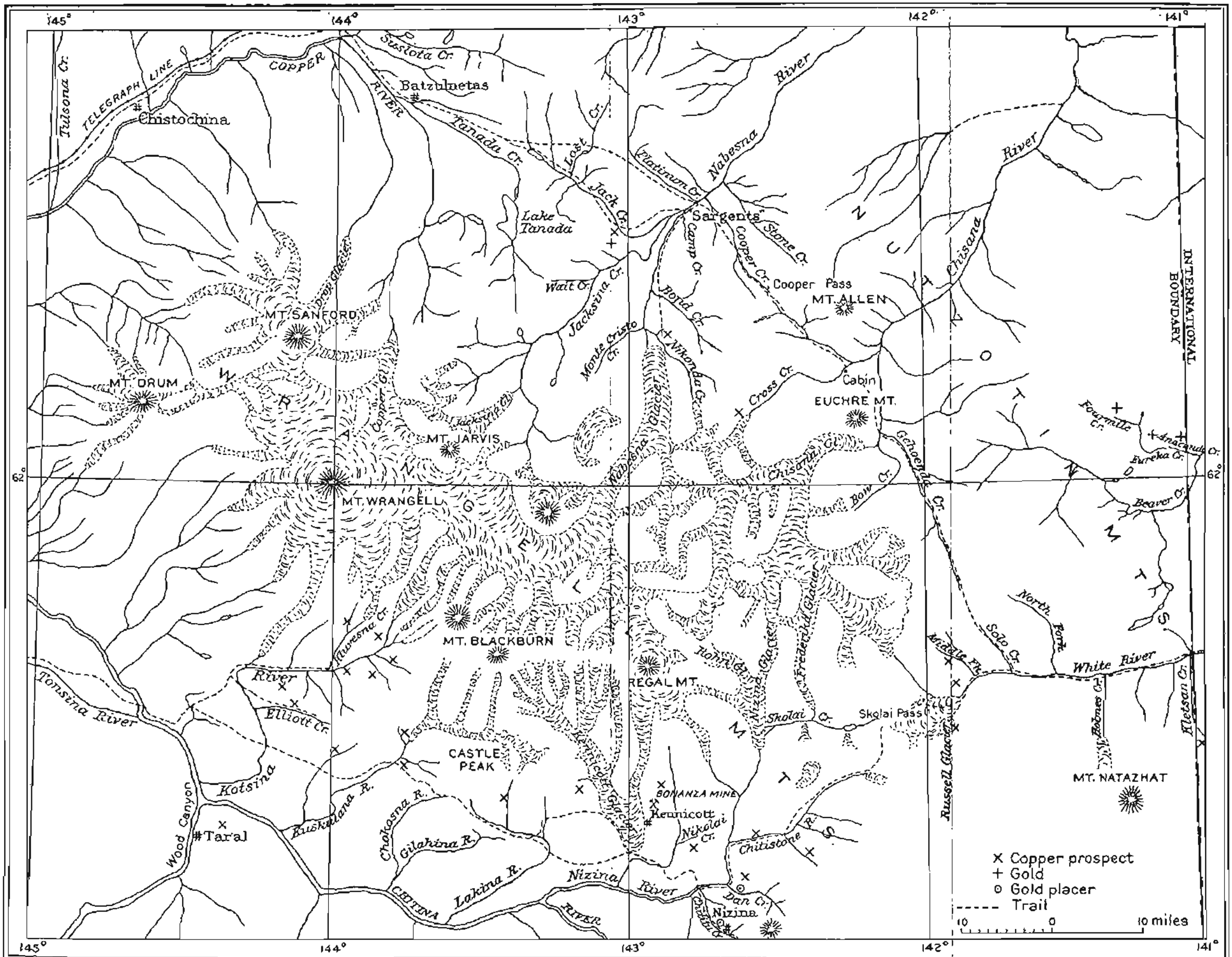
summer's needs had been taken in over the snow and stored at "Sargent's cabin," on Nabesna River, late in February, 1908, so that when the party left in June it was necessary to carry only provisions sufficient for the trip into the interior. Field work began on Nabesna River, July 8, and was ended on White River, August 25, when Skolai Pass was crossed and the return trip to Valdez was begun. Thus only forty-seven days were available for field study on the northeast side of the Wrangell Mountains, but ten days additional were spent on Nizina River before the season's work ended.

GENERAL DESCRIPTION OF THE DISTRICT.

GEOGRAPHIC FEATURES.

The Nabesna-White River district lies in a region of rugged topography, as it includes not only the northeast slopes of the Wrangell Mountains and the north slope of that part of the St. Elias Range which lies between Skolai Pass and Mount Natazhat, but the Nutzotin Mountains also. (See Pl. VII.) The principal peaks within the area range from 6,000 to 12,000 feet in elevation, but on the whole those of the Nutzotin Mountains are lower than those to the west and south. Furthermore, they do not possess such great snow fields and their valley glaciers are much less prominent, both in number and extent. Between the head of Copper River on the northwest and the international boundary line on the southeast three principal streams with sources in the Wrangell and Skolai mountains cross the Nutzotin chain in a northeasterly direction to the lowlands beyond, and there join the Tanana or the Yukon. They are the Nabesna and Chisana,[a] which unite to form Tanana River, and the White, which empties into the Yukon about 75 miles above Dawson. The valleys of the Nabesna and Chisana are narrow and canyon-like. That of the White is broader and less shut in by the mountains, for though it is limited by the lofty snow-covered St. Elias chain on the south, the Nutzotin Mountains immediately north of the river are made up of low rounded and flat-topped hills with summits for the most part less than 3,000 feet above the valleys. The valley floors are broad gravel flats ranging in width from a quarter of a mile or less to 8 or 9 miles, as on White River, near the boundary line. These streams have their sources in the broad snow fields of the Wrangell-St. Elias chain, and like all glacial streams are exceedingly changeable in the amount of water they carry, rising and falling with a daily variation, as well as that depending on season and the irregularities of precipitation. They are heavily burdened with débris brought

[a] The name of the river called Chisana on Witherspoon's map of 1902 is usually pronounced by the prospectors as if it were spelled Shushana. Its exact pronunciation as given by the natives is difficult to determine.



MAP OF THE REGION OF THE WRANGELL AND NUTZOTIN MOUNTAINS.

down by the glaciers, and the deposition of their overload has built up the wide gravel flats of the valley floors.

In the late fall of 1908 the surveyors sent out by the United States and Canadian governments located the position of the international boundary line on White River. It proved to be a short distance east of the mouth of Kletsan Creek, or about 3 miles farther west than it was formerly supposed to be. During the summer of 1909 the line will be permanently marked with the usual monuments, and the custom of recording claims in both Alaska and Yukon Territory when their location is doubtful will no longer be necessary.

TRAILS.

There are three routes by which the Nabesna-White River region may be reached. Prospectors usually approach Nabesna River from the northwest by a trail that leaves the military trail from Valdez to Eagle near the mouth of Slana River. It ascends Copper River to Batzulnetas, whence it continues southeastward to the heads of Jack Creek and Platinum Creek, either of which leads directly to the Nabesna, although Platinum Creek offers the better route for summer travel. After leaving Batzulnetas the trail bears to the east and follows the ridge northeast of Tanada Creek. This portion of the trail is a little hard to pick up at Batzulnetas because of the presence of numerous Indian trails, but when once found it can be followed with little difficulty except that much of it is exceedingly swampy, although possibly no worse than some stretches of the government trail between Tonsina and Copper Center, or between Gakona River and Chistochina. The distance from Slana River to "Sargent's," on Nabesna River at the mouth of Camp Creek, is approximately 40 miles by way of Platinum Creek, and a few miles farther by way of Jack Creek.

The customary route of travel followed by prospectors in entering the White River region is either from the east through Canadian territory or, less commonly, from the Chitina Valley on the southwest by way of Skolai Pass. There is a choice of two Canadian routes, dependent on the means of transportation which it is desirable to use. White River may be ascended from the Yukon in small boats, or the overland trail may be followed from White Horse by way of Kluane Lake. This last-named trail is probably the easiest and best way of reaching either White or Nabesna River with stock in summer, and the best way of reaching White River with stock at any season. A wagon road leads from White Horse to Kluane Lake, a distance of 142 miles, and thence a good trail approximately 120 miles long leads to "Canyon City," on the north side of White River a few miles below the boundary line. Prospectors often bring their supplies up White River from Dawson in poling boats or by tracking, and most of them leave the country by boat in the fall, as it gives them an easy and quick method of reaching the Yukon.

The route from Chitina River by way of Skolai Pass is not regularly traveled, but is used by a few prospectors who have claims in both the Chitina and the White valleys and cross over from the south to do their assessment work. During the earlier days of its use the trail extended over the lower end of Nizina Glacier from a point on the west side about 4 miles above the head of Nizina River to the mouth of Skolai Creek, whose north bank it followed to the pass. At present this trail along Skolai Creek is not used, as Nizina Glacier is so traversed with crevasses as to be practically impassable, and though horses have been taken high on the mountain around the east side of the small lake formed by the damming of Skolai Creek by Nizina Glacier the climb is so great and so difficult that it has been attempted but a few times. Travelers now ascend Chitistone River to its head and cross a broad, high pass with abrupt northern slope to the foot of Russell Glacier, which occupies Skolai Pass, and thence reach the head of White River. This trail will be described in a little more detail, in the hope that such a description may possibly benefit some one who has occasion to use it. It must be borne in mind, however, that the condition of a glacier changes from year to year and that a route followed this year may be impassable next year. In crossing with horses from White River to Skolai Creek, the north side of the glacier should be followed as closely as possible. The top of the "moraine," the débris-covered east end of the glacier, is gained by ascending one of two or three narrow gulches that drain the surface. These gulches are located somewhat north of the central front of the moraine and lead with an easy grade to the summit. When once fairly on top, the traveler will not find it difficult to follow the ill-defined trail or to pick a way across the moraine to the bare ice, a distance of 2 or possibly 3 miles. Little direction can be given for crossing the bare ice further than to follow as closely as possible its north side and not to get out on the middle. The lobe of the glacier at the head of Skolai Creek is greatly crevassed and terminates in an abrupt face or wall not less than 25 feet high at the lowest point. With a little difficulty horses can be taken off the glacier at a point a short distance east of the source of Skolai Creek, but they could not be taken on there without a great deal of work. A better way is to leave the glacier at some point farther east, along the side of Castle Mountain, but it is difficult to describe the proper place where this may be done. From six to eight hours' time are required in crossing the glacier. After leaving it the traveler should immediately cross to the south side of the Skolai Creek valley, being careful to avoid quicksand. If it is needed, a camping place with feed for horses and willows for firewood is available on the low bench above the river flat, at the foot of the steep 1,400-foot climb to the pass between Skolai Creek and Chitistone River. For the first mile or two after crossing the summit traveling is easy, except that care must be taken to avoid soft ground. The greatest difficulty to be overcome on Chitistone River is encountered several miles below the summit, where a high climb over loose talus slopes is necessary to avoid the deep canyons of the river's northern tributaries. This portion of the trail, as well as the glacier in Skolai Pass, should not be attempted after the first winter snows have fallen. Only light packs should be carried, and two days should be allowed for completing the trip, unless the traveler is perfectly familiar with the trail.

The trail from Nabesna River to White River traverses the depression between the Wrangell and Nutzotin mountains. It ascends Cooper Creek, following its eastern fork to the head of Trail or Notch Creek, down which it leads to the Indian village on the south side of Copper or Cross Creek, and thence southeastward across the low timbered point to Chisana River and the mouth of Gehoenda Creek. From Chisana River the trail follows Gehoenda Creek to its head and, keeping close along the lower slope of the mountains on the west, crosses a broad, open divide to the head of Solo Creek, and thus to White River.

Supplies intended for use in this region should be taken in during the winter unless it is intended to bring them up White River in boats. The cost of freighting either from Valdez to Nabesna River or from White Horse to Canyon City is probably not less than 35 cents a pound when conditions are favorable, and may be considerably more.

WORKING SEASON.

The climatic conditions here are those of interior Alaska. Separated from the Pacific by a broad belt of lofty mountains, the region is outside of the immediate influence of the ocean, with its tendency to increase precipitation and minimize the temperature variations. The rainfall is moderate in summer and the winter snows are not excessive. Feed for horses is good in May or early June. On some of the river bars there is an abundance of grass, particularly on upper Nabesna and White rivers. For several years horses have even wintered on the White River bars. Prospectors using stock leave Nabesna River for Valdez at the end of a summer's work about August 25, or not later than September 1, but those on White River remain till October without danger of lack of feed on the trail to White Horse. Thus the working season on White River is considerably longer than on the Nabesna or anywhere in the Copper River basin.

GAME.

Game is plentiful throughout this area. Sheep can be found at the heads of almost any of the streams. In the early spring they feed in the main valleys, but as the summer season advances they work farther and farther back into the higher mountains and seem to choose especially the vicinity of the glaciers. Caribou, although not present in such great numbers as in the Tanana-Yukon country, are frequently seen on the low hills north of White River, and can often be got with little difficulty. Moose in considerable numbers range the flats bordering White River. Black and grizzly bears are numerous, and the natives take a quantity of furs each year—fox, lynx, marten, and mink. A few ptarmigan are found in the higher untimbered valleys.

NATIVES.

The total native population of the area extending from the head of Copper River to White River is probably not far from 45 or 50. The natives are divided between three villages, if such they may be called—one at Batzulnetas on Copper River, one at the mouth of Cooper Creek on Nabesna River, and a third on Cross Creek opposite the mouth of Notch Creek, in the Chisana Valley. The Batzulnetas and Nabesna natives seem to rely on the white men for a considerable portion of their food, but the Chisana natives are more independent. Their more isolated position has brought them less into contact with white men, and they have retained their own manner of living to a greater extent. They depend almost entirely on game for food, and lay up a good supply each fall for the winter's use. All these natives wear clothing obtained from white men, except their moccasins, which they make themselves. Tea and tobacco also are in great demand and can always be used in trade.

GENERAL GEOLOGY.

Both igneous and sedimentary rocks are present in the Nabesna-White River region. In a broad way it may be said that the rocks of the Wrangell and Skolai mountains are prevailingly igneous, although they are associated with important water-laid rocks, and that those of the Nutzotin mountains are prevailingly sedimentary, although igneous rocks are locally prominent. Thus the depression between these two mountain chains separates an area on the southwest characterized chiefly by the results of volcanic activity from one on the northeast characterized chiefly by the accumulations due to sedimentation. The following table gives the important features of the stratigraphic column so far as they are known:

Generalized geologic section of Nabesna-White River district.

Quaternary	Gravels, till, and other unconsolidated deposits.
Tertiary	Volcanic rocks.
	Lignitiferous formation including shales, sandstones, lignite beds, etc.
Jurassic	Shales of Jacksina River.
	Shales, slates, and graywackes of the Nutzotin Mountains.
Triassic	Thin-bedded limestones of Cooper Creek.
Carboniferous or later	Lavas and pyroclastic rocks, tuffs, etc.
	Shales.
Carboniferous	Massive limestone.
	Shales.
	Basic lavas and pyroclastic rocks.

These rocks are not known to be present in a continuous section at any one locality, and the table as given is made up from data collected at various places. All the consolidated rocks are cut by dikes and sills of basic igneous rock, mostly of a basaltic or diabasic nature. The Carboniferous sediments have been further intruded by large masses of quartz diorite and by diorite porphyries and andesites. Whether these more acidic intrusions extend into the Triassic and Jurassic sediments was not determined. In other words, the quartz diorites and diorite porphyries are known to have been intruded after the deposition of the Carboniferous shales and limestones, but it is uncertain whether they were intruded before or after the Triassic beds were laid down.

As is shown by the table, the oldest known rocks of the region are of Carboniferous age. The most conspicuous member of the Carboniferous succession is a massive limestone, highly fossiliferous, ranging in thickness from not less than 200 to 500 or more feet. It is exposed on the mountain sides south of White River and is seen at various places along the northeastern slope of the Wrangell Mountains from Skolai Pass to the head of Jack Creek. It should be stated, however, that the correlation of some of the limestone areas of the Wrangell Mountains is based on field relations rather than on fossil evidence. The massive limestone is underlain by fossiliferous shales or slates of Carboniferous age and by lava flows. Immediately above it, as seen at Skolai Pass, are about 300 feet of shales with intruded diabase sills. These shales, from which no fossils were collected, appear to lie on the limestone conformably and are overlain in turn by a great thickness of tuffs and lava flows. About 4 or 5 miles north of Skolai Pass this succession of volcanic rocks includes water-laid tuffs and conglomerates, as well as diabasic and andesitic flows, and is intruded by light-colored diorites. The evidence for the age of the shales overlying the limestone is not conclusive, but they are nevertheless included provisionally with the Carboniferous sediments because of their seeming conformity with them.

The Carboniferous beds are folded and locally are highly metamorphosed. This difference in the amount of metamorphism at different localities is noteworthy, for in some places, as at a few of the exposures on White River, the limestone seems scarcely to have suffered change, whereas in others, as on Notch Creek, it is completely altered to a fine white marble. This extreme alteration can readily be explained, however, as an effect of the diorite intrusion with which it is associated. The effect of this intrusion is further seen in the region of Orange Hill and at the Fjeld gold property on Jacksina River, where mineralization of contact-metamorphic order is one of its immediate results.

The known Triassic sediments consist of thin-bedded limestones occupying a single small area in the ridge between the two forks of Cooper Creek. They have been greatly disturbed both by folding and by faulting, and their relation to the near-by Carboniferous limestones and the Jurassic shales was not determined.

The Jurassic sediments comprise banded slates and shales, together with smaller amounts of arkose or graywacke, conglomerate, and thin limestone beds. In places they are intruded by basic igneous rocks, principally diabase, in the form of dikes and sills. A small area of fossiliferous Jurassic shales was found near the mouth of Jacksina River, but Jurassic sediments are developed mainly in the Nutzotin Mountains, where, so far as known, they make up the greater part of the chain. In most places the bedding of the Jurassic rocks is easily distinguishable. The beds are folded and are locally metamorphosed, with the production of a slaty cleavage. Small veins of calcite and quartz are numerous, and some of them are known to carry gold. The succession of banded slates and arkoses exhibited in the Nutzotin Mountains, even when allowance is made for possible reduplication of beds due to folding, must have a great thickness, for it is exposed in a belt whose average width is not less than 15 miles. The sediments are only slightly fossiliferous, and the fossil localities found are few, so that the presence in this range of rocks other than those of Jurassic age is entirely possible.

The Tertiary sedimentary deposits, so far as they are known, are confined to a small area near the international boundary, a few miles north of White River. They comprise sandstone, shale, and conglomerate with thin lignite beds, all lying in a nearly horizontal position and cut by basaltic dikes. Furthermore, they appear to be covered locally by lava flows. No fossils were collected from them and their age was not definitely determined.

To the Tertiary period is also assigned a vast quantity of the younger volcanic rocks, chiefly dark vesicular lavas that are best seen in the northern part of the area. These flows are most abundant on the slopes of Mount Wrangell and Mount Sanford, but are less well developed to the southeast and seem to be present only in the highest parts of the mountains. They differ from the older lavas in being entirely fresh and unaltered. Their extrusion is thought to have begun some time in the Tertiary period and to have continued to very recent time,[a] for in places they rest upon unconsolidated gravel deposits.

The Quaternary deposits include the unconsolidated materials occurring throughout the region, and also a part of the lava flows mentioned in the preceding paragraph. The unconsolidated deposits consist principally of stream gravels, till, and other rock material deposited by the glaciers, volcanic "ash," and unassorted débris resulting from rock weathering. In this region much of the material composing the broad gravel flats built up by the streams was originally laid down by glaciers, but has since been transported and redeposited by water, so that indirectly a very large part of the unconsolidated deposits may be considered as of glacial origin. Glacier and stream deposits together constitute the major part of the Quaternary. A conspicuous member of the unconsolidated materials is made up of white volcanic ash and is best developed in the White River region, where it forms immense drifts on the lower slopes north of Mount Natazhat and is present in a bed 30 inches thick overlain by 8 feet of peat on the gravel benches bordering the river. It is found in an easily distinguished bed from 6 to 10 inches thick as far north as Chisana River, but was not noticed on the Nabesna. It consists chiefly of fine white pumice, inclosing a large number of tiny hornblende crystals and biotite. Occasionally pieces of pumice several inches in diameter are found on the river bars, but in the undisturbed beds pieces half an inch in diameter are exceptional. The source of this material is not known, but it is thought to have come from a volcano somewhere to the south of White River.

The Nabesna-White River region is one of profound glaciation, whose existing glaciers are but small remnants of those that have gone before. Till and other glacial deposits high above the valley floors give abundant evidence of a former ice extension which was far greater than that of the present and during which most or all of the valleys were filled by the ice and many hills of considerable height were buried beneath it.

MINERAL RESOURCES.

INTRODUCTION.

The mineral resources of the upper White-Nabesna region that have attracted the attention of the prospector are copper and gold, and, in an incidental way, zinc, lead, and lignite. The probable

[a] Mendenhall, W. C., Geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41, 1905, p. 57.

occurrence of native copper has long been surmised from the reports of the Indians. As early as 1891, the year in which the upper White River country was first penetrated by white men—an exploring party of three, one of whom was C. W. Hayes, of the United States Geological Survey—astonishing Indian stories concerning the enormous quantities of native copper found in that region were told to the members of the expedition while at Fort Selkirk, on the head of the Yukon.[a] During the trip up White River and over Skolai Pass, which was made by back packing and which consequently allowed but a casual examination of the line of travel, nothing, however, was seen to support the exaggerated statements of the Indians; but it was definitely ascertained that some placer copper was present on Kletsan Creek near the international boundary. From 1898 onward, in response to Indian reports which had in popular esteem invested the upper White River country with mineral wealth of a vastness in proportion to its remoteness and inaccessibility, prospectors kept coming into the region in search of native copper and gold.

The first published description of copper as a prospective resource was given by Brooks,[b] who hastily traversed this belt in 1899 as geologist accompanying the Peters exploring expedition and who came to the conclusion from the abundance of copper indications "that this upper region is one that is worthy of careful investigation by the prospector and the capitalist."

In 1902 a placer-gold stampede brought an influx of prospectors into the upper White River country, but as no paying quantity of precious metal was discovered the majority soon left for more promising fields. The few that stayed turned their attention to the copper resources of the region, many of them being incited to this search by the prevalent Indian reports of large deposits of native metal.

In 1905 reports of fabulously rich deposits of metallic copper in the headwater region of Nabesna River were widely circulated in the public press. Examination in the field shows that these statements rest on but a very slender basis.

COPPER.

GENERAL CONDITIONS OF OCCURRENCE.

The reported presence of native copper in vast quantities was, as already pointed out, the original incentive that drew the pioneer to the White-Nabesna region. Prospecting in search of these deposits has shown that copper in its bed-rock sources is widely distributed in

[a] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., 1892, pp. 117-162.

[b] Brooks, A. H., A reconnaissance from Pyramid Harbor to Eagle City, Alaska, including a description of the copper deposits of the upper White and Tanana rivers: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 382.

the form of sulphides (chalcocite, bornite, and chalcopyrite), and on the basis of the facts revealed by the little development work that has been done it may be stated that most of the native copper found in the region is an oxidation product of those sulphides. In mode of occurrence the copper ore shows two different habits, geologically distinct. In one, so far the better known, it occurs associated with the Carboniferous basaltic amygdaloids, and in the other it is found in limestone at or near the contact with the dioritic intrusives.

Native copper occurs as nuggets in the gravels of many of the streams, and green-coated lumps of metal up to 5 pounds or more in weight are occasionally found in the wash of creeks draining areas of amygdaloid bed rock. This stream copper was the source from which the Indians obtained their supply when it was an object of barter among them. From the accounts of Hayes and Brooks, Kletsan Creek appears to have been the placer locality best known to the natives.

Metallic copper occurs also in the surface croppings of sulphide deposits in the amygdaloids, where it is undoubtedly an oxidation product of the sulphides that appear in depth. In such places it is directly associated with the dark-red oxide (cuprite) and more or less green carbonate. At the prospect known as "Discovery," which is located in Canadian territory on White River a few miles below the international boundary, a large slab of native copper averaging 8 by 4 feet by 4 inches thick and weighing probably close to 6,000 pounds has been uncovered in the slide rock. A number of other sheets of copper up to several hundred pounds in weight have been found in the near vicinity. On account of the stimulus that this find has exerted on the prospecting of the adjacent American territory, the occurrence merits some description in this report. The stripping of the bed rock near the great nugget exposes a face of green basaltic amygdaloid 20 feet high and 15 feet wide. The rock is traversed by numerous seams of native copper along fractures and slickensides, but toward the bottom of the open cut stringers of chalcocite begin to appear. About 150 feet from this prospect an opening on an independent occurrence shows stringers of cuprite with admixed copper, stringers of glance and calcite, and chalcopyrite disseminated through the amygdaloid country rock. From these features it is clear that the metallic copper of this deposit is a superficial oxidation product of sulphides, that its downward extension is small, and that the prevailing sulphide at greater depth will probably turn out to be chalcopyrite.

At a few localities native copper is associated with certain highly amygdaloidal portions of the Carboniferous basalts and intergrown with the white minerals that fill the former steam cavities in the ancient lava flows. Slaggy-looking portions produced by the weathering and removal of the amygdules from the lava and amygdaloid that is cut by small irregular veinlets filled with the same minerals as those forming the amygdules appear to be the most favorable places for metallic copper. The copper in the vesicles and stringers is associated with calcite and delicately spherulitic prehnite, but in some of the veinlets calcite, prehnite, quartz, a black lacquer-like mineral, partly combustible, and chalcocite, instead of metallic copper, are associated together.

At a number of places throughout the region narrow stringers of chalcocite cutting the ancient basalts are encountered, but so far as known none have any great persistence. Near the head of Cross Creek, locally known as Copper Creek, a thin quartz-chalcopyrite vein cutting the bedded volcanic rocks has been discovered. At other localities some irregularly disseminated sulphides, in some places chalcocite, in others bornite, occur in the basalts, but these do not appear to be connected with definite vein or lode systems and are consequently of an unencouraging character. Oxidation of these sulphides and disintegration of the containing rock give rise to the nuggets of cuprite and native copper that are found in the talus slopes at several places in the region.

In contrast to these occurrences, which, as shown by the foregoing discussion, are limited to the ancient basalt flows, copper is found as bornite and as chalcopyrite intergrown with contact-metamorphic rock in limestone adjoining diorite intrusives. In deposits of this type the ore mineral is associated with garnet, coarsely crystalline calcite, epidote, specular hematite, and scattered flakes of molybdenite. The garnet is commonly crystallized in dodecahedra and is intimately intergrown with the bornite and chalcopyrite. On account of its weight and especially its appearance, which is not unlike that of cassiterite, it was mistaken for tin ore by some of the early prospectors. Only two deposits of this character were seen in place, but evidences of energetic contact metamorphism were detected at a number of other localities. An extensive contact zone has been produced along the junction of the diorite and the massive limestone exposed on the ridge west of Copper Pass. Various contact-metamorphic rocks, pyritiferous as a rule, are present in this zone, and these rocks on oxidizing give rise to large iron-stained outcrops, which contrast strongly with the surrounding white limestone. In connection with the discussion of the contact-metamorphic deposits it may be stated that the writers were shown some specimens of copper ore containing abundant large octahedra of magnetite and blebs of chalcopyrite in a gangue of coarse calc spar. This ore was undoubtedly obtained from the vicinity of an intrusive diorite-limestone contact, but whether commercially valuable ore bodies of this character exist in this region, which is so remote from transportation facilities, is yet to be demonstrated, in view of the fact that copper deposits of contact-metamorphic origin are characteristically bunchy and low grade.

NABESNA RIVER.

Near the head of Nabesna River and below Nikonda Creek some work has been done on a prospect (the Shamrock claim) situated 2,000 feet above the floor of the valley. The stripping of the talus from the base of the massive Carboniferous limestone has disclosed a large, irregular body of massive garnet rock containing some disseminated bornite and chalcopyrite. Here and there a little molybdenite can be detected. Veinlets of garnet traverse the surrounding coarsely crystalline white limestone. At the time of examination the best exposure of visible ore was a body of solid bornite 4 or 5 inches thick and perhaps a foot long.

On Jacksina Creek the same limestone is intruded by diorite and cut by a large number of diorite dikes. Considerable contact metamorphism has resulted and large garnet masses, locally rich in chalcopyrite, were produced. The metamorphic action was of selective character, certain limestone beds being converted into garnet, whereas others were changed to tabular masses of white silicates. These relations are exposed with diagrammatic clearness in the limestone cliffs. The copper-bearing rock, in typical specimens, consists of garnet, much of it finely crystallized in dodecahedral form, calcite, chalcopyrite, and some specular hematite. The present indications show that the ore occurs rather in a number of scattered bunches than in a single large workable deposit.

CHISANA RIVER.

At the head of Cross Creek, several miles above the lower end of the glacier, a thin quartz-chalcopyrite vein cutting the andesitic lavas and breccias has been discovered, but most of the information concerning it is derived from fragments of ore found in a talus slope 600 feet high. A little galena is associated with the copper mineral. In the same vicinity some outcrops of zinc ore, a resinous sphalerite with scattered galena, have been found, but the exposures are poor on account of the covering of slide rock.

Native copper can be found in some of the streams in the amygdaloid area between Cross Creek and the Chisana. There are also indefinite Indian reports that rich deposits of native metal occur in the mountains bordering Chisana Glacier, but the exact locality has not yet been discovered.

WHITE RIVER.

At the head of the middle fork of White River, a large tributary entering from the northwest 5 miles below the head of the main stream, some claims have been staked on outcrops of rock carrying native copper. Two small open cuts 1,450 feet above the stream were seen on the Copper King claim. The country rock at this locality consists of stratiform basalts of Carboniferous age intercalated with beds of breccia and brick-red tuffs, striking N. 85° E. (magnetic) and dipping 18° S. into the mountain. Native copper is apparently limited in its occurrence to a certain definite volcanic sheet—a reddish lava that is locally amygdaloidal to a high degree. For 200 feet along the outcrop of this sheet metallic copper intergrown with prehnite, calcite, and zeolites can be found here and there in encouraging amounts. The thickness of the cupriferous portion of the amygdaloid appears to be about 6 feet, but as almost no development work has been done on the property figures of this kind have little value. The copper occurs as irregular reticulating masses of metal several inches long and as small lumps and minute particles embedded in the minerals that fill or line the former vesicles in the lava flow. In places these minerals ramify in the shape of small veinlets through the body of the rock surrounding the amygdules, or form irregular masses, and such places are eminently favorable for metallic copper.

This occurrence is the only one seen during the summer in which the native copper appears to be of undoubted primary origin. If the ore shown on the surface has any downward extension, a fact which can be established only by actual exploration, it can be predicted with a high degree of confidence that metallic copper also will persist downward. To this extent the surface indications are distinctly favorable. Some doubt as to the probable amount of ore may well be entertained in view of the character of the deposits. It is well known that native copper associated with zeolites filling amygdules in basaltic lavas is found throughout the world in widely separated localities—the Faroe Islands, the trans-Baikal region, Brazil, Queensland, and Lake Superior—yet only those from the Lake Superior region have yielded ore bodies of commercial value.

On Moraine Creek, a small stream in a glacier-filled valley on the east side of Russell Glacier, a number of claims were staked during 1907 and 1908. The bed rock here also consists of green and reddish amygdaloids, with associated breccias striking N. 85° W. (magnetic), but dipping 55° S. at an angle considerably steeper than on Middle Fork. In some places it can be seen that the upper portion of a lava sheet is more highly amygdaloidal than the rest of the flow. Malachite-stained fragments of rock can readily be found in the talus slopes. Copper occurs in place in small seams cutting the amygdaloid, the veinlets consisting of spherulitic prehnite and calcite, flecked with red metal and chalcocite. There are also small stringers composed of quartz, prehnite, a black combustible mineral (a solid hydrocarbon?), and chalcocite. It seems probable that the native copper and chalcocite are of contemporaneous origin. At another point on Moraine Creek the lava, in addition to containing white amygdules of zeolite, carries irregular blebs of chalcocite, which give the rock somewhat the appearance of a glance-bearing amygdaloid. Such development work as has been done on Moraine Creek indicates that the amygdaloidal phases of the basalts here, too, are the most favorable, and are likely to be found along the contacts of successive lava flows. As the superimposed sheets of lava commonly differ in color and texture the contacts can easily be located.

Near the head of White River similar Carboniferous volcanic rocks form the west wall of the valley. They consist of basaltic tuffs, breccias, amygdaloids, and porphyritic sheets, dipping 10° N. The colors of the lavas are dark red-browns and greens. A number of prospects have been located on chalcocite croppings a few miles below the edge of the moraine of Russell Glacier. In the main, these outcrops consist of small bodies of shattered amygdaloid permeated with seams of chalcocite. At one prospect a thin glance stringer an inch or so in thickness cuts vertically across the nearly horizontal volcanic rocks. It is adjoined by sheared amygdaloid walls, and veinlets of white earthy material ramify through the adjacent rock to great distances. A few hundred feet below this locality, on what is thought to be the same vein, is another open cut on a glance stringer about 3 inches wide, largely solid sulphide, which is intergrown to some extent with a zeolite mineral, probably laumontite. The cliff above the cutting shows that the stringer pinches out vertically within 6 feet.

On Rabbit Creek, at a point near the international boundary and about 7 miles north of White River, an adit 20 feet long has been driven on a shattered zone in basalts, presumably of Carboniferous age like those prevailing throughout the region. At the mouth of the adit the zone, which is about 40 feet wide, is iron-stained and variegated with blue and green carbonates of copper. The unoxidized rock carries sparsely disseminated chalcopyrite.

The copper deposits on Kletsan Creek were not visited on account of lack of time at the end of the field season. The placer copper, according to Brooks,[a] "as far as observed, is confined to a distance of about half a mile above the point where the creek leaves its rocky

[a] Brooks, A. H., A reconnaissance from Pyramid Harbor to Eagle City, Alaska, including a description of the copper deposits of the upper White and Tanana rivers: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, p. 381.

canyon." It is traceable up to the glacier from which the creek is discharged. In 1902, a number of years after this examination, which was necessarily of a hasty character, some attempt was made by interested capitalists to test the placer copper possibilities of the locality. On account of the glacial ice and snow in the high ranges at the head of the creek and a number of other adverse conditions, unfavorable conclusions were reached. Some bed-rock occurrences of native copper were described by Brooks [a] as consisting of an irregular system of veins traversing joints in the greenstones. The filling of the veinlets consists of calcite, and careful search showed that some of them carried native copper. The deposits on which prospecting is being done at present consist, however, of chalcocite, as seen from specimens purporting to have come from Kletsan Creek. It is stated that a good trail has been built from Generk River [b] to the deposits and that considerable work has been done on them.

GOLD.

At the present time prospecting for gold in this region is confined to lode deposits, as placer gold has proved to be present in the streams in unremunerative amounts. The stampede from Dawson in 1902 was directed toward Beaver Creek and its tributaries in the vicinity of the international boundary, and the surrounding territory was soon staked far and wide by the stampeders. A few holes put down in the gravel bench of Beaver Creek are now the only tangible signs of their former activities. It is reported by participants in the stampede that some coarse colors of gold were found in the creek gravels. The wash of the streams is rather coarse, consisting mainly of well-rounded cobbles and bowlders of diorite, and the bench gravels also are coarse, as, for example, in the 50-foot bench of Beaver Creek, where bowlders of diorite up to 6 feet in diameter are not uncommon.

NABESNA RIVER.

At the Royal Development Company's property on Jacksina Creek a number of cuts have been opened on a gossan derived partly from the oxidation of a pyritized sheared diorite and partly from the oxidation of the adjoining pyritized contact-metamorphosed limestone. The trend of the deposit is N. 45° E. (magnetic), and it ranges in width from 4 to 15 feet. The surface ore consists in part of cellular quartz, iron stained and carrying free gold. A 3-stamp mill was erected in 1906 and about 60 tons of surface ore was crushed, yielding, it is reported, $12 a ton in gold. During the summer of 1908 the mill was not in operation, inasmuch as the work of the season was directed

[a] Op. cit., pp. 380-381.

[b] This name conforms to official Canadian usage; on older maps the stream was called "Klutlan."

toward crosscutting the deposit about 200 feet below the outcrop. At the time of visit (middle of July) the crosscut was expected to strike ore within 25 feet. Three men were employed on the property.

WHITE RIVER.

Near the base of the gravel bench on Beaver Creek, about 1 mile upstream from the mouth of Ptarmigan Creek, an outcrop of sulphide ore 2½ feet by 5 feet in surface exposure protrudes through the gravel. It consists of solid pyrrhotite, admixed with a little chalcopyrite and minor amounts of quartz, and is reported to carry $18 to $40 a ton in gold. An adit 30 feet long has been driven 10 feet to the east of the outcrop, but encounters no ore, showing only shattered diorite country rock traversed by narrow quartz seams. As the gravel bench is grown over with moss, the single cropping furnishes the little that is known concerning the lode. About 200 feet downstream the bluffs show that the diorite is intrusive into hard massive shales.

At the head of Eureka Creek, near the international boundary, a number of strong quartz ledges have been discovered. Eureka Creek is situated about 30 miles north of the mouth of the upper canyon of White River, where a small settlement ("Canyon City") has grown up on the north side of the stream. The bed rock at the head of Eureka Creek consists of shales interstratified with limestones and dark-violet andesitic breccias. Locally the limestones are highly tuffaceous and crowded with fossils. The rocks are practically standing on edge and trend N. 87° E. (magnetic). A lenticular bed of limestone 200 feet in maximum thickness and several thousand feet long forms bold crags projecting above the more easily weathering shales that inclose it. The sedimentary rocks are pierced by a large number of porphyritic dikes and intrusions, of which at least four varieties were seen during the very hasty reconnaissance of the region. These include green dioritic and andesitic porphyries and, in the vicinity of the Violet claim, a more siliceous porphyry containing small feldspars and quartzes embedded in a flinty-looking matrix. From the prevalence of diorite bowlders in the gravel of Eureka Creek it can safely be inferred that irruptive masses of diorite, such as were found in neighboring areas, are present in the vicinity. The quartz lodes form prominent outcrops ranging in thickness from 4 to 12 feet, and many of them can be traced for considerable distances. As a rule, the quartz is nearly barren to the eye, showing only a small amount of chalcopyrite and surface stains of azurite. The values are believed to lie in gold, but information on this point is scanty as yet.

The most development work, however, has been done on the Eureka claim, where an argentiferous galena-sphalerite ore has been discovered. Values close to $30 a ton are claimed. The mineralization follows a zone of crushing 6 to 8 feet wide apparently in a porphyry dike crosscutting the shale country rock. The trend of the deposit is N. 25° W. and the dip 74° E. An adit 60 feet long has been driven on the lode.

On the other side of the divide at the head of Eureka Creek a small stream named Anaconda Creek flows eastward to Beaver Creek. Near its head a quartz lode on what is known as the Beaver claim has been staked. It ranges in thickness from 6 to 12 feet of solid quartz and strikes north and south, crosscutting the strata of the country rock. A number of large outcrops expose the ledge for several hundred feet, and it probably extends for several thousand feet. Chalcopyrite and azurite are the only visible ore minerals. Assays are reported to have yielded $1.50 a ton in gold and 1½ per cent in copper. It is possible that the apex of an ore shoot carrying profitable amounts of gold may yet be found in a vein of this size and persistence, and further prospecting with this possibility in view is certainly to be recommended.

Near the head of Fourmile Creek, a large western tributary of Eureka Creek, a considerable number of quartz outcrops have been discovered, and some of these, it is stated, give encouraging returns in gold from panning of the crushed ore. Along the crest of the ridge 2,500 feet above the stream a great number of quartz veins from 8 to 30 feet thick are exposed. The Jumbo quartz vein, approximately 30 feet thick, forms towering pinnacles emerging through the slopes of loose talus. It represents a zone of brecciation and silicification and includes large angular fragments of country rock several feet in diameter. The quartz shows to the naked eye nothing but small sporadic amounts of chalcopyrite. The wall rock of this great quartz mass is a siliceous feldspar porphyry which forms a large intrusion in the surrounding shales and argillites. The porphyry itself is cut by green dikes which are noteworthy on account of the numerous large crystals of hornblende, 2 to 3 inches in size, scattered through them.

The Husky lode is situated in a more accessible place than the Jumbo. The cropping forms a 15-foot stream bluff on the north side of Fourmile Creek and shows that the lode is a zone of silicification, approximately 30 feet wide, in a crushed feldspar porphyry. The top of the bluff reveals the fact that considerable unsilicified porphyry occurs within the lode. Only one wall of the lode is exposed, and this is not sharply defined, but is a zone of imperceptible transition from quartz to unsilicified porphyry country rock. The lode carries a small tenor of chalcopyrite and an undetermined amount of gold.

Along the middle course of Fourmile Creek some desultory prospecting has been done in the tributaries entering from the south side. The geologic features are essentially similar to those on Eureka Creek.

Intrusive masses of a gray medium-grained hornblende-biotite diorite appear here, and large areas of this rock are shattered and reticulated with veinlets of gypsum, a very unusual mode of occurrence for that mineral. The gypsum is fine grained and crystalline and many of the stringers carry considerable pyrite, but are of no economic importance.

LIGNITE.

A formation consisting of sandstones, shales, and conglomerate lying nearly horizontal is developed in the region of Coal Creek near the international boundary, but its areal distribution is not known. Fragments of lignite can be found in the slide rock of stream cuttings on Coal Creek, but at the point examined by the writers they did not appear to come from thick or continuous beds. In addition to these unfavorable features the strata are pierced by large vertical dikes of basalt. Toward the head of Coal Creek the lignite-bearing formation appears to be covered under a heavy series of volcanic flows. Petrified wood is common as float in the gulches cutting the formation. The lignite has a woody, fibrous texture, but on cross fracture shows a brilliant black glossy surface. The subjoined analysis, furnished by the courtesy of Mr. John Sinclair, shows that it is well within the lignite class of coals.

Analysis of lignite from Coal Creek.

[By Atheistan Day.]

Moisture	14.85
Volatile matter	47.20
Fixed carbon	29.15
Ash	8.80
	100.00

CONCLUSIONS.

The White-Nabesna region can be more easily prospected in some respects than many other parts of Alaska, on account of the relative abundance of bed-rock exposures. Most of the showings of ore found thus far are situated well up on the mountain sides, generally beneath walls of rock cliffs and above the encumbering talus slopes. This is, of course, to be expected in a region that is incompletely prospected, but it entails the disadvantage that the prospects are located far from timber. The greater number of the copper prospects are found in the Carboniferous basaltic amygdaloids, a relation which is also essentially true for those of the Chitina country. The geologic investigation of the region has established the fact that these volcanic rocks have a considerable distribution and underlie the greater part of the Wrangell Mountains. Much of this territory, however, is unfortunately not accessible on account of its numerous glaciers and extensive ice fields.

The main interest of the White-Nabesna region has centered in the occurrences of native copper. No phenomenal ore bodies have yet been discovered, but it has been shown that primary native copper occurs in the amygdules of zeolitic amygdaloids, a mode of occurrence unknown on the Chitina side of the Wrangell Mountains. This discovery is sufficiently encouraging to warrant further development, and it is to be hoped that the nature and extent of the deposit will soon be demonstrated.

From the descriptions given in the preceding pages it will be apparent that a lode-quartz region of some promise has been discovered in the Nutzotin Mountains, near the international boundary, and that as yet it has been but imperfectly explored by the prospector. It was shown that the intrusion of quartz diorite produced a number of contact-metamorphic bodies of copper sulphides, and the occurrence on Jacksina Creek suggests that the magma was also capable of effecting an auriferous mineralization. From the meager data at hand it is perhaps unsafe to venture on generalizations, yet it is probable that the quartz veins are genetically related to the intrusion of the post-Carboniferous quartz diorites and that, therefore, the intruded areas are those most likely to be mineral bearing. Such areas are known to occur throughout the Nutzotin Mountains at a number of localities, especially along the northeastern flanks. Brooks has mapped a large area of granular intrusive on the lower Nabesna. It is probable that in the vicinity of such masses the search for lode quartz may be prosecuted with the most hope of success.

THE FAIRBANKS GOLD PLACER REGION.

By L. M. PRINDLE and F. J. KATZ.

INTRODUCTORY STATEMENT.

The Fairbanks region, notwithstanding strikes of the miners in 1907 and an unusually dry summer in 1908, produced during the year approximately $9,200,000 in placer gold. The importance of the region and the demand for accurate maps by miners, prospectors, and others operating or having interests in the region led to the mapping of the most productive area by the Geological Survey in the field season of 1907. The results of this work were published in the summer of 1908 as the Fairbanks special map. The area covered by this map lies in about the central part of Alaska. It is about 35 miles long from northeast to southwest and 16 miles wide. Most of it lies diagonally between parallels 64° 45′ and 65° 10′ and meridians 147° and 148° 15′. The map is on a scale of 1 to 62,500, or about 1 mile to the inch, and has a contour interval of 25 feet. Topographic data, such as the shape of the surface and the drainage areas and grades of the streams, are thus clearly visualized and rendered available for utilization by miners and engineers.

This map was used as a base during the summer of 1908 for the work of a Survey party that was engaged in studying the geology and mining developments. The results of this work will be embodied in a report that is now in preparation. The present preliminary statement includes only those facts which seem most appropriate for emphasis at the present time. To illustrate this statement the accompanying geologic sketch map (Pl. VIII), including the area covered by the Fairbanks special map, has been prepared.

GEOGRAPHIC SKETCH.

RELIEF.

The surface of this area is predominantly one of ridges alternating with valleys of corresponding size, limited on the southwest by the northern edge of the Tanana Flats. The main ridges trend northeast and southwest, but this general trend is obscured somewhat by numerous bulky lateral spurs, trending in various directions, that add to the uniformity of altitude so characteristic of the region. The ridges are crowned locally by flattened domelike prominences of somewhat greater height, and the greatest altitude above sea level is approximately 2,700 feet. The main valleys also trend northeast and southwest and are occupied by southwestward-flowing streams whose waters ultimately reach Tanana River. The numerous lateral tributaries flow in diverse directions corresponding to those of the lateral spurs. The valleys exhibit a uniformity of depth below the level of the even-topped ridges, and the northern edge of the Tanana Flats is about 500 feet above sea level.

DRAINAGE.

The distribution of surface drainage is shown on the accompanying geologic sketch map (Pl. VIII). With the exception of Tanana and Chatanika rivers, most of the drainage of the area is of local origin and the supply of water is dependent on local climatic conditions. The creeks where mining is in progress are small, their drainage areas are of moderate extent, the perennially frozen character of much of the material gives but scant capacity for what little water might otherwise be stored in it, the deforestation as a result of mining and the removal of moss by fires diminish still further the storage capacity of the surface, and the quantity of water in the streams is brought through the interaction of all these factors into very close dependence on the rainfall.

The large number of unsluiced dumps of pay dirt that accumulated during the summer of 1908 bore testimony to the unfavorable effect on mining operations of such conditions. A quantitative discussion of the water supply will be found in the paper by Mr. Covert (pp. 201–228).

CLIMATE AND VEGETATION.

The climate of the region, that of north latitude 65°, has naturally influenced its economic development.

No temperature records for Fairbanks are available, but the temperature at Tanana, in about the same latitude, 120 miles farther west, for the period from August, 1901, to December, 1902, ranged from −76° F. in January to 79° F. in August. The winter of 1907–8 was unusually mild, and December temperatures in that period, according to report, ranged from −36° F. to 20° F., with an average for the month of −3.4° F. Two critical periods for the region are the times of closing and opening of navigation. The last boats from Fairbanks in 1906 for Dawson and St. Michael are reported to have left on September 24 and October 2, respectively; in 1907, on September 22 and October 2. The earliest and latest dates reported for the closing of navigation at Fairbanks for the years 1901 to 1907, inclusive, are October 14 and November 23; at Fort Gibbon, on the Yukon, for the same period of years, October 15 and November 9. The Yukon and Tanana break up at dates varying in different years from May 10 to May 15, and a few days later they are generally open to navigation.

The region being one of semiaridity, the snowfall is not excessive. The lakes and larger streams may freeze to a thickness of about 6 feet, but there is a considerable amount of water in circulation throughout the winter. Overflows are frequent and their repeated freezing, particularly in the smaller valleys, forms constantly accumulating deposits of ice known locally as "glaciers." Such overflows of the larger streams are a source of delay in travel, and such accumulations of ice in the headward portions of small valleys, where they may linger till late in summer, are a source of delay in mining. Under the operation of factors that are not clearly understood much of the superficial portion of the area is permanently frozen to depths that, so far as revealed by mining in the alluvial deposits, may exceed 300 feet. Differences in the material and in the position of the material with reference to drainage, however, have exerted a modifying action on the processes of freezing and there are considerable areas of deep deposits that are unfrozen.

The shortness of the summers is compensated by the length of the days. There are generally no killing frosts until about the first of September.

The mean annual precipitation, including both snow and rain, is not large. Observations taken at Tanana at intervals from 1882 to 1886 gave an annual average of 15.45 inches. The rainfall, therefore, although in some seasons more than sufficient for the needs of mining, is more likely to supply less than the amount required.

Vegetation increases in amount gradually toward the southern part of the region and is most abundant on the slopes adjacent to the Tanana. In this area there is a luxuriant growth of spruce, birch, and poplar on the valley slopes and lower ridges and of large spruce fringing the major streams and sloughs. A scrubby growth of small spruce with scattered larch covers the valley floors. The tops of the higher ridges throughout the region are covered only with a scanty growth of grass, moss, and low bushes. Inroads upon the fine growth of birch and spruce on the slopes of valleys where mining is in progress are resulting in a rapid deforestation of these slopes and the timber is being replaced by an abundant growth of grass and in places clumps of red-raspberry bushes. It has been demonstrated that vegetables can be grown successfully in this area. The lower slopes facing the Tanana Flats and adjacent portions of the flats are favorable for cultivation and such land is being taken up as ranches.

TRANSPORTATION.

The transportation of freight from points on the Pacific coast to the Fairbanks region is being accomplished as heretofore by way of Dawson and the upper Yukon and by way of St. Michael and the lower Yukon. Freight and passenger rates from Seattle remain about the same, averaging in 1908 about $75 a ton on ordinary supplies and for first-class passengers $125 to $140. Freight shipments to Fairbanks up to the close of navigation in 1908 approximated 15,000 tons. The supplies are brought by steamer to the towns of Chena and Fairbanks. The areas of greatest present importance are all within about 30 miles of these supply points, with which they are connected by wagon roads and the Tanana Valley Railway.

Through the agency of these means of transportation the high freight rates formerly prevalent on supplies from Fairbanks to the creeks, about 5 cents a pound in the winter and 25 cents a pound in the summer, have been reduced to a few cents a pound for summer freights to the most extreme points. Besides Fairbanks and Chena, which together have a population of several thousand, a number of small towns of a few hundred population each have developed on the creeks. The region has been in communication with the outside world by means of the government telegraph system for several years and during 1908 additional service was rendered available by the successful installation at Fairbanks of a wireless station operated by the Government.

GEOLOGIC SKETCH.

BED ROCK.

The Yukon-Tanana region lies in the intersectional area of the two dominant structural trends of Alaska—southeast - northwest and northeast-southwest—and includes a variety of formations possessing complicated structures. It has been a field of sedimentation, diastrophism, widespread metamorphism, abundant intrusion, and volcanic action. Mantling the products of all these processes are products of weathering and alluvium.

A formation composed predominantly of schists, mostly of sedimentary origin and regarded provisionally as pre-Ordovician, has a wide distribution throughout the central and eastern parts of the Yukon-Tanana region. Paleozoic rocks, including phyllites, limestone, etc., predominate in the western part of the region. The boundary line between these two groups extends northeast and southwest between Chatanika and Beaver rivers. The placers of the Birch Creek district, many of those of the Fortymile district, and those of greatest present importance in the Fairbanks district are located in areas occupied by rocks of the older group.

The rocks of this group, in the area covered by the Fairbanks special map, include rather massive quartzites, quartz-mica schists, carbonaceous schists, garnetiferous mica schists, lenticular bodies of crystalline limestone, and highly metamorphosed rocks derived partly, at least, from calcareous sediments. A few small bodies of granitic gneiss are present.

The most common types of rock are quartzitic and quartz-mica schists that occur in thin alternating beds. These schists form the predominant bed rock in the valleys where the placers are located and their varying resistance to the process of weathering results in alternating hard and soft bed rock that has an important influence on the distribution of the placer gold. The soft, decomposed bed rock is impermeable to placer gold, which may, on the other hand, sink to a depth of several feet along the cracks and crevices of the hard, blocky bed rock. The general structure has a northeast-southwest trend. Carbonaceous schists with associated calcareous beds, crystalline limestone, and hornblende schists are present, mostly in a zone extending northeast and southwest along the line of the Goldstream Valley. Garnetiferous altered calcareous rock occupies an interrupted zone along the northwest side of the main ridge and is there most common in lenticular masses in the schists of the upper parts of the valleys of Vault, Dome, Cleary, and Captain creeks. Chiastolite schists are limited to the northern portion of the area shown on the map, in the upper valleys of Captain and Alder creeks and the intervening ridges. A small patch of conglomerate and sandstone of comparatively recent date caps Fourth of July Hill, near the eastern limit of the area.

The region is one of close folding, and in some places the rocks have been folded so far upon themselves that the folds are in a recumbent position. The schists are jointed with two prominent sets nearly at right angles. Minor folding and crumpling are rather general, and there is a local development of cleavage and cleavage banding. Quartz veins are common, some of them having been folded with the schists and in places reduced to lenticular fragments and another system having crosscut the schists. Quartz veins up to 8 feet in thickness were observed. The schists and quartz veins have at many localities undergone intense brecciation and these brecciated zones have been recemented with quartz and ferruginous matter which has also penetrated the substance of the schists.

Igneous rocks have played an important part in the geologic history of the Yukon-Tanana region. These rocks are usually distinguishable from the rocks of sedimentary origin with which they are associated, and betray in the characteristics that render them distinguishable the different process to which they owe their origin. Differences in the composition of molten material have resulted in rocks of widely varying mineral composition. Differences also in the conditions under which consolidation has taken place cause great differences in the resultant products. Material that has been intruded into other rocks in a molten condition at great depths below the contemporaneous surface of the earth and has gradually consolidated there forms ultimately a completely crystalline rock which is entirely different in appearance, though having nearly the same composition, from the rock formed of the same kind of material that has been poured out over the surface of the earth as lava and then subjected to rapid cooling. Through the processes of metamorphism to which all rocks are subject the igneous rocks of deep-seated origin and those poured out at the surface may depart far in composition and structure from the original rock. The Yukon-Tanana region contains representatives of three different groups of igneous rocks—intrusive rocks of various kinds formed at various depths below the surface, extrusive rocks formed from igneous material that has welled out upon the surface, and metamorphic igneous rocks formed by the alteration of either of the other groups through the processes of metamorphism.

Igneous rocks may have a far-reaching influence in fracturing and altering the rocks into which they have come and introducing into them many products not originally present, among which are ores of metals or metals themselves. Igneous rocks are common in all the gold-placer areas of the Yukon-Tanana region, and the available evidence points to them as being, indirectly at least, the cause of the gold occurrences from which the placers have been derived. The distribution of igneous rocks, their delimitation from the sedimentary rocks, and detailed information as to their mode of origin and the part they have taken in the geologic history of the region are therefore of prime importance to those interested in mining. For these reasons the main areas of igneous rocks in the Fairbanks district have been roughly outlined on the accompanying sketch map (Pl. VIII). It is noticeable from the map that although there are no very large bodies of these rocks and they occupy but a small part of the total area they nevertheless have a wide distribution throughout the district and occur somewhere in all the valleys where productive placers have been found.

Most of the igneous rocks of the Fairbanks district are unmetamorphosed intrusives of the granodioritic group; they comprise quartz diorite, porphyritic biotite granite, and persilicic rocks. There are a few small areas of granite gneiss. Fresh basalt is found on Fourth of July Hill, where it occurs most probably as a small flow, and it is present also in the lower valley of Alder Creek. A few small, inconspicuous basic dikes occur in the district. The quartz diorite forms the main mass of Pedro Dome. It has intruded the schists, and in the surrounding area there are small dikes derived from the same magma. Small inclusions of quartzite schist are to be found in the marginal area of this rock, particularly on the northwest side of Pedro Dome. The quartz diorite shows but little alteration or mineralization, and the contact effect seems to have been limited to a slight alteration of the schists, expressed principally by the development of biotite.

Porphyritic biotite granite is more abundant than the quartz diorite and forms the largest intrusive mass in the district—that of the ridge between Gilmore and Smallwood creeks. A considerable mass of it occurs also on Twin Creek, in close relation with the quartz diorite of Pedro Dome, which is intruded by related dikes. There are numerous persilicic dikes throughout the district, and these seem on superficial study to be referable to the same magma. The biotite granite is in places heavily mineralized with iron pyrites, which is in some localities distributed along the joint planes of the granite and in others embedded in the mass of the granite itself and surrounded by rusty areas due to the alteration of the pyrites. Small rusty dikes so heavily charged with ferruginous matter that their original character is obscured are of common occurrence throughout the district. They are generally covered by a thick mantle of moss and muck, and their presence in a valley may be revealed only by a small proportion of this material in the heaps of tailings from the placers. One of the largest areas of these highly altered rocks is on the west side of Pedro Dome at the head of Dome Creek; here practically the only original mineral that has escaped alteration is quartz, whose distribution in the rock shows an original graphic relation to feldspar. The altered granitic dikes at this locality, as well as the schists in which they are found and the quartz veins in the schists, have been brecciated and impregnated with secondary quartz and ferruginous matter. In the narrow belt of schists separating the quartz diorite of Pedro Dome from the porphyritic biotite granite of Twin Creek auriferous quartz veins have been found along joint planes, and it seems highly probable that the intrusion of the granitic rocks has been accompanied or followed by the deposition of gold in the surrounding schists.

The extent of mineralization in the Fairbanks region is shown also by the common presence of stibnite (antimony sulphide), either intimately associated with granitic dikes in the schist, as at the head of Cleary Creek, or in quartz veins in the schist, as in the ridge at the head of Ready Bullion Creek, a tributary of Ester Creek. On Chatham Creek gold has been found in a quartz vein with stibnite, zinc blende (zinc sulphide), and iron pyrites.

Native bismuth has been found locally in the gravels, and some pieces are intergrown with gold. Concentrates from the placers are still under investigation and have been found to contain galena, arsenopyrite, wolframite, and cassiterite. Cassiterite is of rather common occurrence in the concentrates, notably in those from Cleary, Twin, and Eldorado creeks.

Neither the age of intrusion nor that of mineralization is known. The nearest similar intrusive rocks whose age is rather definitely determined are those of the Rampart region, 80 miles to the northwest, where Upper Cretaceous rocks have been intruded. The unaltered intrusives of the Fairbanks region may have been intruded at the same time as those of the Rampart region.

The greatest part of the auriferous material has probably been deposited subsequent to most of the intrusive masses, and the deposition may have accompanied an extensive shattering of the schists and a part of the intrusive rocks. This shattering would have furnished abundant avenues for widespread distribution through the schists of the materials resulting from intrusion.

Many of the nuggets found in the placers have quartz attached, and it seems probable, from the general occurrence of placer gold and the manner of its distribution in the valleys and from the fact that it has been found in place in quartz veins in the schist, either alone or in combination with sulphides, that the greatest part of the gold in the placers has been derived from quartz veins in the schists.

Although the distribution of gold is rather general, the fact that it is found on certain creeks while others in the immediate vicinity have up to the present time proved unproductive shows a localization of its occurrence. Moreover, although it has apparently been rather widely distributed in the bed rock of the valleys that have proved productive, as shown by the fact that gold can be detected so generally on the valley slopes, recent work of prospectors indicates that even in such valleys there has been a concentration of gold in the bed rock within narrow limits. If there are any localities in the area where the concentration of gold in the bed rock has been carried so far as to produce bodies of auriferous quartz of economic value such localities are most probably to be found in the vicinity of the igneous intrusives, especially in those valleys which have yielded placer gold.

During the later part of the season of 1908 there was considerable interest in quartz prospecting in this region, and auriferous quartz had been found in place at several localities. Surface material was taken for assay at many localities other than those where gold has been found in place in the quartz veins in such form as to be visible to the eye, and while the greatest part of the material assayed was found to contain only negligible quantities of gold the specimens from a few localities showed amounts of gold which, although small—$11.02, $1.24, and 83 cents to the ton being the highest—were yet sufficient to indicate a rather widespread mineralization. It may be stated in this preliminary discussion that the assays reaffirm the close association of gold and stibnite observable at some localities in hand specimens.

UNCONSOLIDATED DEPOSITS.

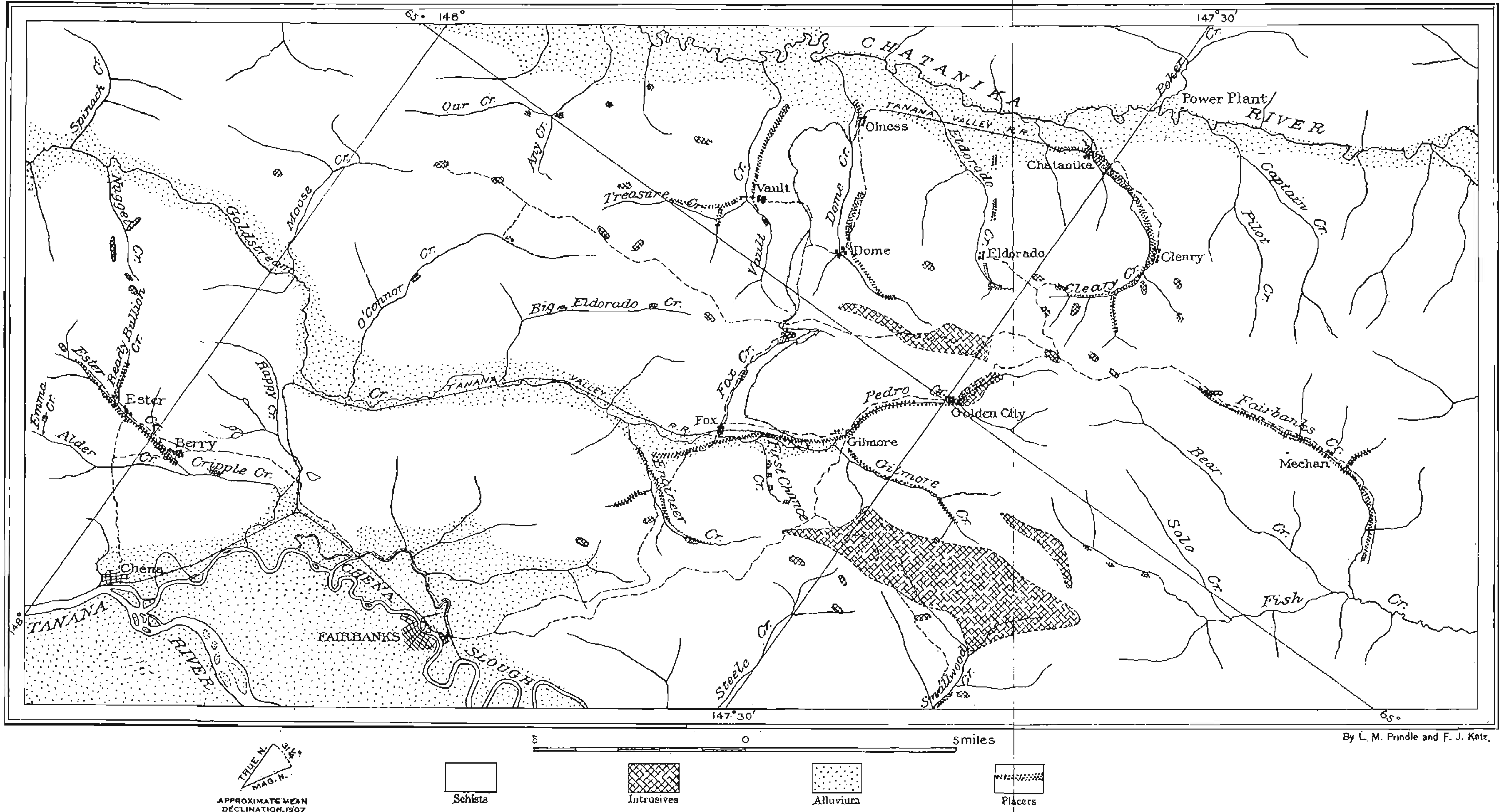
The bed rock of this region is for the most part covered with a deep mantle of residual and transported material. The evidence available indicates that this material has been deposited in an area where glaciation was absent under conditions predominantly fluviatile. The noteworthy characteristics of these deposits are their thickness and their consolidation by ice. The maximum thickness that has been revealed by mining operations is over 300 feet, and, so far as known, the greatest depth to which the ground may be found frozen has not yet been reached. Although most of the ground is frozen, in some localities unfrozen ground and circulating waters complicate the mining problem. The unconsolidated material includes slide rock, muck, sand, silt, clay, barren gravels, and the gravels in which the gold is found. These deposits are generally separable, in the vertical section from surface to bed rock, into three divisions, designated by the miners muck, barren gravels, and pay gravels or pay dirt. The term "muck" has been applied by the miners to all the fine material overlying the main body of gravels, with a thickness up to 100 feet, and it includes not only material derived from the decomposition of vegetation, but also clay and sand that occur either intimately mixed with the organic matter or in beds and lenticular masses. There are also intercalated beds of ice up to 40 feet in thickness.

Where the productive gravels are more or less continuous in a valley they form the "pay streak" of the miners. So far as has been determined the position of the productive gravels in the vertical section of the unconsolidated deposits is almost without exception next to bed rock. They include from a few inches to 6 or 8 feet of gravel and clay and a foot, or in some places several feet, of bed rock where this is of a blocky character. The gravels are composed predominantly of schist fragments, generally subangular, and the proportion of bowlders is small. The productive gravels as a rule contain a considerable proportion of fine material, termed by the miners "sediment," made up of minute rock fragments, quartz and other minerals resistant to alteration, and much clay derived from rock decomposition. There is in some places a sharp line of demarcation between these sediment-containing gravels and those above them, and this is further emphasized by difference in color. In other localities these gravels grade imperceptibly upward into gravels free from sediment. The productive gravels, under present costs, are mined to an average width for the entire region of about 200 feet, but in exceptional cases the width of gravel mined is much greater. The value of the gold recovered from the ground that is being mined ranges from less than $1 to $8 or more to the square foot of bed-rock surface. The average value, as estimated from a preliminary study of the available data, is about $1.25 to the square foot of bed rock, or about $5.25 to the cubic yard of pay gravels. Some of the gold is coarse and nuggets worth over $500 have been found; most of it, however, occurs in small flattish pieces. Assay values ranging from about $16 to more than $19 per ounce have been reported. The most common mineral associates of the gold are garnet, black sand, and rutile.

The total length of ground along which productive areas are scattered at the present time is approximately 75 miles, and the proportion of this distance where the depth to bed rock is less than 40 feet is probably not more than 20 per cent. The areas that have been productive of placer gold are indicated on Plate VIII. The valleys that have proved most productive during 1908 are those of Ester, Dome, Vault, Cleary (with the adjacent portion of the Chatanika Valley), Goldstream, Pedro, Engineer, and Fairbanks creeks. During the fall of 1908 promising discoveries were being made in the lower part of the Eldorado Valley and on the Chatanika Flats.

The valleys are narrowly V-shaped at the heads and gradually open out, the valley floors widening from 100 or 200 feet near the head to half a mile or more in the largest valleys. The grades range from 150 feet to the mile near the heads of the valleys to 25 feet to the mile in the wide, flat portions. The cross sections of the valleys are as a rule unsymmetrical, one side being steep and the other a gradual slope that merges into the base of the ridge slopes. The bed-rock surface on which the alluvial deposits have been laid down is in many places flatter than the present surface of the valleys. The course of the streams is generally close to the steeper slope. The location of the productive gravels is only in part coincident with that of the present streams. In many valleys they occupy a position far back from the stream on the side of the gradual slope and rest on a bed-rock surface at about the same level as the bed rock underlying the present stream bed.

The following tabular statement summarizes the entire thickness of the unconsolidated deposits, the thickness of the muck, and the width of the valley floors in the productive valleys:



GEOLOGIC MAP OF FAIRBANKS DISTRICT.

Depth to bed rock, thickness of muck, and width of valley floor at claims in Fairbanks region.

Claim.	Depth to bed rock.	Thickness of muck.	Width of valley floor.
Cleary Creek:	*Feet.*	*Feet.*	*Feet.*
8 above	35-65	16-40	300
3 above	52	40	450
Discovery	14-20	......	800
6 below	68-90	20-55	1,200
10 below	65	20	1,000
12 below	71-85	......	1,200
15 below	40-100	18-20	2,000+
18 below	125	10	......
Chatanika Flats:			
1 above	75	......	......
Discovery	80-125	18-25	......
Hope	65	40	......
Stier	105	72	......
Eldorado Creek:			
7 above	87	62	600
3 above	140	125	1,200
3 below	135	59	1,200
6 below	160	80	1,500
Idaho group	122	46	......
Dome Creek:			
6 above	50	27	400
3 above	100	60-70	600
Discovery	140-150	90	1,200
3 below	175	65-70	1,500
6 below	198	160	2,000
14 below	150	90	2,300
16 below	160	30	4,000+
20 below	175-180	15-20	......
Vault Creek:			
9 above	65	55	200
Hard Luck group	200	165	700
Isabella group	150	60	1,800
Victor group	175	90	1,800
Oregon group	180	150	2,000
Sierra group	202	102	3,000+
Treasure Creek:			
6 above	100	80	300
Tonaskate group	110	90	1,300
Do	171	164	1,600
Victoria group	200	135	1,500
Do	140	100	1,200
Our Creek:			
Georgia group	120	54	400
Junction of Any Creek	61	......	......
Washington group	75	58	......
Fairbanks Creek:			
9 above	12	3	300
6 above	15	3	350
3 above	18	4	400
Discovery	18	4	400
3 below	21	5	450
6 below	20	5	500
9 below	57-168	12-53	1,000
12 below	110	80-90	1,100
15 below	100	50	1,200
Fish Creek:			
10 above	25	15	500
4 above	24	12	800
Smallwood Creek:			
3 below	100	17	600
4 below	135	25	700
5 below	140	40	800
Goldstream:			
Discovery	45	33	1,000
4 below	33	......	1,200
8 below	22	9	1,400
12 below	51	......	2,500
16 below	80	55	3,000
21 below	70	......	3,000
Engineer Creek:			
Engineer Bench	103	78	1,000
Owl group	70-95	55-70	2,000
2 above	55-60	35	......
Discovery	50	15-25	......
Big Eldorado Creek:			
5 above	54	20	......
6 below	98	38	......
Fox Creek:			
11 above 10 above	10-19	3-11	300

Depth to bed rock, thickness of muck, and width of valley floor at claims in Fairbanks region—Continued.

Claim.	Depth to bed rock.	Thickness of muck.	Width of valley floor.
	Feet.	*Feet.*	*Feet.*
Pedro Creek:			
2 above	12	....	400
2 below	22-35	....	800
6 below	9	4	900
10 below	15	8	1,000
Twin Creek:			
2 above	8	4	250
Gilmore Creek:			
4 below Upper Discovery	4-8	....	400
8 above Lower Discovery	8	5	400
Lower Discovery	15-18	10	800
Ester Creek:			
7 above	20	6	150
6 above	22	7	250
4 above	20	12	350
2 above	34	14	350
Discovery	85	50	600
4 below	100	55	800
8 below	95	50	1,200

MINING DEVELOPMENT.

PRELIMINARY STATEMENT.

The mining operations in this region will not be described in detail in the present paper, but the development in mining methods which has taken place since the last report on the region [a] will be briefly summarized.

During the summer season of 1908 about 300 mining plants were in operation on the placers of the Fairbanks district, 85 per cent of these being used in drift mining and the remainder in various methods of open-cut work. Mining practice in this district has been determined largely by the great depths of the placer ground and operations have been facilitated by improvements in transportation from the supply towns, Fairbanks and Chena, to the producing creeks. The Tanana Valley Railway, a narrow-gage road about 50 miles long, was, in 1907, finished to Chatanika, at the mouth of Cleary Creek, and wagon-road improvement and construction had so far advanced by the close of the season of 1908 that large and heavy loads could be conveniently laid down at the workings on all the creeks of present importance except Treasure Creek, the lower few miles of Vault Creek, and Eldorado Creek. A large portion of the road building was made possible by the voluntary and substantial cooperation of the Fairbanks citizens with the Alaska road commission. The resulting system of public roads is highly creditable to so young a community. The development has been furthered also by the establishment in Fairbanks of foundries and machine shops, excellently equipped and

[a] Prindle, L. M., The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska: Bull. U. S. Geol. Survey, No. 337, 1908. See also Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905.

under the direction of clever mechanics and foresighted business men. Much machinery that is especially adapted to the mining conditions of the district has been devised and entirely constructed in these local shops.

PROSPECTING.

The prospector, as a rule, still heavily taxes his funds and energies in sinking shafts to bed rock. A great advance over the hand-windlass method, which is barely practicable on ground approaching 200 feet in depth, is offered by an outfit now furnished in Fairbanks, consisting of a 4-horsepower boiler, hoisting engine, automatic self-dumping carrier and bucket, cable, pipe, steam points and fittings, etc., at a cost of about $600. This equipment is compact and light enough to be transported by dog team. The prospector is in the main still unable to cope with live water in his shaft. The method of prospecting by drilling promises, however, to increase in favor. A small-sized modification of the well-known churn drill was designed and built in Fairbanks to be supplied, with complete equipment, to prospectors for approximately $1,600. This machine is readily transportable and thus overcomes the chief obstacle to the use of the larger drills.

OPEN-CUT MINING.

Forty open-cut plants in actual operation were visited during the course of the present investigation. Of these, nine were working without mechanical or hydraulic equipment, on Pedro and Fox creeks. Hoisting by steam power appears to be the favorite method of handling gravels in open cuts, 23 such plants being in operation.

The cuts are generally opened by cutting off the vegetation and ground sluicing the muck and barren gravels in the spring or late fall. Occasionally, as on Discovery claim, Cleary Creek, steam scrapers are used for stripping; on "No. 5 below," Pedro Creek, horse plows and scrapers are used. In ground sluicing, the overburden is washed into a previously worked-out cut; in scraping, the material is carried to a waste pile. For draining the pits, bed-rock drains, pulsometers, centrifugal pumps, and ram pumps are in use, and on two claims China pumps were seen. On Pedro Creek, where most of the open-cut work is done, bed-rock drains are preferred when any considerable amount of water is to be removed. Cuts are opened on the lower end of the block of ground, claim, or series of claims to be mined, and are carried upstream as the work progresses, thus facilitating drainage and waste disposal. Artificial thawing is usually not necessary when stripping is far enough in advance of the handling of the auriferous gravels. At one plant, however, steam points were set vertically and 6 feet apart. On a few claims gravels are handled by hand shoveling from the cut directly to the sluice boxes, or are carried short distances in wheelbarrows to the sluice boxes. Much more commonly, however, the gravels are hoisted by steam power in buckets on self-dumping carriers. One such plant, using two buckets dumping to the same sluice box, had a capacity of nearly 1,000 square feet of bed-rock surface in twenty-four hours. The use of derricks and rock pumps has been abandoned in this district. The method of handling gravels with steam scrapers was employed with marked success on three claims during 1908. Where bed rock is not too hard, is not deeply creviced, and is not broken into heavy blocks this is probably the most advantageous system for open-cut mining. The auriferous gravels are scraped directly to the sluice boxes, where the scraper automatically trips and dumps itself. Where the gravels and bed rock are too firm to be scraped they are loosened up by a grading plow rigged in place of the scraper. Plowing was done at night on the one claim where it was found necessary. Plants thus equipped can handle as much as 135 cubic yards of pay gravels a day, employing 5 or 6 men—the equivalent of the duty of 15 to 20 men working with pick, shovel, and wheelbarrow. The greatest depth worked by open-cut methods is 20 feet, on "No. 7 above," Fairbanks Creek. This is in ground whose rich portions had been drifted out.

The cost of open-cut mining is materially less than that of drift mining. Even where work is exceptionally hindered by heavy, blocky, deeply creviced bed rock, rather thick overburden, and the necessity of artificial thawing, open-cut work costs no more than drifting. Operating expenses are reported on various claims to be 25, 28, 32, and 60 cents, and exceptionally $1, to the square foot of bed rock cleaned.

Conditions in the Fairbanks district are unfavorable for hydraulic mining. Only five hydraulic operations were seen. On First Chance Creek two small plants working with a scanty water supply under low head were practically ground sluicing into boxes set in bed-rock cuts. On Gilmore Creek, at the junction of Tom Creek, a small outfit was working with a monitor on the point between the creeks, where about a sluice head of water was available under a pressure of 45 feet. On Twin Creek a more efficient plant was installed during 1908, ditches, pipe line, and bed-rock cut being made ready for work in 1909.

DRIFT MINING.

The methods of drift mining have materially improved, with the result that plants are larger, capacity and efficiency are increased, and values are extracted from ground formerly regarded as unprofitable. During the last season not more than 20 outfits engaged in drift mining were equipped only with a hand-windlass hoist, and several of these outfits were either just opening ground or were taking out "pillars" left in the course of larger operations. Nearly all the productive mining is done with large steam-power plants averaging about 40 boiler horsepower. The usual mine equipment comprises boiler, hoist, steel bucket, automatic carrier, trolley cables, poles, blocks, etc., a small ram pump, steam points with pipe hose and fittings, and blacksmith's, carpenter's, steam fitter's, and machinist's outfit and tools. Such an equipment costs about $7,000. To it must be added the gold-washing apparatus, consisting generally of a dump box and string of sluice boxes on a light trestle 10 or 15 feet high and a ditch or flume for bringing water to the plant. Each plant is also generally provided with housing and mess for 15 or more men. The initial investment further includes the cost of transportation to the claim and installation of the plant, together with that of sinking a working shaft and blocking out the ground by prospect tunnels. The total first cost to the operator of a modern drift-mining plant amounts to about $12,000. This sum is in some plants further increased by the installation of a pumping plant for sluicing (about $1,000), and of an underground car system (about $1,000). Where the latter is used there is usually a corresponding increase in size and cost of boiler and hoist capacity.

The average plant of this description employing 15 men will hoist about 80 cubic yards of pay streak or clean about 360 square feet of bed rock to the shift of ten hours. Several plants on Ester, Vault, Dome, Cleary, and Goldstream creeks have twice and some even three times that capacity. It is common practice in the larger plants to hoist from two shafts simultaneously, dumping to one string of sluice boxes erected between the two holes. One such plant on Ester Creek employed 45 men in two ten-hour shifts daily and could hoist 270 cubic yards (the equivalent of about 1,250 square feet on bed-rock surface) a day.

The operating expense of these plants is estimated by the operators at 50 cents to $1 for every square foot of bed rock mined. It would be difficult to strike a fair average, as conditions vary greatly, even from claim to claim on the same creek. Chief among the factors affecting the operating expenses are the character of the bed rock and the readiness with which the ground thaws and can be handled with pick and shovel—conditions which affect the duty per man per day—and the amount of live water in the ground.

Working shafts range in depth from 20 to 260 feet in this district, the more common depths being from 100 to 180 feet. The usual cross section is square, 6 by 6 feet in the clear, though many of the small operations in shallow ground use smaller shafts, and some of the larger plants in deep ground hoist through 7 by 7 feet openings. The cost of sinking and timbering a shaft 7 feet square in the clear is about $15 a foot. Shafts are cribbed with 4 to 6 inch spruce poles, dovetailed at the corners and chinked with moss, and a filling of gravel and moss is put in behind the cribbing. Heavy upright spruce posts are used as underpinning at the bottoms of the shafts. A small chamber is usually excavated and timbered at one side of the shaft and in it a pump is set up over a sump. Main tunnels, or runways, are driven upstream and downstream from the shaft along the pay streak. These runways are timbered with square sets of native spruce and lagged overhead and on the sides with spruce poles, the side lagging being carried from the ceiling preferably only halfway down the sides. The pay streak is crosscut at the ends of the tunnel, and sometimes also at a few places between the shaft and the ends of the main tunnel. In this way the ground is prospected and blocked out. From these end crosscuts the ground is breasted out, a face being worked back from each end toward the shaft. Where the distance from face to shaft does not much exceed 125 feet the shovelers carry the gravels in wheelbarrows to the shaft, where the bucket is lowered into a sump so that its rim is flush with the floor. Greater wheeling distances cut down the capacity, so that it becomes economical to install dump cars on rails in the tunnels. Some operators run the cars direct to the face; others wheel from the face to a platform at the end of the tunnel and there dump into cars. The face is carried back rapidly, so that there is usually no danger from caving of the unsupported roof. In unusually favorable ground, chambers 200 feet in diameter can be excavated without timbering. Sometimes unthawed pillars are left as supports, to be "pulled" as the face is carried far enough back, or cribs of birch poles filled with waste gravels and bowlders are built.

Thawing is done with steam points. The use of wood fires and of hot-water hydraulicking has been abandoned in the Fairbanks district. Points of 7, 8, 10, 12, and 16 feet length are used, and exceptionally 20-foot points in driving tunnels. Local manufacturers have designed and patented an improved connection for the steam supply hose and an implement to facilitate the "pulling" of the points after thawing. In the drifts the points are driven at about bed-rock surface and usually from 2½ to 3 feet apart, depending on the amount of moisture in the gravel, a factor that governs also the time required for a thaw—eight to forty hours. The usual duty of a steam point is to thaw about 3 to 3½ cubic yards. Water from the sump, heated by the exhaust from the pump, is forced through the points while they are being driven. Then dry steam at a pressure of about 25 pounds at the point is admitted. Where many points are set in a long face, it is a growing practice to withdraw the points after driving and replace them with light iron pipes termed "sweaters." Skillful operators carefully plug the holes around the points or sweaters with cotton waste or sand and always try to allow the ground to cool after thawing before they remove it, in order that the air in the drifts and tunnels may remain cold and dry and that in consequence the roof and walls of the working may not thaw and "slough," causing inconvenience and extra handling of waste. For this reason thawing and excavating are done on alternate days in the drift on each side of the shaft.

In some of the deeper workings it is difficult to maintain drainage and keep clearance for cars in the tunnels because the floors rise as the pressure on them is relieved by the removal of the gravel, 12-inch to 15-inch spruce timbers being bent inward and broken. This trouble is known as "swelling ground." It is mitigated somewhat by omitting the lagging from the lower half of the tunnel walls, thus relieving side pressure on the timbers. However, the difficulty can not be entirely avoided, and it is necessary to watch the timbers closely, replacing them when they show signs of failing. Fortunately, the timbers bend and break slowly and no sudden failures have been experienced. Trouble with the shaft cribbing is due primarily to thawing around the shaft and can be minimized only by careful packing of the steam supply pipes and the prevention of steam leakage in the workings.

The length of time tunnels and shaft will remain in working condition—that is, the ability of the ground to stand up—governs the size of the block of ground worked with one "set up" of the plant. The utmost limit thus far reached by the larger plants is about 700 feet along the pay streak worked from one shaft. Commonly 500 feet is the length of pay streak leased to individual operators.

Drift mining has recently been extended to the working of unfrozen ground containing live water on Ester Creek, with some promise of success. The cost of pumping is offset by the facts that the water so raised is used for sluicing and that thawing is mostly or entirely obviated. On one claim the shaft was sunk in frozen ground, the main tunnel was driven on the lower side of the pay streak, and the pay streak was crosscut at short intervals and on the upper side was to be drained by a drainage tunnel parallel with the main tunnel A sump 5 by 7 by 9 feet in bed rock collected the water and two 3-inch pumps raised it over 100 feet to the surface. The operating expense of the plant was about $2 a square foot of bed rock, or twice the average cost in frozen ground.

In the recovery of gold from the gravels there has been no essential advance in the Fairbanks district. The miners have so far not considered it necessary to save a larger proportion of the gold than has been possible by the methods hitherto in use. With a few exceptions all the operators use nothing but a string of sluice boxes with riffles of rough peeled spruce poles. The head box into which the gravel is dumped (hence called the "dump box") is longer, broader, and deeper than the other boxes and provided with pole riffles. One man is stationed on the dump box, armed with a fork with which he removes large bowlders and pieces of bed rock, and thus keeps the gravel running freely through the boxes. At a few plants dressed poles with iron straps on the upper surface were seen in use, and on one claim an undercurrent was used which, though crudely constructed, was doing good service in saving fine gold. The 12-foot boxes are given a grade of 9 to 12 inches.

It is hardly necessary to point out the inefficiency of the gold-saving devices at present in use in comparison with the machinery employed on modern dredges. At plants of large capacity otherwise expensively equipped, the additional expense of gold-saving machinery would not be prohibitive and would probably be entirely offset by the saving of the expense involved in the maintenance of strings of sluice boxes and by the larger returns resulting from more thorough handling of the tailings and increased recovery of gold. Gold-saving machinery is especially to be commended for this region, where fine sticky sediment is abundant in the auriferous gravels and where the water is scanty in amount and, through repeated use, frequently overloaded with sediment.

When gravels are hoisted and piled in dumps in the winter or during droughts, the practice of carefully clearing shrubbery, moss, etc., from the ground and of setting strings of boxes under the dump in shallow cuts in the ground wherever feasible should be more widely adopted. By this procedure the bottom of the dump can be easily and completely taken up and the boxes will still hold their alignment and grade.

The hydraulicking of dumps into sluice boxes set beneath, by means of a pulsometer or centrifugal pump delivering water under pressure to a nozzle, has been successful and economical on several claims.

FUEL AND POWER.

Wood is still the only fuel and source of power of this district. Near the towns and mines the hills are consequently being rapidly stripped of their birch and spruce groves, so that the price is likely to rise with the distance fuel has to be hauled. In 1908 the average cost per cord delivered on the ground was $10. Not only is the fuel supply of Cleary Valley and nearly all of that in Dome and Ester and parts of other valleys almost exhausted, but through forest fires the covering of underbrush and moss also is being rapidly destroyed.

The power station in operation at the mouth of Poker Creek was designed as a hydro-electric plant, but on account of the insufficient water supply it is being run part of the time by steam power with wood fuel. Ten or twelve plants on Dome and Cleary creeks use power from this station for driving pumps and lighting. It has been suggested in a previous report[a] that the coals south of the Tanana might be used for the development of electric power for the Fairbanks district.

COSTS.

The data at hand on the cost of mining in the Fairbanks district are not as abundant as could be desired, but the following statements are believed to be warranted and conservative. The lower limit of the operating expense of drift mining under the usual present conditions is about 75 cents a square foot of bed rock, or about $3.50 a cubic yard of pay gravels; for open-cut mining, by means of steam scrapers, about 25 cents a square foot of bed rock, or about $1 to the cubic yard of pay gravels.

The common practice of the operators in the district is to lease from the owners portions of claims in blocks 500 to 1,000 feet in length measured along the pay streak, or from 50,000 to 200,000 square feet of workable ground. Individual 20-acre claims 1,000 to 1,320 feet long are usually worked by two and sometimes by three independent plants, and on group claims of 160 acres, extending 1 mile along the pay streak, as many as eight leases have been let. Over 65 per cent of all the 1908 operations were on leases or "lays," the lessees or "laymen" paying royalties of 20 to 50 per cent of the gross production. On a "lay" of 200,000 square feet of workable drifting ground the operator would expend about $175,000 on plant, installation, blocking out ground, and extracting the auriferous gravels, so that a gold content of $1 to the square foot, the lowest limit of value of drifting ground under the conditions prevailing in 1908, would just permit him to pay his royalties. Wages in 1908 were $5 a day and board, and the usual length of a shift ten hours, but a small number of operators were paying $5 for eight hours, or $6 for ten hours.

LENGTH OF WORKING SEASON.

The weather at best permits ordinary sluicing from about the last week in April until the middle of September—at the most, 150 days. Open-cut operators can not get in as many days as this unless they adopt artificial methods of thawing during the early part of the season. Drift mining can, of course, be conducted continuously through the year. An attempt at winter sluicing was made in 1907–8 on Ester Creek, where a sluice head of water was running all winter. This water was warmed by the exhaust from the hoisting and pumping engines and pumped to the sluice boxes. Sluicing was continued into

[a] Prindle, L. M., The Bonnifield and Kantishna regions: Bull. U. S. Geol. Survey, No. 314, 1906, p. 226.

January. That this experiment was satisfactory is indicated by the fact that several operators were preparing for winter sluicing during 1909.

PRODUCTION.

The total and annual production of gold from the Fairbanks district for the years 1903 to 1908, inclusive, is approximately as given in the following table:

Production of gold from Fairbanks district.

1903	$40,000
1904	600,000
1905	4,000,000
1906	9,000,000
1907	8,000,000
1908	9,200,000
	30,840,000

WATER SUPPLY OF THE YUKON-TANANA REGION, 1907–1908.

By C. C. Covert and C. E. Ellsworth.

INTRODUCTION.

It is the purpose of this report to summarize the water-supply investigations of the Yukon-Tanana region during 1907 and 1908. The work in this region was started in 1907,[a] when streams in the Fairbanks district were gaged and general conditions affecting the water supply and its development were considered, the investigations covering a field season from June 20 to September 15. In March, 1908, in order to procure data concerning the spring break-up, C. C. Covert, of the Geological Survey, went to the field of operations and made such preparations as seemed practical for collecting data regarding the high-water flow. Records were kept in three drainage basins—those of Chatanika River, Little Chena River, and Washington Creek. In June the engineer in charge was joined by C. E. Ellsworth as assistant engineer, one field assistant, a cook, and a packer, with four pack horses, and the work was extended to the Circle and Rampart districts.

The records of 1908 covered the period from May 1 to October 21 and an area of about 4,200 square miles. The work was continued along lines similar to that of 1907. A few regular stations were established at convenient points in the different drainage basins, and daily records were kept at these stations, miscellaneous measurements being made in the surrounding country. This plan afforded the best opportunities for procuring comparative data. In this country, without storage, daily records are an important factor in determining the amount of water available, and it is difficult to obtain such records over an extended area. Outside of the gold-producing creeks the country is practically a wilderness, where it is almost impossible to get observations other than those made on the occasional visits of the engineer. In such localities no daily or even weekly records could have been assured, and the results obtained from occasional

[a] Henshaw, F. F., and Covert, C. C., Water-supply investigations in Alaska, 1906–1907: Water-Supply Paper, U. S. Geol. Survey, No. 218, 1908.

measurements furnish no comprehensive idea of the actual daily run-off of the stream throughout the open season.

Among the many who rendered valuable assistance in procuring the data given in the accompanying tables, acknowledgment is due to Mr. John Zug, superintendent of the Alaska roads commission; Mr. C. W. McConaughy, chief engineer of the Chatanika Ditch Company; Mr. Falcon Joslin, president of the Tanana Valley Railroad Company; Mr. Herman Wobber, Fairbanks Creek; Mr. Martin Harrais, of the Chena Lumber and Light Company, Chena; Mr. W. H. Parsons, general manager of the Washington-Alaska Bank; Mr. Frank G. Manley, Baker Hot Springs; Mr. A. V. Thorns, general manager of the Manley mines; Mr. M. E. Koonce, Rampart; and numerous miners who are personally interested in the work.

GAGING STATIONS.

Discharge measurements were made in 1907 at 45 points in the Fairbanks district, and in 1908 at 39 in the Fairbanks district, 33 in the Circle district, and 56 in the Rampart district. These gaging stations are given in the following lists:

Gaging stations in Fairbanks district, 1907–8.

Little Chena River above Elliott Creek.
Elliott Creek above Sorrels Creek.
Sorrels Creek near mouth.
Fish Creek above Fairbanks Creek.
Bear Creek below Tecumseh Creek.
Fairbanks Creek.
Miller Creek near mouth.
Miller Creek below Heim Creek.
Miller Creek above Heim Creek.
Charity Creek 1 mile above Hope Creek.
Hope Creek near Zephyr Creek.
Faith Creek near mouth.
McManus Creek above Montana Creek.
McManus Creek below Montana Creek.
McManus Creek 1 mile below Idaho Creek.
McManus Creek 500 feet above Smith Creek.
McManus Creek below Smith Creek.
McManus Creek at mouth.
Smith Creek below Pool Creek.
Smith Creek above Pool Creek.
Pool Creek at mouth.
McManus Creek near mouth.
Chatanika River near Faith Creek.
Boston Creek at elevation 800 feet.
McKay Creek at elevation 800 feet.
Belle Creek at elevation 800 feet.
Crooked Creek near mouth.
Kokomo Creek near mouth.

Poker Creek near mouth.
Poker Creek near elevation 800 feet.
Little Poker Creek at mouth.
Caribou Creek above Little Poker Creek.
Chatanika River below Poker Creek.
Cleary Creek near Cleary.
Eldorado Creek above trail to Dome Creek.
Dome Creek near Dome.
Goldstream Creek near Claim "No. 6 below."
Fox Creek near elevation 900 feet.
Beaver Creek above East Branch.
East Branch of Beaver Creek near mouth.
Nome Creek near mouth.
Bryan Creek at elevation 1,800 feet.
Trail Creek about 4 miles above mouth.
Brigham Creek near mouth.
Fossil Creek near mouth.
Little Chena River below Fish Creek.
Fish Creek below Miller Creek.
Fish Creek at mouth.
Pedro Creek at claim "No. 1 above."
Murphy Creek above McCloud Creek.
Washington Creek below Aggie Creek.
Washington Creek above Aggie Creek.
Aggie Creek at mouth.
Chatanika River below Murphy Creek.
Cleary Creek above Chatham Creek.
Chatham Creek at mouth.
Wolf Creek at mouth.
Belle Creek at elevation 1,200 feet.
Ophir Creek at mouth.
Nome Creek above Ophir Creek.
Beaver Creek above Nome Creek.
Flat Creek below 3d Pup.
Sourdough Creek 1 mile above mouth.
West Fork of Chena River at elevation 1,600 feet.

Gaging stations in Circle district, 1908.

Twelvemile Creek at elevation 2,500 feet.
Twelvemile Creek above East Fork.
Twelvemile Creek at mouth.
East Fork at Twelvemile Creek near mouth.
North Fork Birch Creek above Twelvemile Creek.
North Fork Birch Creek below Twelvemile Creek.
Tributary of North Fork Birch Creek from north.
Ptarmigan Creek at mouth.
Eagle Creek at mouth.
Eagle Creek below Cripple Creek.
Eagle Creek below Mastodon Fork.
Miller Fork of Eagle Creek above ditch intake.
Miller Fork ditch at intake.
Miller Fork ditch at outlet.
Mastodon Fork of Eagle Creek above storage dam.
Harrison Creek near elevation 2,200 feet.

North Fork of Harrison Creek near elevation 2,600 feet.
Mastodon Creek at claim "No. 21 above."
Mastodon Creek at claim "No. 1 above."
Flume on Mastodon Creek at Discovery claim.
Independence Creek near mouth.
Miller Creek near mouth.
Mammoth Creek at Miller House.
Bonanza Creek near elevation 2,200 feet.
Porcupine Creek near elevation 2,200 feet.
Porcupine Creek below Bonanza Creek.
Boulder Creek near mouth.
Crooked Creek at Central House.
Deadwood Creek above Switch Creek.
Switch Creek at mouth.
Albert Creek at trail crossing.
Quartz Creek at trail crossing.
Birch Creek at Fourteenmile House.

Gaging stations in Rampart district, 1908.

Minook Creek above Little Minook Creek.
Hunter Creek at claim "No. 14 above."
Hunter Creek at claim "No. 17 above."
Little Minook Creek at claim "No. 9 above."
Hoosier Creek at claim "No. 11 above."
Little Minook Junior Creek at mouth.
Russian Creek 3 miles above mouth.
Hoosier Creek below pipe intake.
Hoosier Creek above pipe intake.
Squaw Creek at mouth.
Ruby Creek at mouth.
Slate Creek at mouth.
Minook Creek below Chapman Creek.
Chapman Creek at mouth.
Granite Creek at road crossing.
Minook Creek 4½ miles above Chapman Creek.
Troublesome Creek below Quail Creek.
Troublesome Creek above Quail Creek.
Quail Creek above Nugget Gulch.
Quail Creek above South Fork.
South Fork of Quail Creek at mouth.
Buckeye Creek at mouth.
Goose Creek below Buckeye Creek.
Starvation Creek at mouth.
West Fork of Tolovana River below junction of Moose and Starvation Creeks.
Moose Creek at mouth.
Goose Creek 4 miles above mouth.
Hutlinana Creek below Caribou Creek.
Ohio Creek at trail crossing.
Elephant Gulch at mouth.
Hutlinana Creek below Cairo Creek.
Goff Creek one-half mile above mouth.
Applegate 1 mile above mouth.
Pioneer Creek at What Cheer Bar ditch intake.
What Cheer Bar ditch near Seattle Creek.

What Cheer Bar ditch below spillway.
Eureka Creek at claim "No. 14 above."
Eureka Creek at claim "No. 5 above."
Thanksgiving ditch 800 feet above outlet.
Thanksgiving ditch 30 feet below weir.
Thanksgiving ditch near outlet.
New York Creek at Thanksgiving ditch intake.
California Creek branch of Thanksgiving ditch near intake.
California Creek at Thanksgiving ditch intake.
New York Creek at trail crossing.
Allan Creek at trail crossing.
Allan Creek 5 miles above mouth.
Wolverine Creek 2 miles above mouth.
Wolverine Creek at mouth.
North Fork of Baker Creek below Wolverine Creek.
Eureka Creek at mouth.
Baker Creek at road crossing.
Quartz Creek one-half mile above mouth.
Sullivan Creek 3 miles above mouth.
Cache Creek at trail crossing.
Woodchopper Creek at trail crossing.

DISCHARGE AT REGULAR STATIONS.

Records of gage height have been kept for periods ranging from a few weeks to two seasons at 29 stations in the Yukon-Tanana region, including 16 in the Fairbanks district, 3 in the Birch Creek drainage basin, and 8 streams and 3 ditches in the Rampart district. The daily discharge has been computed for these stations, and the monthly maximum, minimum, and mean are given in Tables 1 to 8. Table 9 gives the minimum daily discharge in second-feet and second-feet per square mile. Tables 10 to 13 give the mean weekly discharge in second-feet, which can be reduced to miner's inches of 1.5 cubic feet per minute by multiplying by 40. Table 14 gives the mean weekly discharge in second-feet per square mile. Tables 15 to 17 are lists of miscellaneous measurements.

TABLE 1.—*Monthly discharge of streams in Little Chena River drainage basin, Fairbanks district, 1907–8.*

LITTLE CHENA RIVER ABOVE ELLIOTT CREEK.

[Drainage area, 79 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1907.					
July 22-31	80	42	49.3	0.625	0.23
August	157	53	85.4	1.08	1.24
September 1-10	95	66	86.2	1.09	.40
51 days	157	42	78.4	.993	1.87
1908.					
May 20-31	405	210	296	3.75	1.67
June	223	65	142	1.80	2.01
July	65	33	43.2	.547	.63
August 1-26	79	28	41.1	.520	.49
99 days	405	28	103	1.30	4.80

ELLIOTT CREEK ABOVE SORRELS CREEK.

[Drainage area, 13.8 square miles.]

Month.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off, depth in inches.
1907.					
July 22-31	9	2.5	5.94	0.430	0.16
August	23	5.8	11	.797	.92
September 1-10	12.3	9	10	.724	.27
51 days	23	2.5	9.82	.711	1.35
1908.					
May 20-31	216	11	67.8	4.91	2.19
June	32	8.6	14.8	1.07	1.19
July	7.5	4.5	5.22	.378	.44
August 1-26	4.6	4.4	4.48	.324	.31
99 days	216	4.4	15.5	1.12	4.13

SORRELS CREEK NEAR MOUTH.

[Drainage area, 21 square miles.]

Month.	Maximum.	Minimum.	Mean.	Mean per square mile.	Run-off, depth in inches.
1907.					
July 22-31	14.7	6.0	10.5	0.500	0.19
August	32.1	10.3	18.2	.867	1.00
September 1-10	19	14.7	16	.762	.28
51 days	32.1	6.0	16.3	.777	1.47
1908.					
May 20-31	131	36	73.0	3.48	1.55
June	72	27	42.8	2.04	2.28
July	38	11	19.9	.948	1.09
August 1-26	18	10	12.5	.595	.58
99 days	131	10	31.3	1.49	5.50

TABLE 1.—*Monthly discharge of streams in Little Chena River drainage basin, Fairbanks district, 1907–8*—Continued.

FISH CREEK ABOVE FAIRBANKS CREEK.

[Drainage area, 39 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Mean per square mile.	
1907.					
July 22–31	24	18	22.5	0.577	0.21
August	155	24	36.8	.944	1.09
September 1–10	35	24	26.6	.682	.25
51 days	155	18	32.0	.820	1.55
1908.					
May 22–31	227	90	132	3.38	1.26
June	137	36	56.7	1.45	1.61
July	33	12	19.9	.510	.59
August 1–27	17.7	12	14.8	.380	.38
98 days	227	12	41.1	1.05	3.84

FISH CREEK AT MOUTH.

[Drainage area, 90.2 square miles.]

1908.					
May	682	105	404	4.48	5.16
June	327	69	125	1.39	1.55
July	65	22	32.2	.356	.41
August 1–27	31	22	25.9	.287	.28
119 days	682	22	151	1.67	7.40

MILLER CREEK AT MOUTH.

[Drainage area, 16.7 square miles.]

1908.					
May 13–31	122	13.8	62.7	3.77	2.65
June	55	10.6	18.2	1.08	1.20
July	11.1	4.3	7.50	.449	.52
August 1–27	6.4	4	4.98	.298	.30
107 days	122	4	19.7	1.12	4.67

LITTLE CHENA RIVER BELOW FISH CREEK.

[Drainage area, 228 square miles.]

1908.					
May	1,668	265	832	3.65	4.21
June	651	161	284	1.25	1.40
July	161	64	94.9	.416	.48
August 1–27	122	59	79.2	.347	.35
119 days	1,668	59	332	1.46	6.44

TABLE 2.—*Monthly discharge of streams in Chatanika River drainage basin, Fairbanks district, 1907–8.*

FAITH CREEK NEAR MOUTH.

[Drainage area, 51 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
1907.					
June 20–30	45.9	34.4	40.5	0.795	0.32
July	62.5	19.2	29.2	.572	.66
August	87.4	26.9	47.5	.932	1.07
73 days	87.4	19.2	38.5	.755	2.05

McMANUS CREEK NEAR MOUTH.

[Drainage area, 80 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
1907.					
June 20–30	34.8	21.7	28.5	0.356	0.15
July	.40	15.0	21.4	.268	.31
August	114	32.2	66.4	.830	.96
73 days	114	15.0	41.5	.510	1.42

CHATANIKA RIVER NEAR FAITH CREEK.

[Drainage area, 132 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
1907.					
July 17–31	96	55	67.8	0.514	0.28
August	205	72	125	.947	1.09
September	1,990	119	342	2.59	2.89
76 days	1,770	54	178	1.31	4.26
1908.					
May 12–20	1,340	320	598	4.53	1.85
July 13–31	200	82	131	.992	.70
August	270	95	137	1.04	1.20
September	530	102	208	1.58	1.76
89 days	1,340	82	241	1.82	5.51

KOKOMO CREEK NEAR MOUTH

[Drainage area, 26 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
1907.					
July 9–31	25.8	7.9	14.2	0.546	0.47
August 1–14	112	22.7	41.6	1.60	.83
37 days	112	7.9	23.8	.916	1.30

TABLE 2.—*Monthly discharge of streams in Chatanika River drainage basin, Fairbanks district, 1907–8*—Continued.

CHATANIKA RIVER BELOW POKER CREEK.

[Drainage area, 456 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
1907.					
June 20-30	250	192	228	0.500	0.20
July	283	167	211	.463	.53
August	1,160	216	428	.939	1.08
September	3,160	300	954	2.09	2.33
October 1-14	860	232	506	1.11	.47
117 days	3,160	167	496	1.08	4.61
1908.					
May 16-31	4,120	1,730	2,730	5.99	3.56
June	2,280	283	984	2.16	2.41
July	942	204	332	.728	.84
August	455	192	284	.623	.72
September	1,160	266	461	1.01	1.12
October 1-21	342	179	234	.513	.40
159 days	4,120	179	699	1.53	9.05

GOLDSTREAM CREEK NEAR CLAIM "NO. 6 BELOW."

[Drainage area, 28.6 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches.
1907.					
June 20-30	30.2	4.9	13.4	0.469	0.19
July	34.4	2.2	13.1	.458	.53
August	32.2	10.8	20	.699	.81
September	41	15.4	24	.839	.94
October 1-7	24.4	17.1	20.7	.724	.19
110 days	41	2.2	18.5	.649	2.66

TABLE 3.—*Monthly discharge of streams in Washington Creek drainage basin, Fairbanks district, 1908.*

WASHINGTON CREEK BELOW AGGIE CREEK.

[Drainage area, 147 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
May 5-31	1,400	234	774	5.26	5.28
June	600	52	182	1.23	1.37
July	88	24	41.3	.281	.32
August	37	28	30.8	.210	.24
September 1-4	124	38	73.1	.498	.07
123 days	1,400	24	234	1.53	7.28

WASHINGTON CREEK ABOVE AGGIE CREEK.

[Drainage area, 117 square miles.]

May 23-31	408	183	282	2.41	0.81
June	557	45	159	1.36	1.52
July	63	18	33.2	.284	.33
August	30	22	24.6	.210	.24
September 1-4	104	30	59.8	.512	.08
105 days	557	18	89.1	.762	2.98

AGGIE CREEK AT MOUTH.

[Drainage area, 35.8 square miles.]

May 23-31	125	50	91.2	2.55	0.85
June	79	7.8	22.5	.629	.70
July	14	4.5	7.58	.211	.24
August	7.5	6.0	6.26	.174	.20
September 1-4	16	8.5	12.2	.341	.05
105 days	125	4.5	18.8	.525	2.04

TABLE 4.—*Monthly discharge of streams in Birch Creek drainage basin, Circle district, 1908.*

MAMMOTH CREEK AT MILLER HOUSE.

[Drainage area, 37.1 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
September 8-30	36	14.4	22.6	0.609	0.52
October 1-13	14.4	13	14	.376	.18
36 days	36	13	19.5	.525	.70

PORCUPINE CREEK BELOW BONANZA CREEK.

[Drainage area, 39.9 square miles.]

July 4-31	147	17.8	40	1.00	1.04
August 1-10	21.7	15.5	17.1	.429	.16
38 days	147	15.5	34.0	.852	1.20

BIRCH CREEK AT FOURTEEN MILE HOUSE.

[Drainage area, 2,150 square miles.]

June 26-30	1,190	1,020	1,090	0.507	0.09
July	2,630	847	1,140	.530	.61
August	1,620	825	1,080	.502	.58
September 1-29	6,070	900	2,150	1.00	1.08
96 days	6,070	825	1.423	1.48	2.36

TABLE 5.—*Monthly discharge of streams in Minook Creek drainage basin, Rampart, district, 1908.*

MINOOK CREEK ABOVE LITTLE MINOOK CREEK.

[Drainage area, 130 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
June 7-30	200	77	134.0	1.03	0.92
July	110	34	56	.431	.50
August	38	30	34	.262	.30
September 1-22	128	38	70.4	.542	.44
109 days	200	30	69.2	.532	2.16

HUNTER CREEK AT CLAIM "NO. 17 ABOVE."

[Drainage area, 33.4 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
August 11-31	5.5	3.7	4.6	0.138	0.11
September 1-12	27.7	6.6	15.8	.473	.14
33 days	27.7	3.7	8.68	.260	.25

HOOSIER CREEK AT CLAIM "NO. 11 ABOVE."

[Drainage area, 25.7 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
August 16-31	4.7	4.7	4.7	0.183	0.10
September 1-21	42	4.7	13.6	.529	.41
37 days	42	4.7	9.73	.379	.51

LITTLE MINOOK CREEK AT CLAIM "NO. 9 ABOVE."

[Drainage area, 5.9 square miles.]

Month.	Maximum.	Minimum.	Mean.	Per square mile.	Run-off, depth in inches.
June 21-30	6.8	1.60	2.48	0.420	0.16
July	26.4	.62	3.78	.641	.74
August	.87	.62	.80	.136	.16
September 1-15	10.1	1.4	3.60	.610	.34
87 days	26.4	.62	2.54	.431	1.40

TABLE 6.—*Monthly discharge of streams in Hess Creek drainage basin, Rampart district, 1908.*

TROUBLESOME CREEK BELOW QUAIL CREEK.

[Drainage area, 43.2 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
August 12-31	9.4	6.2	7.48	0.173	0.13
September 1-25	48	4	22.2	.518	.48
45 days	48	4	15.7	.363	.61

TABLE 7.—*Monthly discharge of streams in Baker Creek drainage basin, Rampart district, 1908.*

HUTLINANA CREEK, BELOW CAIRO CREEK.

[Drainage area, 44.2 square miles.]

Month.	Discharge in second-feet.				Run-off, depth in inches.
	Maximum.	Minimum.	Mean.	Per square mile.	
June 9-30	122	24	69.6	1.57	1.28
July	32	22	22	.498	.58
August 1-21	12.8	10.5	11.7	.265	.20
74 days	122	10.5	33.3	.753	2.06

PIONEER CREEK, NEAR WHAT CHEER BAR DITCH INTAKE.

[Drainage area, 8.1 square miles.]

June 7-30	10.8	2.9	5.44	0.672	0.60
August	4.1	2.6	2.52	.311	.36
September 1-20	6.6	2.6	4.18	.516	.39
75 days	10.8	2.6	3.90	.481	1.35

NEW YORK CREEK AT THANKSGIVING DITCH INTAKE.

[Drainage area, 4.7 square miles.]

June 6-30	8.2	0.7	3.15	0.670	0.62
July 1-14	1.7	.7	.843	.179	.09
August 8-31	3.0	.7	1.29	.275	.25
September 1-20	8.2	2.3	4.10	.873	.65
83 days	8.2	.7	2.45	.521	1.61

CALIFORNIA CREEK AT THANKSGIVING DITCH INTAKE.

[Drainage area, 6.7 square miles.]

August 8-30	3.2	2.4	2.45	0.366	0.31
September 1-20	8.7	3.2	5.07	.757	.56
43 days	8.7	2.4	3.67	.548	.87

TABLE 8.—*Monthly discharge of ditches in Baker Creek drainage basin, Rampart district, 1908.*

THANKSGIVING DITCH NEAR OUTLET.

Month.	Discharge in second-feet.		
	Maximum.	Minimum.	Mean.
June 6-30	12.0	2.4	6.84
July 1-14	3.3	2.1	2.37
August 8-31	3.9	1.6	2.25
September 1-20	12	3.3	6.46
83 days	12.0	1.6	4.67

CALIFORNIA BRANCH OF THANKSGIVING DITCH NEAR INTAKE.

June 6-30	17.0	2.1	4.68
July 1-14	2.5	1.8	2.08
August 8-31	3	2.1	2.20
September 1-20	7.9	3	4.67
83 days	17.0	1.8	3.52

TABLE 9.—*Minimum daily flow of streams in Yukon-Tanana region, 1907–8.*

FAIRBANKS DISTRICT.

Point of measurement.	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum discharge per square mile.	Duration of record. From—	To—
1907.	*Feet.*		*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*		
Little Chena River above Elliott Creek.	800	July 22-25, 29-31	42	79	0.532	July 22	Sept. 10
Elliott Creek above Sorrels.	800	July 31	2.5	13.8	.181	...do.....	Do.
Sorrels Creek above mouth.	800	.....do	6	21	.286	...do.....	Do.
Fish Creek above Fairbanks Creek.	925	July 30-31	18	39	.462	...do.....	Do.
Faith Creek at mouth	1,400	July 10	19.2	51	.376	June 20	Sept. 4
McManus Creek at mouth	1,400	July 10-12	15	80	.188	...do.....	Do.
Chatanika River below Faith Creek.	1,350	July 31	54	132	.409	July 17	Sept. 30
Kokomo Creek near mouth	750	July 23, 30-31	7.9	26	.304	July 9	Aug. 14
Chatanika River below Poker Creek.	700	July 4-7, 10	167	456	.366	June 20	Oct. 14
1908.							
Little Chena River above Elliott Creek.	800	Aug. 11	82	79	.354	May 20	Aug. 26
Elliott Creek above Sorrels Creek.	800	Aug. 4-7, 9-13	4.4	13.8	.319	...do.....	Do.
Sorrels Creek near mouth	800	Aug. 3-14	10	21	.476	...do.....	Do.
Fish Creek above Fairbanks Creek.	925	Aug. 21, Sept. 12-13	12	39	.308	May 22	Aug. 27
Fish Creek at mouth	700	July 17-18, 31, Aug. 6, 12-13.	22	90.2	.244	May 1	Do.
Miller Creek near mouth	750	Aug. 12-13	4.0	15	.267	May 13	Do.
Little Chena River below Fish Creek.	700	.....do	59	228	.259	May 1	Do.
Chatanika River near Faith Creek.	1,350	July 21-22	82	132	.621	July 13	Sept. 30
Chatanika River below Poker Creek.	700	Oct. 15-16, 21	179	456	.386	May 16	Oct. 21
Washington Creek below Aggie Creek.	600	July 23	24	153	.157	May 5	Sept. 4
Washington Creek above Aggie Creek.	600	.....do	18	117	.154	May 23	Do.
Aggie Creek above mouth.	600	July 31	4.5	35.8	.126	...do....	Do.

CIRCLE DISTRICT.

Point of measurement.	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum discharge per square mile.	From—	To—
1908.							
Mammoth Creek at Miller House.	1,700	Oct. 10-13	13.0	37.1	0.350	Sept. 8	Oct. 13
Porcupine Creek below Bonanza Creek.	1,900	Aug. 7	15.5	39.9	.388	July 4	Aug. 10
Birch Creek at Fourteenmile House.	700	Aug. 8	825	2,150	.384	June 26	Sept. 29

TABLE 9.—*Minimum daily flow of streams in Yukon-Tanana region, 1907–8*—Continued.

RAMPART DISTRICT.

Point of measurement.	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum discharge per square mile.	Duration of record.	
						From—	To—
1908.	*Feet.*		*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*		
Minook Creek above Little Minook Creek.	425	Aug. 15	30	130	0.231	June 7	Sept. 22
Hunter Creek at claim "No. 17 above."	600	Aug. 23	3.7	33.4	.111	Aug. 11	Sept. 12
Hoosier Creek at claim "No. 11 above."	600	Aug. 16–31, Sept. 21.	4.7	25.7	.183	Aug. 16	Sept. 2
Little Minook Creek at claim "No. 9 above."	1,000	July 17–Aug. 1	.62	5.9	.105	June 21	Sept. 15
Troublesome Creek below Quail Creek.	1,750	Sept. 25	4.0	43.2	.093	Aug. 12	Sept. 25
Hutlinana Creek below Cairo Creek.	1,050	Aug. 19–21	10.5	44.2	.238	June 9	Aug. 21
Pioneer Creek at What Cheer Bar ditch intake.	900	Aug. 8–13, 25–28, Sept. 13.	2.6	8.1	.321	June 7	Sept. 20
New York Creek at Thanksgiving ditch intake.	800	June 30–July 14, Aug. 9–17.	.7	4.7	.149	June 6	Do.
Thanksgiving ditch ¼ mile above outlet.	800	Aug. 12–16	1.6			do	Do.
California branch Thanksgiving ditch near intake.	800	July 2, 8	1.8			do	Do.

TABLE 10.—*Mean weekly water supply, in second-feet, from Little Chena and Chatanika River basins, Fairbanks district, 1907.*

Date.	Available for use by diversion at elevation 1,350 feet.	Available for use by pumping at elevation 700 feet.	Available for use by diversion at elevation 800 to 900 feet.				Total, Little Chena drainage area.
	Chatanika River near Faith Creek.	Chatanika River below mouth of Poker Creek.	Little Chena River above Elliot Creek.	Elliott Creek above Sorrels Creek.	Sorrels Creek above mouth.	Fish Creek above Fairbanks Creek.	
June 17–23	86						
June 24–30	64	216					
July 1–7	44	178					
July 8–14	36	190					
July 15–21	64	250					
July 22–28	67	224	52	7	12	24	95
July 29–August 4	84	510	80	12	18	55	165
August 5–11	138	516	110	12	24	42	188
August 12–18	85	313	73	10	16	26	125
August 19–25	110	260	56	6	10	24	96
August 26–September 1	180	413	90	11	18	26	145
September 2–8	130	321	82	9	15	26	132
September 9–15	592	1,360					
September 16–22	451	1,480					
September 23–29	238	737					
September 30–October 6		655					
October 7–13		415					
Mean	158	504	78	10	16	32	136
Maximum	592	1,480	110	12	24	55	188
Minimum	36	190	52	6	10	24	95

TABLE 11.—*Mean weekly water supply, in second-feet, from Little Chena River, Chatanika River, and Washington Creek basins, Fairbanks district, 1908.*

Date.	Available for use by diversion at elevation 1,350 feet.	Available for use by pumping at elevation 700 feet.	Available for use by diversion at elevation 800 to 925 feet.					Available for use by diversion at elevation 600 feet.
	Chatanika River near Faith Creek.	Chatanika River below mouth of Poker Creek.	Little Chena River above Elliott Creek.	Elliott Creek above Sorrels Creek.	Sorrels Creek above mouth.	Fish Creek above Fairbanks Creek.	Total in Little Chena drainage basin.	Washington Creek below Aggie Creek.
May 16-19		3,220						[a] 1,200
May 20-26		3,020	339	93	87	[b] 162	681	546
May 27-June 2		1,980	227	30	55	98	410	360
June 3-9		1,360	181	15	31	79	306	198
June 10-16		1,160	172	25	34	50	281	200
June 17-23		775	118	9.3	54	44	225	226
June 24-30		331	77	8.9	48	42	176	68
July 1-7		394	59	6.8	33	30	129	52
July 8-14	[c] 150	468	48	5.3	24	23	100	56
July 15-21	110	278	38	4.6	15	16	74	35
July 22-28	127	207	33	4.5	11	13.5	62	29
July 29-August 4	151	271	32	4.5	11	13.5	61	31
August 5-11	101	211	31	4.4	10	13.5	59	29
August 12-18	112	236	36	4.5	12	14	66	29
August 19-25	202	402	[d] 59	[d] 4.6	[d] 16	17	97	32
August 26-September 1	157	306						35
September 2-8	351	743						[e] 85
September 9-15	176	407						
September 16-22	153	423						
September 23-29	[f] 152	313						
September 30-October 6		284						
October 7-13		228						
October 14-21		205						
Mean	162	749	104	15.7	31.5	44.0	195	225
Maximum	351	3,220	339	93	87	162	681	1,200
Minimum	101	205	31	4.4	10	13.5	59	29

[a] May 13-19. [b] May 22-26. [c] July 13-14. [d] August 19-26. [e] September 2-4. [f] September 23-30.

TABLE 12.—*Mean weekly water supply, in second-feet, of various streams in the Circle district, 1908.*

Date.	Birch Creek at Fourteenmile House.	Porcupine Creek below mouth of Bonanza Creek.	Mammoth Creek at Miller Roadhouse.	Date.	Birch Creek at Fourteenmile House.	Porcupine Creek below mouth of Bonanza Creek.	Mammoth Creek at Miller House.
June 26-July 3	1,240			September 5-11	4,090		[b] 32.5
July 4-10	1,600	73.5		September 12-18	1,510		21.9
July 11-17	1,160	45.3		September 19-25	1,290		23.3
July 18-24	936	21.5		September 26-October 2	[c] 942		14.6
July 25-31	870	19.7		October 3-9			14.4
August 1-7	850	16.0		October 10-13			13.0
August 8-14	1,060	[a] 19.5					
August 15-21	964			Mean	1,420	32.6	17.1
August 22-28	1,280			Maximum	4,090	73.5	32.5
August 29-September 4	2,110			Minimum	850	16.0	13.0

[a] August 8-10. [b] September 8-11. [c] September 26-29.

TABLE 13.—*Mean weekly water supply, in second-feet, of various streams in the Rampart district, 1908.*

Date.	Minook Creek above Little Minook Creek.	Little Minook Creek at claim "No. 9 above."	Hunter Creek at claim "No. 17 above."	Hoosier Creek at claim "No. 11 above."	Troublesome Creek below Quail Creek.	Hutlinana Creek below Cairo Creek.	Pioneer Creek at What Cheer Bar ditch intake.	Thanksgiving ditch near outlet.	New York Creek at Thanksgiving ditch intake.	California branch Thanksgiving ditch near intake.
June 6-12	[a] 136	....	....	....	....	[b] 82.6	[c] 7.2	8.4	4.4	4.6
June 13-19	164	....	....	....	....	103	7.0	8.7	3.4	4.6
June 20-26	136	[d] 3.1	....	....	....	51.4	3.8	6.0	2.8	7.2
June 27-July 3	75	1.6	....	....	....	31.1	3.0	2.7	1.0	2.3
July 4-10	77	9.9	....	....	....	27.0	....	2.3	.8	2.1
July 11-17	63	5.0	....	....	....	23.8	....	[e] 2.2	[e] .8	[e] 2.1
July 18-24	41	.62	....	....	....	18.5	....	....	....	....
July 25-31	35	.62	....	....	....	14.8	....	....	....	....
August 1-7	36	.78	....	....	....	12.5	2.9	....	....	....
August 8-14	32	.71	[f] 4.8	....	[g] 6.7	11.8	2.6	1.7	.8	2.1
August 15-21	33	.82	4.6	[h] 4.7	6.6	10.8	2.9	2.5	1.5	2.4
August 22-28	34	.87	4.4	4.7	7.5	....	2.7	2.4	1.4	2.2
August 29-Sept. 4	62	4.4	12.2	16.4	20.9	....	4.6	5.6	3.9	3.9
September 5-11	83	2.8	[i] 14.9	14.8	37.6	....	3.6	6.0	3.8	4.3
September 12-18	58	[j] 1.6	....	8.5	16.1	....	3.8	5.1	3.3	4.7
September 19-25	[k] 33	....	....	[l] 7.3	8.5	....	[m] 6.1	[n] 10.4	[n] 6.8	[n] 4.8
Mean	68.6	2.53	8.18	9.40	14.8	35.2	4.18	4.92	2.67	3.64
Maximum	164	9.9	14.9	16.4	37.6	103	7.2	10.4	6.8	7.2
Minimum	32	.62	4.4	4.7	6.6	10.8	2.6	1.7	.8	2.1

[a] June 7-12.
[b] June 9-12.
[c] June 7-12.
[d] June 21-26.
[e] July 11-14.
[f] August 11-14.
[g] August 12-14.
[h] August 16-21.
[i] September 5-12.
[j] September 12-15.
[k] September 18-22.
[l] September 18-21.
[m] August 19-20.
[n] September 19-20.

TABLE 14.—*Mean weekly discharge, in second-feet per square mile, at regular stations in the Yukon-Tanana region, 1908.*

	Chatanika River below Poker Creek.	Little Chena River below Fish Creek.	Washington Creek below Aggie Creek.	Hutlinana Creek below Cairo Creek.	Minook Creek above Little Minook Creek.	Birch Creek at Fourteenmile House.	Mean.	Chatanika River near Faith Creek.	Little Chena River above Elliott Creek.	Mean.
Drainage area, in square miles	456	228	147	44.2	130	2,150	......	132	79	......
May 1-5	....	3.84	....	....	....	....	......	......	......	......
May 6-12	....	3.53	5.51	....	....	....	4.52	......	......	......
May 13-19	7.03	5.10	7.84	....	....	....	6.66	......	......	......
May 20-26	6.61	3.44	3.57	....	....	....	4.54	......	4.29	......
May 27-June 2	4.34	1.92	2.35	....	....	....	2.87	......	2.87	......
June 3-9	2.98	1.69	1.29	1.67	1.18	....	1.76	......	2.29	......
June 10-16	2.52	1.14	1.31	2.32	1.05	....	1.67	......	2.18	......
June 17-23	1.70	1.10	1.48	1.57	1.30	....	1.43	......	1.49	......
June 24-30	.72	.83	.44	.82	.68	0.51	.67	......	.98	......
July 1-7	.86	.62	.34	.68	.51	.50	.58	......	.75	......
July 8-14	1.02	.45	.37	.55	.61	.80	.63	0.97	.61	0.79
July 15-21	.61	.33	.23	.48	.38	.46	.42	.83	.48	.66
July 22-28	.45	.31	.19	.38	.28	.40	.35	.96	.42	.69
July 29-August 4	.59	.32	.20	.28	.27	.40	.36	1.15	.41	.78
August 5-11	.46	.29	.19	.27	.26	.45	.32	.76	.39	.58
August 12-18	.52	.31	.19	.25	.24	.46	.33	.85	.46	.66
August 19-25	.88	.43	.21	.24	.26	.54	.43	1.55	.75	1.15
August 26-September 1	.67	....	.23	....	.28	.64	.46	1.19	......	......
September 2-8	1.63	....	.55	....	.73	1.93	1.21	2.66	......	......
September 9-15	.89	....	....	....	.44	.99	.77	1.33	......	......
September 16-22	.92	....	....	....	.48	.66	.69	1.16	......	......
September 23-29	.68	....	....	....	....	.47	.58	1.15	......	......
September 30-October 6	.62	....	....	....	....	....	......	......	......	......
October 7-13	.45	....	....	....	....	....	......	......	......	......
October 14-21	.45	....	....	....	....	....	......	......	......	......

NOTE.—In comparing the various records it was found that the rate of run-off from the upper portions of the drainage areas was greater per square mile than from those farther down.

MISCELLANEOUS MEASUREMENTS.

Miscellaneous measurements were made at points where no regular gage readings could be obtained. They show the discharge at these points for only a few days, but an approximate idea of the seasonal average can be obtained by comparing the discharge on the date of measurement with that at some regular station on the same or an adjoining stream. The miscellaneous measurements made in 1908 are given in the following tables:

TABLE 15.—*Miscellaneous measurements in Fairbanks district, 1908.*

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
	LITTLE CHENA RIVER DRAINAGE BASIN.			
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 13	West fork of Chena River at elevation 1,600 feet	24.7	9.2	0.372
July 19	Bear Creek below Tecumseh Creek	12.0	5.4	.450
July 21	Miller Creek above Heim Creek	6.0	2.5	.416
August 1	do	6.0	2.2	.367
July 21	Miller Creek below Heim Creek	10.0	3.1	.310
August 1	do	10.0	2.4	.240
	CHATANIKA RIVER DRAINAGE BASIN.			
July 12	Pool Creek at mouth	14	15.4	1.10
July 13	do	14	11.0	.786
July 14	do	14	12.3	.879
July 13	Smith Creek above Pool Creek	17	11	.647
July 14	do	17	9.3	.547
August 30	do	17	14.2	.835
September 1	do	17	20.5	1.21
July 12	Smith Creek at mouth	34	33.8	.995
July 13	do	34	27.4	.806
July 14	do	34	22.7	.668
Do	McManus Creek at mouth	80	59	.738
Do	McManus Creek above Smith Creek	42	36	.858
July 12	Faith Creek at mouth	51	66.9	1.31
July 13	do	51	77.7	1.52
July 14	do	51	67.7	1.33
July 13	Sourdough Creek 1 mile above mouth	15.9	22.5	1.42
July 15	Flat Creek below 3d Pup	7	2.8	.400
August 29	do	7	3.7	.529
August 9	Belle Creek at elevation 1,200 feet	....	1.4	....
August 14	Poker Creek at ditch intake	18.1	9.3	.514
Do	Little Poker, and Caribou Creek ditch	....	6.2	....
July 23	Wolf Creek at mouth	3.8	.91	.239
Do	Cleary Creek above Wolf Creek	2.7	1.6	.593
Do	Chatham Creek at mouth	3.0	1.3	.434
July 26	Murphy Creek above McCloud Creek	17	1.7	.100
August 20	do	17	1.3	.076
July 26	Chatanika River below Murphy Creek	677	263	.388
	GOLDSTREAM CREEK DRAINAGE BASIN.			
July 23	Pedro Creek at claim "No. 1 above"	6.3	3.2	0.508
August 24	Fox Creek at elevation 900 feet	3.4	.43	.127
	BEAVER CREEK DRAINAGE BASIN.			
August 12	Ophir Creek at mouth	33	2.0	0.066
August 11	Beaver Creek above East Branch	122	80.3	.658
August 12	Beaver Creek above Nome Creek	226	108	.478
August 11	East Branch of Beaver Creek at mouth	67	44.3	.661
August 12	Nome Creek at mouth	120	33.6	.280
Do	Nome Creek above Ophir Creek	87	26.0	.298

TABLE 16.—*Miscellaneous measurements in Circle district, 1908.*

BIRCH CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
July 10	Twelvemile Creek at mouth	44.5	38.0	0.854
Do	Twelvemile Creek above East Fork	18.9	15.6	.826
Do	Twelvemile Creek at elevation 2,500 feet		6.3	
September 4	Twelvemile Creek at mouth	44.5	73.3	1.64
July 11	Twelvemile Creek at elevation 2,500 feet		6.0	
July 10	East Fork of Twelvemile Creek near mouth	22.9	24.4	1.07
September 4	do	22.9	23.9	1.04
July 9	North Fork of Birch Creek below Twelvemile Creek	132	125	.947
July 10	do	132	129	.977
Do	North Fork of Birch Creek above Twelvemile Creek	87	87	1.00
September 4	do	87	191	2.20
July 9	Tributary of North Fork of Birch Creek from north, at mouth	11.6	20.3	1.75
Do	Ptarmigan Creek at mouth	19.0	26.2	1.38
September 5	do	19.0	24.7	1.30
July 7	Eagle Creek below Cripple Creek	12.4	10.5	.847
July 9	Eagle Creek at mouth	15.5	15.4	.994
September 5	do	15.5	24.7	1.59
September 6	Eagle Creek below Mastodon Fork	8.4	[a] 4.2	.50
Do	Miller Fork ditch at intake		2.8	
Do	Miller Fork ditch at outlet		1.4	
Do	Miller Fork of Eagle Creek above ditch intake	2.6	2.1	.808
July 7	Mastodon Fork of Eagle Creek above storage dam	4.1	1.1	.269
September 6	do	4.1	1.3	.317
July 8	Harrison Creek at elevation 2,200 feet	17.9	4.9	.274
Do	North Fork of Harrison Creek at elevation 2,600 feet	6.2	7.1	1.15
July 5	Mastodon Creek at claim "No. 1 above"	10.4	7.7	.740
July 7	Mastodon Creek at claim "No. 21 above"	6.9	9.1	1.32
September 6	do	6.9	3.9	.565
September 7	Mastodon Creek at mouth		11.5	
July 5	Flume on Mastodon Creek at Discovery claim		7.3	
Do	Independence Creek at mouth	13.2	4.6	.348
September 7	do	13.2	11.9	.902
July 6	Miller Creek at mouth	10.5	5.9	.562
September 7	do	10.5	11.2	1.07
July 4	Bonanza Creek at ditch intake	7.9	12.4	1.56
July 6	do	7.9	13	1.64
September 7	do	7.9	12.3	1.56
July 6	Porcupine Creek at elevation 2,200 feet	17.8	12.6	.708
July 1	Boulder Creek at mouth	38.8	8.0	.206
July 2	do	38.8	5.8	.150
June 30	Crooked Creek at Central House	161	57.7	.358
July 1	do	161	52.0	.323
September 9	do	161	86.4	.536
July 1	Deadwood Creek above Switch Creek	21.3	9.1	.427
Do	Switch Creek at mouth	5.8	.72	.124
Do	Albert Creek at trail crossing	92.7	9.1	.098
June 29	Quartz Creek at trail crossing	8.4	2.7	.322

[a] Does not include diversion for hydraulicking by ditch about 2 miles below.

TABLE 17.—*Miscellaneous measurements in Rampart district, 1908.*

HESS CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
August 12	Quail Creek above Nugget Gulch	17.6	4.3	0.244
Do	Quail Creek above South Fork	13.3	2.8	.210
Do	South Fork Quail Creek at mouth	3.7	1.4	.378
Do	Troublesome Creek above Quail Creek	21.4	2.5	.117

TABLE 17.—*Miscellaneous measurements in Rampart district, 1908*—Continued.

MINOOK CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
		Sq. miles.	*Sec.-ft.*	*Sec.-ft.*
August 8	Minook Creek 4 miles above Chapman Creek	9.2	2.9	0.315
Do	Minook Creek below Chapman Creek	58.3	7.1	.122
Do	Granite Creek at road crossing	26.9	5.7	.212
Do	Chapman Creek at mouth	14.8	2.9	.196
Do	Slate Creek at mouth	7.9	2.2	.278
Do	Ruby Creek at mouth	10.6	1.7	.160
August 10	Hoosier Creek above pipe intake	21.2	4.8	.226
September 9	do	21.2	11.1	.523
Do	Hoosier Creek below pipe intake		1.2	
August 10	Hunter Creek at claim "No. 14 above"		2.3	
September 5	Little Minook Junior Creek at mouth	1.3	.32	.246

MINOR YUKON RIVER DRAINAGE.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
September 11	Squaw Creek at mouth		27.7	
September 18	Russian Creek 3 miles above mouth	9.9	1.91	0.193

BAKER CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
June 6	Thanksgiving ditch near outlet		11.1	
June 7	What Cheer Bar ditch below spillway		4.0	
August 6	Eureka Creek at mouth	37.7	4.8	0.127
August 20	Hutlinana Creek below Caribou Creek	16.1	1.9	.118
September 2	do	16.1	3.1	.192
August 20	Ohio Creek at trail crossing	3.2	.93	.290
Do	Elephant Gulch at mouth	3.3	1.1	.334
Do	Goff Creek ½ mile above mouth	11.4	2.4	.210
Do	Applegate Creek 1 mile above mouth	18.9	2.8	.148
August 21	Eureka Creek at claim "No. 14 above"	2.8	.77	.275
Do	Eureka Creek at claim "No. 5 above"	5.8	1.3	.224
August 22	New York Creek at trail crossing		1.4	
Do	Allen Creek at trail crossing	15.3	4.9	.320
Do	Allen Creek 5 miles above mouth	5.9	2.7	.458
August 29	Thanksgiving ditch 30 feet below weir		1.7	
August 30	North Fork of Baker Creek below Wolverine Creek	19.7	5.2	.264
Do	Wolverine Creek at mouth	8.2	2.6	.317
Do	Wolverine Creek 2 miles above mouth	6.2	2.1	.339

PATTERSON CREEK DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
August 4	Cache Creek at trail crossing	22.7	3.2	0.141
August 25	Woodchopper Creek at trail crossing	19.7	4.4	.223
August 26	Quartz Creek ½ mile above mouth	8.0	2.8	.333
August 4	Sullivan Creek 3 miles above mouth	20.7	5.7	.275
August 24	do	20.7	4.5	.217

TOLOVANA RIVER DRAINAGE BASIN.

Date.	Locality.	Drainage area.	Discharge.	Discharge per square mile.
August 13	Goose Creek 4 miles above mouth	41	3.2	0.078
August 14	Goose Creek below Buckeye Creek	20.8	1.6	.077
August 13	Starvation Creek at mouth	23.8	2.2	.092
Do	Moose Creek at mouth	19.8	1.9	.096
Do	West Fork Tolovana River at junction of Moose and Starvation creeks	43.8	4.0	.091
August 14	Buckeye Creek at mouth	10.6	.20	.019

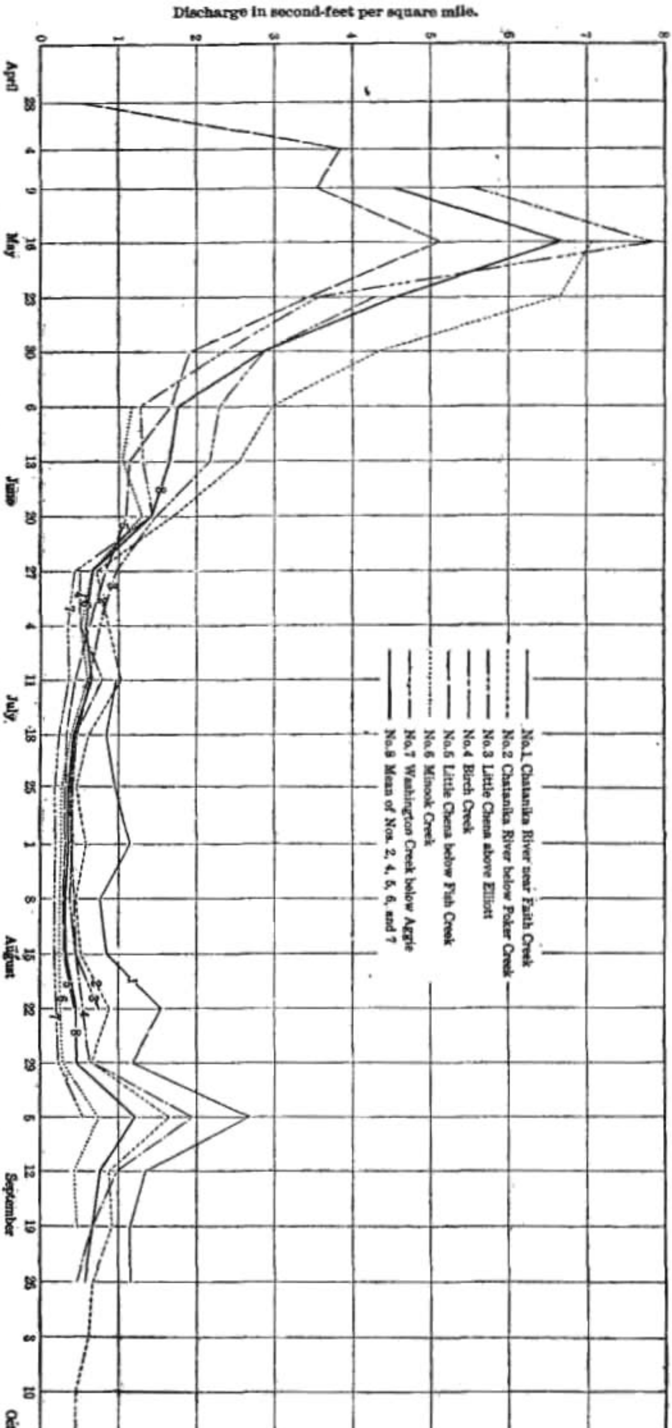


FIGURE 17.—Diagram illustrating relative discharge, in second-feet per square mile, of various streams in Yukon-Tanana region, 1908.

COMPARATIVE DISCHARGE.

Figure 17 shows the mean weekly discharge, in second-feet per square mile, of various streams in the Yukon-Tanana region on which records have been kept. This diagram is intended to illustrate graphically the relative discharge per square mile of streams in this section of Alaska, and may be used with some degree of accuracy in connection with the following table of drainage areas. Although the data represent weekly periods, they are far more comprehensive than was expected, and when used in connection with precipitation records will give the engineer sufficient information to determine whether a project is worthy of detailed study.

TABLE 18.—*Drainage areas of streams in Yukon-Tanana region outside of district covered by records in 1907 and 1908.*

Stream and location.	Elevation above sea level.	Drainage area.	Approximate fall below point.
	Feet.	*Sq. miles.*	
Salcha River basin:			
East Fork of Salcha River	1,975	475	200 feet in 9 miles.
Salcha River at the splits	1,400	1,290	200 feet in 8 miles.
Charley River	2,200	449	400 feet in 9 miles.
Do	1,000	1,470	200 feet in 5 miles.
Fortymile River 3 miles below Fortymile telegraph station	1,300	1,620	100 feet in 4 miles.

NOTE.—Areas and elevations were obtained from the reconnaissance topographic maps of the Fortymile and Circle quadrangles.

RAINFALL.

In connection with these investigations the following rainfall stations were established:

Summit road house near Pedro Summit; elevation 2,310 feet.
Cleary City; elevation 1,000 feet.
Chatanika River near mouth of Poker Creek; elevation 730 feet.
Chatanika River near mouth of Faith Creek; elevation 1,400 feet.
Charity Creek; elevation 2,800 feet.
Eagle Creek; elevation 2,590 feet.
Baker Hot Springs; elevation 370 feet.

The results of the observations taken at these stations and at Fairbanks, Circle, and Rampart in 1906 to 1908, together with a summary of records for stations in the Yukon-Tanana region, are given in the following tables:

TABLE 19.—*Monthly precipitation, in inches, at stations in Yukon-Tanana region, 1907–8.*

Station.	Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Baker Hot Springs......	1908	......	......	......	......	......	......	......	......	......	0.41	.20	......	......
		......	......	......	......	......	......	......	......	......	4.1	2.0	......	......
Circle..........	1907	1.02	0.57	0.28	0.15	0.29	......	1.36	2.79	1.73	......	......	0.63	......
		8.5	7.8	3.25									8.2	......
Do.........	1908	1.23	.25	.76	1.45	.29	0.20	.87	1.08	2.21	.40	.75	......	......
		9.2	2.5	6.75	8.0	......	......	......	......	......	3.0	8.5	......	......
Charity Creek.	1908	......	......	......	.11	.27	1.33	2.80	2.33	2.28	.20	......	......	......
		......	......	......	......	......	......	......	......	......	3.0	......	......	......
Cleary.........	1907	......	......	......	......	......	.84	2.55	2.88	3.82	......	......	......	......
Eagle Creek...	1908	......	......	......	......	......	......	......	2.99	......	......	......	......	......
Fairbanks.....	1907	3.30	.86	2.42	.03	.35	1.47	1.51	1.81	3.58	2.44	.35	.59	18.71
		33.0	8.6	24.2	.3	......	......	......	......	......	24.4	3.5	5.9	99.9
Do.........	1908	.42	.21	1.1	.11	.52	.96	.73	.71	.15	.47	.51	......	......
		4.2	2.1	11.0	.8	......	......	......	......	1.53	......	4.0	......	......
Faith Creek...	1907	......	......	......	......	......	......	1.87	3.00	2.97	......	......	......	......
Fort Egbert...	1907	1.45	.21	.75	.25	.40	1.89	1.48	1.98	1.45	1.12	.40	......	......
		2.0	2.0	7.5	.15	.55	......	......	......	......	13.0	4.0	......	......
Do.........	1908	.12	.25	.75	.10	......	2.16	2.47	1.02	1.48	.18	.82	......	......
		3.0	2.5	7.5	1.0	......	......	......	......	......	6.0	7.0	......	......
Fort Gibbon..	1907	1.26	......	.53	0	.30	......	2.58	2.31	2.32	1.22	.03	......	......
		12.6	......	5.0	......	......	......	......	......	4.00	12.0	1.5	......	......
Do.........	1908	.23	.26	.90	0	1.16	......	.96	1.13	1.60	.45	......	......	......
		4.0	6.0	17.0	0	......	......	......	......	2.25	6.0	......	......	......
Kechumstuk..	1907	.12	.20	.27	Tr.	1.30	2.30	1.60	2.14	.49	.72	.40	......	......
		2.0	3.0	4.0	......	12.0	......	......	......	......	9.0	4.0	......	......
Do.........	1908	0	0	.41	.40	1.78	1.77	2.30	2.22	1.35	......	......	......	......
		......	......	5.0	4.0	......	......	......	......	......	......	......	......	......
North Fork...	1907	.69	.28	.27	Tr.	1.34	1.92	1.57	3.19	2.00	1.40	.20	......	......
		15.5	3.0	3.0	......	4.0	......	......	......	5.0	12.0	2.0	......	......
Do.........	1908	.50	......	......	......	......	......	......	......	......	......	......	......	......
		5.0	Tr.	......	......	......	......	......	......	......	......	......	......	......
Poker Creek...	1907	......	......	......	......	......	......	......	1.40	3.70	1.70	.25	1.07	......
		......	......	......	......	......	......	......	......	......	24.0	3.3	6.8	......
Do.........	1908	......	1.32	......	.42	.58	1.80	2.02	.99	2.45	.75	......	......	......
		......	10.5	......	5.0	......	......	......	......	4.5	6.9	......	......	......
Rampart......	1907	1.17	.44	1.17	.02	.44	1.64	2.29	3.38	2.52	.65	.55	......	......
		12.0	4.5	12.8	2.5	......	......	......	......	......	......	6.3	......	......
Do.........	1908	1.08	.52	.81	.58	.82	1.38	1.13	.46	1.56	.39	......	......	......
		11.5	6.9	8.1	......	......	......	......	......	......	5.10	......	......	......
Summit road house.......	1907	......	......	......	......	......	......	2.71	3.27	[a]3.33	......	......	......	......

[a] September 1-22.

NOTE.—Where there are two lines rainfall or melted snow is given in the first line; snowfall in the second line.

TABLE 20.—*Summary of precipitation records, May to August, inclusive, at stations in Yukon-Tanana region.*

Station.	Maximum.		Minimum.		Mean, inches.	Duration of records.
	Inches.	Year.	Inches.	Year.		
Fairbanks..............................	5.73	1906	2.92	1908	4.60	1906–1908.
Circle..............................	4.15	1907	2.44	1908	3.30	1907–8.
Rampart..............................	7.75	1907	3.79	1908	5.58	1905–1908.
Fort Egbert..............................	6.31	1908	4.87	1906	5.75	1903–4 and 1905–1908.
Fort Gibbon..............................	10.26	1905	3.30	1904	5.76	1903–1908.
Kechumstuk..............................	9.06	1906	3.66	1905	6.73	1904–1908.

Table 20 shows that a total precipitation as high as 10.26 inches or as low as 2.44 inches may be expected during the mining season. In general, the season of 1908 was one of low precipitation in the Fairbanks, Circle, and Rampart districts. Kechumstuk, Fort Egbert, and the Dawson country had perhaps more than a normal amount. The precipitation was above the normal also in a small area at the head of Chatanika, Twelvemile, and Preacher creeks, the records at Charity Creek, tributary to the Chatanika, showing 6.73 inches, which accounts for the fact that the run-off of Chatanika River was higher at the station near Faith Creek than at the Poker Creek station, and higher at these two stations than at those on other streams studied.

HYDRAULIC DEVELOPMENTS.

FAIRBANKS DISTRICT.

Little work has been done in the Fairbanks district toward constructing ditch lines from larger drainage areas to obtain additional water, present developments being confined to small ditches which convey water to mines in their immediate vicinity on the creeks from which they draw their supply.

The district lies in three drainage basins, separated by high dividing ridges, and in order to supply the producing creeks in one basin with water by ditch line from another the ditch must have a high elevation, which throws its intake so far into the headwaters that the ditch has only a small drainage area from which to draw and consequently carries but little water. The records kept during the season of 1907 prove conclusively that had the proposed high-line ditch from the upper Chatanika basin to the mining camp been built it would have had, instead of a daily supply of 125 second-feet as was estimated, less than half that amount during the greater part of the open season.

In the spring of 1908 water began to run in the mining creeks and the more open country from the 20th to the 25th of April, and by the 1st of May the larger streams were breaking up. If the run-off of 3 to 5 second-feet per square mile incident to the break-up during the month of May and part of June could have been distributed through July and August an adequate supply would have been at hand for any reasonable development. Could storage be provided for this period of excessive run-off, a number of projects which have been considered in the Fairbanks district would have a brighter aspect; in fact, they could rightly be considered as commercial possibilities.

The development of water power for electric transmission in the Fairbanks district seems worthy of consideration. Records relating to such development have been kept in the Little Chena drainage basin for two seasons, and in the spring of 1908 similar records were started on Washington Creek.

CIRCLE DISTRICT.

GENERAL CONDITIONS.

The situation in part of the Circle district is more favorable for hydraulicking than that in the Fairbanks or Rampart regions. The camps on Mammoth and Eagle creeks lie on streams of relatively high gradients and consequently the water supply, though small, can be delivered to the mining property by comparatively short ditch lines, which give high heads for operating.

Up to 1906 practically the only hydraulic development in this district was a small plant on North Fork of Harrison Creek, but owing to miscalculations the project proved a failure. However, considerable construction work was done during 1908.

EAGLE CREEK.

The ditch that taps Miller Fork of Eagle Creek about 1 mile above its mouth, started by Berry & Lamb in 1907, was finished in 1908. It carries the water to a storage reservoir on Mastodon Fork. From this reservoir a small ditch conveys the water for about 2 miles along the left bank of Eagle Creek, to a point where a 200-foot head is obtained for hydraulicking. This ditch was not completed until early in July and consequently could not utilize the water from the spring break-up. The storage reservoir was not finished until the end of the season, and very little hydraulicking was done.

The method employed at the Eagle Creek plant is somewhat different from the usual hydraulic methods practiced in Alaska. A channel was first ground sluiced along the bed of the creek, and the sluice boxes were set in it. On the side of the sluice box opposite the pipe line an iron back stop was erected. The plan is to elevate the auriferous gravels by the use of water direct from the nozzles. This method requires at least two nozzles in operation at the same time—one for washing gravel against the back stop, from which it falls into the sluice boxes, and the other for furnishing at the head of the boxes water sufficient for sluicing.

PORCUPINE CREEK.

About 6 miles of ditch were built in 1908 along the right bank of Porcupine Creek. The ditch taps Bonanza Creek about 2 miles above its mouth and leads the water to ground on Mammoth Creek near the mouth of Miller Creek, where a head of about 500 feet is obtained. The water will be used for hydraulicking the Mammoth Creek flats.

RAMPART DISTRICT.

GENERAL CONDITIONS.

The situation concerning water supply in the Rampart district is similar to that in the Fairbanks district. The topography is most unfavorable to an outside supply by gravity, and it seems that water will have to be obtained by pumping unless some extensive system of storage can be devised. The producing creeks are all small and supply a very meager amount of water during the greater part of the mining season. Present data fail to show where any extensive system of ditch construction for carrying water to the mines is warranted.

MINOOK CREEK GROUP.

Very little if any new work was done on the Minook Creek side of the Rampart placer region in 1908. The hydraulic elevator on Hoosier Creek was operated for a short period in June and September. The work on Little Minook Creek was carried on as usual by the operation of splash dams. On Hunter Creek some hydraulicking was done, but in this section, as elsewhere in the Yukon-Tanana region, the work was very much hampered by lack of water, and during July and August was practically at a standstill.

BAKER CREEK GROUP.

The Baker Creek diggings are situated on the north or right bank of Tanana River, about 150 miles below Fairbanks. In 1907 Frank G. Manley, of Baker Hot Springs, completed several small ditches to convey water for mining the bench gravels on Thanksgiving and Pioneer creeks. The ditch for work on Thanksgiving Creek taps New York and California creeks a short distance above their confluence. It is about 4 miles long, is 5 feet wide, and has a grade of about 6¾ feet to the mile. The water is used for ground stripping and for washing gravels that are shoveled into the sluice boxes. The What Cheer Bar ditch taps Pioneer Creek well toward its headwaters and carries the water along the right bank for use on Seattle Bar and What Cheer Bar. The water is used principally in the same way as on Thanksgiving Creek.

During 1908 Jerome Chute built a small ditch for operations on Eureka Creek above Pioneer Creek. There are several other small ditches that carry water for use on Glen, Gold Run, and Chicago creeks. Owing to the scarcity of water, very little work was accomplished during the last summer, except the stripping of ground to get mining property in shape for shoveling in.

SULLIVAN CREEK.

During the summer of 1908 a short ditch line was constructed along Sullivan Creek for working ground near the mouth of Tufty Gulch. Several other small ditches were in process of construction.

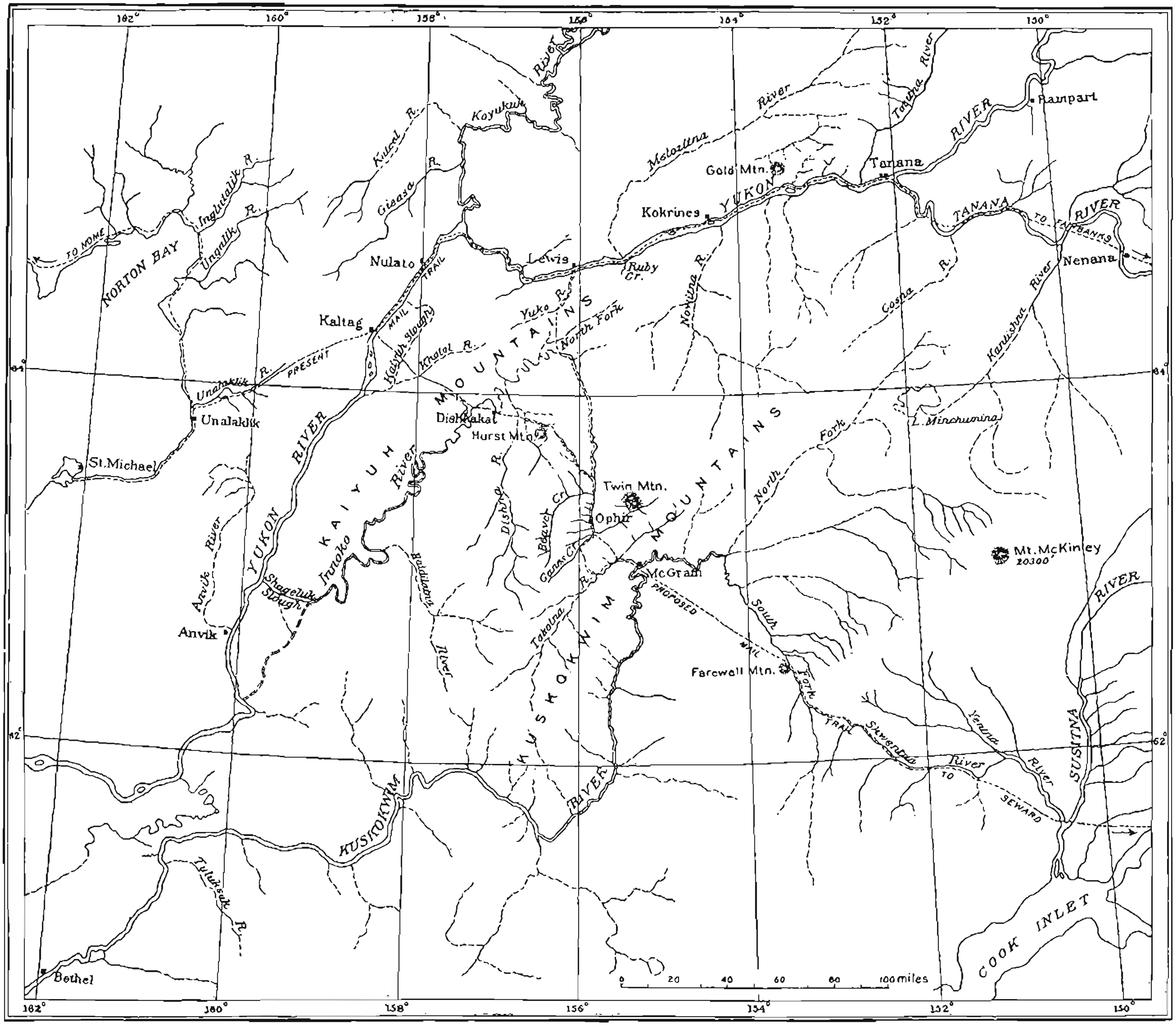
CONCLUSIONS.

Throughout the Yukon-Tanana region mining in general has been carried on by means of the meager water supply from individual creeks, with very little consideration for methods or economy. Fortunately, most of the ground that has been worked has been wonderfully rich, and the miner has been able to follow haphazard methods and still reap a substantial harvest. The time is rapidly approaching when cheaper ground will have to be worked, and the miner of the future will be forced to give careful consideration to the water supply. The camps have already attained a stage of development that demands a greater amount of water than the local creeks can furnish.

The topographic relation of the mining camps to the surrounding country is not favorable to the procurement of an outside water supply by gravity, ditch lines from the larger drainage areas being not altogether practical. The region lies in a semiarid belt, having an annual precipitation of only 10 to 18 inches. Consequently it is necessary to look to streams of considerable drainage area to obtain a supply commensurate with any reasonable development. This necessity usually places the supply at too great a distance, or at too low an elevation for use on the auriferous gravels.

There are several streams in this region, however, so situated that their development for transmission of electric power to the mining camps seems practical. Table 18 indicates the most desirable of these streams. Unfortunately, however, the data are insufficient to show what these streams are actually doing, and on account of a lack of development in their drainage areas it is very difficult to procure the desired information. The diagram (fig. 17) shows that the streams that have been studied exhibit a considerable degree of similarity in run-off per square mile of drainage area, and the diagram and the accompanying table of drainage areas may be used as a guide to the localities most favorable for electric development.

The small miner can not be expected to investigate possible water-power developments, but the capitalist looking for an investment could well afford to consider them. There is little doubt that an era of what is termed low-grade mining has a future in this country. The coming of better transportation facilities, modern machinery, and up-to-date methods is bound to create a demand for power that can not be supplied by the moderate growth of timber which is used at present for fuel to generate steam. Modern methods in electric transmission make hydro-electric development seem the most feasible solution of the water-supply and power problems of the Yukon-Tanana region. This method of utilizing the available water supply would dispense with many miles of ditch construction and would furnish the camp not only with water but also with power for running the hoist, elevating the tailings, pumping water from the mines, lighting the underground work, pumping water to the sluice box, and, in some localities, running dredges.



SKETCH MAP OF LOWER YUKON AND KUSKOKWIM VALLEYS.

GOLD PLACERS OF THE RUBY CREEK DISTRICT.

By A. G. Maddren.

INTRODUCTION.

Late in the summer of 1907 a report was circulated that prospects of placer gold had been discovered on Ruby Creek, a small stream about 3 miles long that flows into Yukon River on its south side, opposite the mouth of the Melozitna. (See map, Pl. IX.) The discovery was made at the mouth of the creek, in some fine gravel at the level of the spring high-water mark of the Yukon. As this locality is very accessible, especially from the settlements of Tanana, Rampart, and Fairbanks, a good many men went to Ruby Creek during the latter part of 1907, and extensive tracts of land on a number of the streams were located as placer-mining ground. About 30 men remained in the vicinity of Ruby Creek during the winter of 1907–8, prospecting on the various creeks in this district. A number of shafts were sunk during the winter, largely with the aid of three small steam boilers, but the results of these operations do not appear to have been very encouraging, for by July, 1908, most of the men had left the district, and Discovery claim, on Ruby Creek, was the only property that was being actively worked. The writer spent seven days in this locality in July, 1908, and made a hasty examination of the general geology.

GEOGRAPHIC SKETCH.

LOCATION.

The locality known as the Ruby Creek district—from the name of the small stream on which gold was first discovered in the area—is situated along the south bank of Yukon River, directly south of and opposite the mouth of Melozitna River, about 175 miles below the town of Tanana or 110 miles above Nulato, the two nearest large settlements on the Yukon.

The district is within the St. Michael recording precinct, as it is now defined by the court for the second judicial division of Alaska. The nearest points where supplies may be obtained are at the village of Kokrines, 24 miles up the Yukon, and at Lewis's store, 23 miles down the Yukon. The United States military telegraph station called Melozi is on the north bank of the Yukon 8 miles below Ruby Creek. The region is easily reached throughout the year by way of Yukon River.

RELIEF.

For a distance of 10 miles along the south bank of the Yukon the Ruby Creek area presents rolling hills from 400 to 500 feet high that overlook the river with rock bluffs 200 to 300 feet high. These hills may be considered to form the northeast end of the Kaiyuh Mountains, which extend for about 175 miles toward the southwest to lower Innoko River. The Ruby Creek hill country is noteworthy as being the only place along the south side of Yukon River between Tanana River and Bering Sea, a distance of over 800 miles, where the highland is made up of the older rocks, and bluffs of consolidated bed rock form the immediate bank of the Yukon. The south bank of the Yukon throughout all the rest of this distance is made up of low bluffs of unconsolidated, alluvial silt, which covers the older hard-rock formations for distances of 5 to 20 miles or more back from the stream. The rolling hills near the Yukon gradually rise to low, dome-shaped mountains 1,200 to 1,500 feet in height 10 miles south of the stream, and these low mountains continue southward and southwestward to the Innoko Valley.

DRAINAGE.

The drainage of this area is of the kind that may be expected to characterize a low, rolling region. None of the streams carry much water and their grades are not steep. Nowitna River discharges into the Yukon from the south about 36 miles above Ruby Creek, after meandering across extensive flats that extend southward from the Yukon for 20 miles or more. Along the wide valleys of the larger tributaries of the Nowitna broad strips of flat bottom land extend far back into the hills, and the Ruby Creek hills descend eastward to these flat lands of the lower part of the Nowitna Valley. A large western tributary of the Nowitna called the Solatna rises southeast of the northeast end of the Kaiyuh Range, which is formed by the low-domed mountains southwest of the Ruby Hills. The largest streams whose sources are in the Ruby Creek district flow toward the east into the Nowitna Flats. These streams, named in order from north to south, are Big, Independence, and Eureka creeks and the headwater tributaries of the Solatna—Wolf, Joe, New York, Beaver, and Dome creeks. There are also several large creeks that rise in the Ruby Hills and drain toward the west, across the wide flats that are occupied by sloughs, small lakes, and the meandering lower course of Yuko River, which discharges into the Yukon about 23 miles below Ruby Creek. Only two of these streams have been named—Ora and

Main creeks; both empty into a slough that leaves the Yukon just below the bluffs along the main river.

Big and Ora creeks run east and west, respectively, 3 or 4 miles south of the Yukon and somewhat parallel to it. The divide that separates these creeks from the Yukon is the southern boundary of the strip of hilly country, from 2 to 3 miles wide and about 10 miles long, that extends along the south bank of the Yukon with the bluffs already mentioned overlooking the river. The bluffs are separated by small valleys, at right angles to the Yukon, that are occupied by creeks from 1 to 3 miles in length. Named from east to west these streams, which drain directly into Yukon River, are as follows: Flat, Center, Melozi, Ruby, Short, and Hannah creeks. They are all small streams with a very scanty supply of water. Thus, the Ruby Creek hills and the low dome-shaped mountains that rise to the southwest of them form a divide between waters that flow eastward into the Nowitna and westward to the Yuko Flats, and thence into Yukon River.

VEGETATION.

The vegetation of the Ruby Creek district is that typical of this part of the Yukon Valley. The white spruce is the only tree of importance, and it grows to a good size only on the flats, being small and scrubby on the hills.

GEOLOGIC SKETCH.

The bed rock of the hills and low mountains of the Ruby Creek district comprises a variety of old altered sedimentary rocks—crystalline limestones, garnet-mica schists, and mica-quartz schists with so fine a grain that they may well be called coarse slates. These rocks occur in the bluffs along the Yukon. The bluff exposures show local zones of shearing, with quartz stringers deposited along the fractures. Near Flat Creek the results of shearing in the schists are somewhat pronounced and large quartz lenses and stringers occupy the openings thus produced. On the surface these quartz deposits are of the lens or bunch type, with no particularly uniform trend or thickness for any considerable distance. Two principal exposures of quartz were seen, one about 100 yards below the mouth of Flat Creek that shows a maximum thickness of 4 or 5 feet on its face, and another about 100 feet downstream that is several feet in thickness but of no marked linear extent. Assays of samples of quartz from these exposures are said to have shown good values in gold. In 1906 a tunnel, now caved in, was run in on the largest of these quartz deposits, it is said for a distance of 150 feet, with the object of following the quartz that shows on the surface of the bluff. After the work had progressed for a few feet it was found impracticable to follow the irregularities of the quartz stringers with a straight tunnel, and most of the tunnel was run through the slaty schist country rock, as is shown by the material on the dumps. In brief, the bodies of quartz were found to be too irregular and uncertain in extent to be mined by tunnels, and what has been demonstrated at this place will probably be found to be true of any other quartz deposits in this region.

Farther inland, quartzite schists, mica-quartz schists, cherty limestone, and cherts make up the low mountains. All these rocks have been considerably changed from their original form by metamorphism, but not to a degree that noticeably obliterates their sedimentary origin and arrangement. They are similar to and are presumably to be correlated with formations that occupy large areas of the mineral belt between Yukon and Tanana rivers, 200 miles to the east.

The rocks of the district have been intruded to some extent by dikes of igneous rock. These dikes are of diabasic and granitic types.

The alluvial deposits that fill the bottoms of the valleys are moderate in amount and thickness, and appear to be the gradual accumulations produced by a meager drainage such as now prevails. The rounded forms of the hills and mountains suggest that the present aspect of the country is the result of a long period of uniform erosion.

GOLD.

Colors of placer gold are reported to have been found in the alluvial deposits of nearly all the streams that rise in the Ruby Creek district, but no rich gold-bearing gravels have yet been found.

In the fall of 1907 a number of men, following the usual practice adopted when a new placer district first attracts attention, located practically all of the alluvial bottom lands along the streams of this district as placer-mining ground. These locations comprised both association placer groups containing 160 acres and single 20-acre tracts. Large areas of the valley slopes were also located as so-called "bench claims."

During the winter of 1907–8 about 30 men prospected for placer gold in the alluvial deposits of the creeks by sinking a number of holes to bed rock. Most of this work was done on Ruby and Big creeks, but a few holes were sunk on Boston Creek and two of its head-water tributaries, Logger and Boston gulches. Some prospecting was also done on the headwaters of the Solatna—Beaver and Dome creeks. One hole that did not reach bed rock was sunk on Melozi Gulch.

On Big Creek about 15 holes from 15 to 60 feet deep were dug to bed rock. The deeper holes are on the upper part of the creek. Farther downstream the unconsolidated deposits are not so thick. Washed gravel of schist rocks lies on bed rock in a layer from 1 to 7 feet thick and is overlain by sandy clay and muck. Bowlders of igneous rocks and quartz up to 1 foot in diameter are also present. It is reported that colors of gold were found in all the holes on Big Creek. A good deal of iron pyrite is included in the gravel, both as washed grains and inclosed or attached to the larger fragments of slaty bed-rock material.

The unconsolidated valley deposits on Ruby Creek probably average about 15 feet in depth. They are composed of muck, loamy sands, patchy layers of flat schist and slate pebbles, and a good many water-rounded bowlders of igneous rock. The bed rock is schist, slate, and limestone in the form of rectangular blocks and slabs.

The results that had been obtained by the close of the winter prospecting season do not appear to have been of sufficient promise to encourage the prosecution of summer work, except at the mouth of Ruby Creek. In July, 1908, two men were carrying on open-cut work on Discovery claim, the first above the Yukon. They were working about one-eighth of a mile back from the river on the east side of Ruby Creek, in a bank of muck, silt, gravel, and bowlders. A small ditch had been built with an intake about 400 yards above to bring a sluice head of water to the open cut. The bed rock in this cut is a blocky, impure, banded crystalline limestone similar to that exposed on the Yukon in the "lime bluff" just below the mouth of Ruby Creek. It is in the shape of sharp-cornered rectangular blocks and bricklike slabs that have not been rounded by erosion. It is all in a shattered condition, so that it has to be handled in working.

The material handled consists of this loose blocky limestone, flat pieces of coarse mica slate similar to that seen above and below Ruby Creek on the Yukon, close-grained cobbles of diabase, and large, heavy bowlders of medium-grained diorite, similar to that seen in a large dike on the Yukon. These bowlders are from 12 to 18 inches in diameter and are well rounded. The large, heavy bowlders do not lie on bed rock, as might be expected, but for the most part several feet above it in the muck. The finer wash is below the muck, on bed rock, and is made up mostly of flattish slate pebbles mixed with loamy sand. This sand also fills the spaces between the blocky limestone fragments of the bed rock. Mixed with the sand and in patchy layers within it and on top of the blocky limestone are finer waterworn gravels consisting of slate pebbles, mostly flat. These layers of fine washed material do not appear to be continuous for any great extent, nor are they very thick. They carry most of the placer gold, which is in the form of fine, flaky, light particles, not as large as bird shot. Owing to this fineness, it is hard to save all of the gold in the sluice boxes.

Up to July, 1908, about $1,000 worth of this fine gold had been produced from the open cut on Discovery claim on Ruby Creek.

PLACERS OF THE GOLD HILL DISTRICT.

By A. G. Maddren.

INTRODUCTION.

In 1907 deposits of placer gold were found on several small streams that flow into the Yukon from the north about 25 miles below the town of Tanana. Further prospecting showed that placer gold occurs also in streams that lie across the divide and flow northward into the upper course of Melozitna River. This district may be easily reached by way of Yukon River, and as soon as the news spread that placer gold had been found on these creeks, all of the alluvial ground on them was located for placer-mining purposes. Most of the locations were made by association groups, covering 160 acres each, a plan which enables a few persons present on the ground, provided with the powers of attorney of a number of absent persons, to tie up completely many thousands of acres of alluvial gold-bearing deposits. As the healthy growth of the placer-mining industry depends largely on individual effort, there has not been as much prospecting in the Gold Hill district as its accessible situation and other favorable conditions appear to warrant. About 25 men spent the winter of 1907–8 in this locality prospecting on the various creeks. The writer made a hasty examination of the district from June 25 to July 4, 1908.

GEOGRAPHIC SKETCH.

The name Gold Hill district is loosely applied to an area in the central Yukon Valley, about 25 miles below the mouth of Tanana River, that lies along the north side of the Yukon and extends westward from the western slopes of the valley of Tozitna River to the higher mountains north of the United States military telegraph station called Birches. The Yukon forms the southern boundary of this district, and its northerly extent is limited in a general way by the headwater drainage of Melozitna River. Roughly, the district embraces an area extending 30 miles east and west and 20 miles north and south, covering about 600 square miles. Most of this area consists of mountains that form a divide extending east and west about midway between the main courses of the Yukon and the headwaters of the Melozitna.

This divide separates the region into two areas that are drained to the north and south by creeks of moderate length and volume. The principal southward-flowing streams on which placer locations have been made, named from east to west as they join the Yukon, are Grant, Illinois, and Mason creeks and their tributaries; those flowing northward into the Melozitna, named in the same order, are Moran, Eureka, Hudson, Langford, and Tiffany creeks and their tributaries. All these streams are of moderate length and volume. The topography is one of comparatively low, rolling mountains with wide, moderately sloping valleys that appear to be the result of a long period of rather uniform downcutting and wearing away of the country rock by a drainage system similar to that of the present day. With the exception of the silts along the immediate banks of the Yukon, there are no detrital deposits that occupy elevated positions with reference to the present drainage in the sense in which this distinction is usually made; that is, all the alluvial deposits of the streams now lie in the bottoms of the valleys and may be properly classed as stream deposits or creek gravels, none of them being sufficiently above the present stream grades to place them in the class usually called bench gravels.

The mountains of the district have an average altitude of about 3,000 feet above sea level. For the most part they form wide undulating ridges, but a few of the mountains rise to heights of 4,000 feet and have more rugged forms. Yukon River cuts into the southern slopes of these mountains and exposes bed-rock bluffs where the ridges between the creeks come down to the main river. The tributary valley spaces between the ridges show low banks of recent alluvium about 10 feet high and also a few benches of the older silt deposits that stand in places from 20 to 50 feet above the river level.

The Yukon has an elevation of about 300 feet above the sea at Gold Hill. Owing to this low level, the tributary valleys along the south side of these mountains have been eroded more deeply than those on the north side, and they all have considerable grades, especially in their upper portions. These valleys are in the form of wide basins extending from 5 to 10 miles back into the mountains and opening out into the Yukon Valley with widths of one-half mile to 3 miles.

The valleys on the north side of the mountains lie from 600 to 1,000 feet above the level of the Yukon, and for this reason the headwater streams corresponding in length to those flowing into the Yukon have lower grades and their valleys have not been eroded so deeply into the country rock as those on the south side of the divide.

GEOLOGIC SKETCH.

The low, rolling mountains of the Gold Hill district appear to be made up entirely of a typical development of an assemblage of metamorphic rocks that have been given the general name Birch Creek schist. This name was first used by Spurr for the bed-rock formations in the Birch Creek gold-placer district, and he considered the rocks of Gold Hill to belong to the same group because of their similarity. These schist rocks make up a general group of formations that have been recognized as a characteristic part of the bed rock in all the better-known placer-mining districts of the Yukon Valley. In the Gold Hill area the predominating rocks are quartzite schists and micaceous quartz schists. More or less vein quartz occurs in the schists, mostly in the form of small and nonpersistent stringers and lens-shaped bodies. Many of these quartz fillings appear to have been shredded and faulted by movements in the rocks that have occurred since most of the quartz was deposited, so that they can not be traced very far. Much of the quartz is recemented by iron mineral matter, and some of it is known to carry gold.

ECONOMIC DEVELOPMENTS.

Probably the first attempt to open a lode mine in the interior of Alaska was made about 1890 at the locality since known as Gold Hill. The prospect on which work was done is situated on the river slope of a ridge that comes down to the north bank of the Yukon 20 miles below Tanana. A tunnel 110 feet long was run in on a vein of sheared and broken rusty quartz that outcrops on the surface with a width of 2 or 3 feet. The tunnel is now abandoned and caved. It is said that the vein became more and more broken away from the surface and that at the breast only a few streaks of it remained in a decomposed schist, between talcose schist walls, in a country rock of micaceous quartz schist. The quartz taken from this tunnel is known to be gold bearing, but the prospect has not been developed into a mine. This occurrence of gold-bearing quartz is similar to that seen in the Ruby Creek district.

Placer gold is reported to occur in the creek gravels of all the streams that have been named, but, although many thousands of acres of ground have been located, only a very small amount of prospecting work has been done, because there have not been many men in the district.

About 20 holes were dug in the stream deposits during the winter of 1907–8. All of this work was done with the aid of wood fires for thawing the frozen ground, as there are no steam prospecting plants in the district. Some of these holes reached bed rock and showed prospects of gold; others tapped live water in thawed ground and did not reach bed rock.

Open-cut ground-sluicing operations have been begun at several localities in the Gold Hill district, but owing to the scarcity of water, due to the unusual dryness of the summer of 1908, very little gold has yet been produced. Some gold found on the head of Mason Creek is mostly in the form of small rounded pellets about the size of bird shot.

GOLD PLACERS OF THE INNOKO DISTRICT.

By A. G. Maddren.

INTRODUCTION.

Since the discovery of placer gold in paying quantities on some of the headwaters of Innoko River, in 1906, that part of Alaska has received more attention from prospectors looking for new fields than any other district in the Yukon Valley. During the last three years probably as many as 1,500 men have visited the Innoko country and remained there for the whole or part of a season. Although it is reported that prospectors visited the Innoko in 1898, during the earlier days of the gold excitement in Alaska, they do not appear to have been much encouraged by what they found, for they did not remain in the valley. The real discovery of placer gold in commercial quantities was made during the summer of 1906 by a party of prospectors consisting of Thomas Gane, F. C. H. Spencer, Mike Roke, and John Maki. These men came into the headwater country of the Innoko Valley from the Kuskokwim and found a few colors of gold on the bars of the main Innoko a short distance below the mouth of its principal headwater tributary, now named Ganes Creek. Later in the season of 1906 they ascended Ganes Creek with the hope of finding the source from which these colors of gold were derived, and during August or September they located Discovery claim on Ganes Creek about 10 miles above its mouth. At this time, their provisions having become exhausted, the party returned to the Kuskokwim for a new outfit of supplies; but these they failed to find there, so they again crossed to the headwaters of the Innoko and descended that river to the settlements on the lower Yukon. They returned to Ganes Creek during the winter of 1906–7, hauling supplies with them on sleds. In the meantime news of the discovery had spread to prospectors who were scattered in various parts of the upper Kuskokwim Valley, so that during February and March, 1907, stampeders from the Kuskokwim arrived on Ganes Creek. The news also reached Nulato, on the Yukon, and others rushed to the Innoko from that place and the settlements near by. By early spring encouraging reports of the discovery had reached Nome and Fairbanks, so that as soon as summer navigation of the rivers was possible a great many people were ready to go to the new placer district. It is estimated that during 1907 about 800 or 900 people went to the Innoko from Fairbanks, and several hundred from Nome.

Up to the time of the 1907 summer arrivals attention had been devoted to locating claims on Ganes Creek. Over 50 claims were located on this stream below Discovery claim, and over 80 claims above it. These claims covered all the ground on Ganes Creek from its mouth to its source. Besides the creek claims along the present valley floor, all of the promising bench ground within the valley was located, though more as a last resort by those who had arrived too late to get creek claims than from any particular knowledge as to where the values were to be found, for most of the locating on Ganes Creek was done before the winter snows had left the ground.

Many of those who flocked into the Innoko district in the summer of 1907, finding Ganes Creek completely located, became discouraged and left the country. Others, however, remained and devoted their energies toward prospecting other streams. As a result of this search prospects were found on Little, Spruce, and Ophir creeks, which drain into the Innoko to the northwest of Ganes Creek. These streams were thoroughly covered by locations during the summer of 1907, although gold in paying quantities had not been demonstrated to exist on them at that time. In fact, with the exception of a small production of gold on one or two of the bench claims on Ganes Creek, little was done during the summer of 1907 but to locate a great many claims on nearly every water course within the mountainous part of the upper Innoko Valley. As a result most of those who had come to the region during the summer had by early fall so exhausted their means that they could not remain during the winter, and so left for Fairbanks and Nome.

The recording office for the precinct was established in September, 1907, on Ganes Creek at the mouth of Last Chance Gulch, opposite claim No. 6 above Discovery. It was named Moore City and consisted of about 20 log cabins. This place was the center of settlement at the diggings during the winter of 1907–8.

It is estimated that about 150 men spent the winter of 1907–8 in the Innoko precinct. The greater part of the time of these men was taken up with the task of providing themselves with food from rather distant points on Yukon and Kuskokwim rivers, for entirely inadequate amounts of supplies had been brought to the region during the previous summer. However, some winter prospecting was carried on, notwithstanding the discouraging conditions. Most of the prospect holes were sunk on Ganes Creek, but a few were put down to bed rock on Little and Ophir creeks. In the latter part of January, 1908, rich auriferous gravels were discovered by different parties at several separate localities on Ophir Creek within one week. As a result of the finds, all but three or four men stampeded from Ganes Creek to Ophir Creek in February, 1908. From the meager facts at hand very optimistic surmises were hastily made concerning the width, length, and richness of the pay streak that was presumed to extend along the whole course of Ophir Creek. Without further investigation, enthusiastic reports were at once dispatched to Fairbanks and Nome, and had the effect of restoring a keen interest in the Innoko country. As a result half a dozen small stern-wheel river steamboats went from Fairbanks to the Innoko on the opening of river navigation early in June. These boats carried about 500 persons and several hundred tons of miscellaneous cargo, and landed them at the upper limit of navigation for such boats on the banks of the Innoko at points from 75 to 100 miles below Ophir Creek.

In the meantime a new settlement had been established on upper Innoko River at the mouth of Ophir Creek, and this place was the objective point for most of those bound for the diggings. Attempts were made to form settlements at the points where the various steamboats landed their passengers and freight, but these settlements were maintained for only a short time.

The United States commissioner removed the recording office for the precinct from Moore City to Ophir early in the summer of 1908. At the present time Ophir, with a population of about 150 whites, and Dishkakat, with a population of about 25 whites, are the only two settlements of a substantial character within the Innoko Valley. Ophir is in the mining area, and Dishkakat serves as a halfway station between the diggings and the settlements of Anvik and Kaltag, on the lower Yukon.

During August and September, 1908, the writer made a hasty examination of the region drained by Innoko River, more especially of the area of its southern headwater tributaries.

CLIMATE.

The temperature, precipitation, and seasons of the Innoko Valley are those which prevail throughout the lower Yukon country. The streams usually freeze over in October and thaw out in May. Early in September killing frosts make the grass practically worthless for forage. Locally, in the narrow valleys and gulches where the drainage is feeble, much of the alluvial material remains permanently frozen, but in the wider bottoms of the larger streams and the main river the alluvial deposits probably carry live water in some quantity throughout the year.

In temperate climates the superficial winter freezing temporarily consolidates only a small part of the detrital cover, but in most of

Alaska the effects of the longer cold period are such that unfrozen detrital ground, even in summer, is the least common kind. The final result of the annual superficial freezing in Alaska tends to add to the amount of detrital material that remains permanently consolidated by the frost.

The alluvial covering of the bed-rock floor is in general permanently frozen over most of that part of Alaska lying north of the area that drains into the Pacific Ocean, though there are local variations of this condition. The extent and development of the ground frost depend on the extent, position, thickness, and proportions of the gravel, sand, clay, and humus members that compose the alluvium and the amount of underground and surface water present. Generally the alluvial deposits are permanently frozen where they are not well drained by an abundant supply of surface water and where the circulation of underground water is feeble. There is, however, no uniformity of condition even within small areas, either vertically or horizontally, for often while shafts are being sunk in ground that appears to be solidly frozen layers charged with live water are encountered and flood the workings in such quantity that the workers are "drowned out."

In general the climate of Alaska tends to retard the processes of stream erosion and transportation. The almost universal frost binder, together with the widespread humus and muck insulation it fosters and the consequent arrested condition of the available supply of running water for the greater part of the year, prevents the streams from moving and reworking the otherwise loose-textured detrital deposits and adding new material to them as rapidly as they would if the material were wholly unfrozen and the flow of water continuous. Probably the concentration of the placer gold in this country is a slower process than it would be under the conditions of a more temperate climate, where the alluvium would be moved more frequently, the lighter materials carried farther, and consequently the heavier gold concentrated more rapidly.

VEGETATION.

The valley floors and the lower slopes of the mountains in the Innoko country are mostly covered by the characteristic blanket-like accumulation of sphagnum mosses. This moss covering, with low bushes, is thickest in the lowlands, and gradually becomes thinner as the hillsides are ascended, except in favorably moist places and on cool sheltered slopes. The highest ridges are generally well covered by mosses, heathers, stunted bushes, and grasses. The highest mountain tops of this region are the only places where a ground-covering vegetation is sparse or absent.

Several kinds of grasses suitable for summer forage for horses and cattle grow in the rather meager meadow areas in the valleys and in open places, many of them old burnt areas, on the ridges. In the meadows and along the banks of the streams where they are free from brush a moderate amount of grass may be cut and cured into hay of fair quality if the season is not too rainy and advantage is taken of the sunny days.

Timber suitable for fuel grows in moderate abundance throughout the larger valleys, up the gulches, and locally well up the slopes of the lower ridges. On the evenly undulating tops of the ridges timber is usually scarce. White spruce is practically the only tree that reaches a size suitable for cabin logs or sluice-box lumber, and even this is not plentiful in desirable sizes except in small patches along the valleys of the main river and its larger tributaries. The more scrubby black spruce, together with stunted white spruce, grows in scattered clumps on the slopes of the ridges.

In swampy areas in the middle Innoko Valley there are considerable groves of larch, or tamarack. In these localities it reaches a diameter of 8 to 10 inches and a height of 30 feet. Smaller larch saplings are scattered in the smaller valleys and on their lower slopes.

Birch grows here and there throughout the region and also in thick groves of considerable extent on the drier banks of the lower Innoko, where it has been cut as cord wood for the small river steamboats.

GEOGRAPHIC SKETCH.

LOCATION AND EXTENT.

The Innoko is the lowest noteworthy tributary of the Yukon entering from the left. It is about 500 miles long and with its tributaries drains the largest part of an extensive area that lies between the central lower courses of Yukon and Kuskokwim rivers and is approximately bounded by the meridians of 156° and 160° west longitude and the parallels of 62° and 64° north latitude. (See Pl. IX.)

RELIEF.

This extensive area as a whole is primarily one of moderately mountainous character. It is mostly occupied by broad, undulating, rather even-topped ridges separated by deep, relatively narrow valleys. The average height of the ridges above the stream beds is from 800 to 1,200 feet. Isolated mountain masses rise above the general level of the ridges, more especially in the headwater region of Innoko.

The Innoko Valley is separated from the Yukon basin to the northwest by the Kaiyuh Mountains, which extend from the south side of the Yukon, opposite the mouth of Melozitna River, in a southwesterly direction to the lower course of the Innoko, at the point where it is joined by Shageluk Slough, a distance of about 175 miles. These mountains are comparatively low, being little more than high hills at their northeast and southwest extremities. They are crossed by several low, flat passes, especially where the north fork of the Innoko lies opposite Yuko River, which drains into the Yukon, and also where Kluklakl̓atna River, a lower tributary of the Innoko, heads against a branch of the Khotol on the Yukon side. The higher parts of the Kaiyuh Range between these low passes rise to a maximum height of about 2,000 feet above sea level. Throughout their extent they present rather smooth, evenly rounded, and undulating outlines with no sharp peaks.

To the southeast the valley of the Innoko is divided from that of Kuskokwim River by a range of the Kuskokwim Mountains, which, although not uniformly high, form a definite belt that trends northeast and southwest. These mountains are higher and more rugged than the Kaiyuh Mountains, and the passes across them are not so low and flat as those through that range. In the Kuskokwim Mountains isolated mountainous masses of greater or less extent rise to over 4,000 feet above sea level, and at least one area, lying between the heads of Ganes and Beaver creeks and Dishna River, is occupied by a comparatively high, rugged group that was formerly the center of extensive local glaciation. This group stands up in rugged contrast above the more flat-topped, gently rolling forms presented by the surrounding mountains. It presents a thoroughly glaciated appearance, with ample and well-developed cirque basins and U-shaped valleys within the mountains themselves, extensive deposits of morainal material spread out as broad lobe-shaped ridges, and piedmont benches extending from them into the wide valleys around the group.

DRAINAGE.

The Innoko Valley presents two kinds of drainage that naturally divide it into two large and distinct provinces, corresponding approximately with the upper and lower halves of the valley. The upper province is characterized by hills and low mountains and is drained by clear streams that flow with currents of moderate strength in valleys whose flood plains are well developed to a width commensurate with the amount of water carried by the main river and its tributaries. In this province the streams flow for the most part over flat valley floors composed mostly of well-washed gravels, but also locally to some extent through small areas of sands, and here and there through deposits of silt. Toward the headwaters there are a few localities where the streams run directly upon bare bed rock. The upper province is one where erosion and transportation by the streams have been going on for a long time and are still in progress.

On the other hand, the lower half of the Innoko Valley is an area characterized by stream deposition. The main river and its principal tributaries in this province meander widely over a great extent of low, flat country made up of silt and clay deposits. The channels and banks are for the most part cut in these fine-grained water-laid sediments, although here and there in its lower course the Innoko touches low rock bluffs on its right-hand side as it passes around the southwest end of the Kaiyuh Range and makes its tortuous way toward the Yukon. These low, flat, swampy plains occupy all of the wide belt of country lying between the Kaiyuh and Kuskokwim ranges. They are more than 20 miles wide from east to west and extend from the hilly country of the upper Innoko on the northeast to the great Yukon-Kuskokwim delta on the southwest. In fact, the lower half of the Innoko Valley is merely a tonguelike extension inland between two low mountain ranges of the vast coalescent coastal delta plains of the Kuskokwim and Yukon.

Where the Innoko emerges from its upper valley, its banks are on an average from 10 to 15 feet above the normal stage of the river. Here and there the river cuts banks of silt that are 20 to 25 feet high, but its banks gradually decrease in height downstream, and on the lower river they are in many places only 3 or 4 feet above the usual water level. During the spring freshets the whole lower valley is inundated, and after the floods have subsided large areas of swamps, shallow ponds, and lakes remain over its surface. Good examples of natural levees are built up along the banks of the main course of the lower Innoko as a result of floods and subsequent run-off. Dishkakat and some of the other settlements are located on the higher silt banks, to avoid the spring floods.

The group of mountains between Dishna River and Ganes Creek that now rise to heights of about 4,500 feet were during Pleistocene time occupied by snow and ice fields of considerable local extent. The former glaciers eroded this mountain group strongly and laid down extensive moraines of unassorted angular rock blocks and bowlders about the base of the group and out into the wide surrounding valleys for considerable distances; while the large volumes of water from the melting snow and ice carried considerable quantities of cobbles, gravel, sand, and silt still farther down the valleys and laid them down with some degree of assortment.

The higher silt banks cut by the lower Innoko are considered to have been formed during the glacial period and therefore to be of Pleistocene age. The present course of the lower Innoko cuts through some of these high silt deposits, and no doubt a number of areas of similar old silts are present in the wide expanse of flat country forming the lower province of the Innoko Valley. Nearer the mountains deposits of Pleistocene age appear to be represented here and there by banks of gravel that stand from 20 to 30 feet above the present stream grades.

Except on Ganes Creek, this local glaciation does not appear to have effected any widespread changes in the relative positions or character of the drainage of the southern headwaters of the Innoko, outside of the area surrounding the mountains that was occupied by the ice streams and the débris they carried. This area is now deeply covered by morainal deposits of angular rock fragments and bowlders. Within the area occupied by these moraines, especially on the north side of the mountains, where the glaciers appear to have been most strongly developed and consequently where the glacial deposits are most widespread, the present drainage is all relatively young, for it inherits its arrangement from the land forms eroded by the ice and left after the glaciers had melted.

Outside of the area now occupied by morainal deposits there is, however, one marked exception where the preglacial drainage has been strongly modified as a direct result of the glacial activity. Ganes Creek, one of the streams on which placer gold is found, is at least twice as long as it was before the glacial period, and its volume of water has greatly increased owing to an enlargement of its drainage basin, which is three or four times greater than formerly. Before the glacial period Ganes Creek was little longer or larger than Ophir Creek is to-day, and its valley was confined to the slate formation that occupies the lower half of its present course. Previous to the development of glaciers on the group of mountains situated between the upper valleys of Beaver Creek and Dishna River, the area that now makes up the upper part of the Ganes Creek drainage basin was part of the Beaver Creek valley. One of the marked results of glacial activity was to fill the upper part of the wide Beaver Creek valley deeply with deposits of morainal material. In addition to this morainal filling, the ice streams themselves, when at their maximum extent, appear to have occupied the whole, or at least a large part of this basin, completely covering the previous land surface. When the ice melted, it left the upper Beaver basin clogged with a thick filling of morainal dumps. Although the detailed features of this glacial filling and damming of the upper Beaver Valley are not well known, it is very evident that the former drainage channels were so disarranged that a large volume of the water produced by the melting snow and ice could not find an outlet into the Innoko, toward the northwest, by way of the lower Beaver Valley. As a result, it backed up and found an outlet across the lowest divide to the northeast, into what was then the head of Ganes Creek. The large supply of water that was thus diverted down Ganes Creek rapidly cut a canyon down through the slate bed rock of the former divide. This canyon, which is several hundred feet deep and 5 or 6 miles long, is situated about midway between the present source of the stream and its mouth. The rapidity of the downcutting is shown not only by the typical box-canyon features, but also by the rock-cut bluffs, with bench gravels on top of them, that rise on either side of the valley at intervals below the canyon for a distance of about 8 miles, to the point where its flood plain widens out to coalesce with that of the Innoko.

TRANSPORTATION TO INNOKO VALLEY.

SUMMER ROUTES.

There are two principal summer routes available by which the Innoko placer district may be approached. These are determined by the geographic position of the Innoko Valley between the easily navigable portions of the two largest rivers in Alaska—the Yukon and the Kuskokwim.

YUKON RIVER.

By way of Yukon and Innoko rivers it is about 244 miles from Anvik to Dishkakat, and about 190 miles farther upstream to Ophir, or 434 miles by the summer water route from Anvik to the diggings. As already stated, small river steamboats can deliver freight as far up the Innoko as Dishkakat throughout the season of navigation, from June to October. In early June and at other uncertain times of high water, these boats can occasionally ascend the main river to points within 55 to 75 miles of Ophir.

As the summer of 1907 was one of much rainfall and a consequent high stage of water in the streams, and that of 1908 was one of very scanty rainfall with a low stage of water, a comparison of the navigation limits reached in these two years probably represents the maximum and minimum availability of the Innoko as a route for transporting supplies into the country with steamboats of the size and type now employed. In 1907, during a period of high water, a steamboat with a draft of about 22 inches when loaded reached a point on the upper Innoko about 55 miles below the present town of Ophir. A cargo of 50 or 60 tons of freight might be landed at this distance below Ophir under such conditions of high water. It will probably always be necessary to transport freight from this point to Ophir in small lots of 3 or 4 tons by light-draft flat-bottomed scows, or in 1 to 2 ton lots by still smaller poling boats. In 1908 conditions were not so favorable. Even at the time of the early summer high water the same steamboat could get only within 70 miles of Ophir, and during July and August this boat found it difficult to ascend the Innoko to the village of Dishkakat and was obliged to discharge its freight there, being unable to go farther upstream.

Most of the freight shipped into the Innoko has been brought from Fairbanks, the largest town in the Yukon Valley, situated on Tanana River, 770 miles above Anvik and about 1,014 miles from Dishkakat by the rivers. The freight charge from Fairbanks to Dishkakat has been $80 a ton. The transportation companies operating large steamboats on the Yukon from St. Michael, where they connect with ocean steamers, have quoted a rate of $38 a ton from Seattle or San Francisco to Anvik or near-by points on the Yukon. One of these companies has also published a through rate of $70 a ton to Dishkakat from Seattle or San Francisco, and a local rate of $35 a ton to Dishkakat from Anvik, but the company did not offer a regular service on Innoko River and reserved the right to operate steamers thereon only when business warranted. These rates expired on September 1, 1908. No attempt has yet been made to ship freight direct from the United States to the Innoko. The ocean distance from San Francisco to St. Michael is 2,846 miles, and from Seattle to St. Michael 2,487 miles. If the traffic should amount to much, probably a lower freight charge would be quoted over this route, and another advantage it has over shipping from Fairbanks is that the original cost of supplies is much lower in the United States.

A few individual outfits have been purchased at Nome and shipped a distance of 115 miles by ocean vessels to St. Michael, there reshipped on Yukon River boats to Anvik, 405 miles from St. Michael, and there again transferred to the smaller boats which ascend the Innoko. The distance from Nome to Dishkakat by this route is about 764 miles, and it appears that if a reliable line of transportation was established between Nome and Dishkakat by way of the lower Yukon the merchants of Nome, enjoying a comparatively low freight tariff afforded by direct ocean communication with the Pacific ports of the United States, should be able to bid successfully for the Innoko trade in competition with the merchants of Fairbanks. It is doubtful, however, whether the Innoko route is as good as that by way of Kuskokwim River if an equally reliable line of communication should be established from Nome to Bethel.

KUSKOKWIM RIVER.

The Kuskokwim is the second largest stream in Alaska, and is perhaps the best river for steamboating in that country, with the possible exception of the Yukon. Steamboats of large size can ascend the river about 633 miles, to the confluence of its two principal headwater branches, the North and South forks, and smaller steamboats have been up the South Fork about 40 miles above this junction, and no doubt could also ascend the North Fork for some distance. Boats with a draft of 2 feet have ascended Takotna River, a large tributary of the Kuskokwim that heads against the sources of the Innoko, for a distance of about 60 miles to a point within 25 miles of Ganes Creek, whence supplies may be forwarded 30 miles farther up the Takotna to the mouth of Big Creek, which is only about 12 miles from Ganes Creek.

The Kuskokwim has not been used to any great extent as a route for the transportation of supplies, because the country within its drainage basin has not been prospected or developed, as has the territory within the Yukon basin. Another reason is that Kuskokwim Bay and the estuary or tidal portion of the river's mouth has been considered a hazardous locality in which to navigate ocean vessels, but this opinion appears to be due rather to the fact that this part of the Alaskan coast is mapped only in rough outline and is not known in detail, even by the very few who have some personal knowledge of these waters, than to the presence of any real dangers to navigation other than those caused by lack of acquaintance and proper charts for guidance. When accurate surveys of Kuskokwim Bay and the mouth of the river are made and the good channels that run through its extensive shoals are properly marked, ocean vessels with a draft of 12 feet may enter and ascend it to Bethel with safety and dispatch.

The Kuskokwim route was traveled by many of the people who went to the Innoko from Nome in 1907. The passengers and their supplies were taken across Bering Sea from Nome to the mouth of the Kuskokwim, a distance of 480 miles, by various small unseaworthy craft. Thence they were taken up the river on several steamboats to Takotna River and up the very winding course of that stream to points 12 to 20 miles from Ganes Creek, which may be reached by several trails across a low mountain range over which supplies can be packed by men or horses during the summer or hauled on sleds during the winter.

In the spring of 1908 a company with trading interests on Kuskokwim River brought several hundred tons of freight direct from San Francisco to Bethel on a large two-masted ocean schooner equipped with auxiliary gasoline power. During the summer this company sent about 40 tons of supplies up the Kuskokwim and Takotna to the mouth of Big Creek, a point about 90 miles above McGrath, which is on the Kuskokwim at the mouth of the Takotna. This freight was taken up the Takotna about 60 miles by a small stern-wheel boat which could go no farther owing to the unusually low water. From this point the goods were taken in scows and poling boats the remaining 30 miles to the mouth of Big Creek. Here a log store has been built and the place is known as Joaquin. From Joaquin it is about 12½ miles to the settlement called Moore City, on Ganes Creek, half a mile below Glacier Gulch. A trail that may be used by pack horses in summer and sleds during winter follows Big Creek for 9 miles to its head with an ascent of about 900 feet, all of which is gradual except in the upper quarter of a mile, where the trail rises more steeply for 200 feet. This trail passes over a saddle divide to the head of Glacier Gulch, down which it goes for 3 miles to Ganes Creek with an even descent of 600 feet. This route offers no particular difficulties to the construction of a wagon road. If a wagon road or permanent winter trail is to be built from the Kuskokwim drainage area to the Innoko Valley, however, it appears best to select a somewhat longer route which would connect a point on the lower Takotna more directly with the Innoko at the mouth of Ganes Creek, 10 miles below Moore City. This point on the Innoko side is more central to the placer-gold area, as it is now known; the advantage on the Kuskokwim side lies in the fact that some point on the lower Takotna can be reached at all stages of water by steamboats plying direct from Bethel, where direct connection can be made with ocean vessels from Seattle or San Francisco. By such a route it may be possible to deliver freight at a centrally located distributing point in the mining region with fewer transfers, and consequently a lower transportation charge, than is possible by any other route into the headwater portion of the Innoko Valley. A wagon road, or at least a good winter sled trail, could be built from a point on Takotna River 15 to 25 miles above its confluence with the Kuskokwim to the upper Innoko Valley near the mouth of Ganes Creek, or about 5 miles farther to the town of Ophir. Such a road would not be over 30 or 35 miles long, and the divide to be crossed from the Kuskokwim to the Innoko is not high or rugged. The road would probably not be as high or present as steep grades as the Big Creek-Glacier Gulch trail does, and it would lead more directly to a suitable central distributing point for the placer region. In the fall of 1908 an auxiliary gasoline schooner of about 15 tons burden, with a draft of 4 feet, made a continuous trip from Nome to a point on the Takotna, 30 miles above its mouth, without any difficulty. This trip shows the advantages of this route, for the same boat could not have proceeded farther than Dishkakat by the Yukon-Innoko route, and even if successful in reaching that place it would still be 55 miles by the winter trail from Ophir. The distance from Nome by way of the Kuskokwim to a point on the Takotna 25 miles above its mouth and within 35 miles of the Innoko diggings is 1,170 miles. The distance over the Yukon-Innoko route from Nome to Dishkakat, 55 miles from Ophir by winter trail, is about 764 miles.

The difference in favor of the Kuskokwim route is not only in the shorter distance of its terminus from the diggings, but also in the smaller number of transfers of freight necessary. At St. Michael, which is a more or less shallow, open roadstead rather than a protected harbor, it is necessary to lighter all cargo from ocean vessels to the shore and then reload the freight into the river boats at the docks or warehouses. Moreover, it is often necessary for the river boats to wait several days or even a week, after being loaded, for calm weather on Norton Sound during which to make the passage of 60 miles around the shoal coast to the mouth of the Yukon. This passage is hazardous for the small steamboats that can ascend the Innoko. Consequently, safety will make it advisable to send freight from St. Michael to Anvik on large steamboats and to transfer it again at Anvik to smaller boats for the trip up the Innoko. Thus three transfers are necessary between starting point and destination. By the Kuskokwim route, on the other hand, only one transfer is necessary, that at Bethel, and it can be made directly from the ocean vessel to the river boat in a safe port.

During 1907–8 supplies have been transported to the Innoko gold diggings in a rather unsatisfactory manner by means of small river steamboats to the head of navigation and thence by small scows towed by horses and poling boats propelled by men to Ophir. This settlement has never been a well-stocked distributing point, however. In fact, many of the necessities have often been entirely lacking, and a shortage of provisions in the whole Innoko Valley has prevailed throughout the last two years. During the winter of 1907–8 it became necessary for many of those who wished to remain in the country to journey over difficult winter trails to Anvik, Kaltag, and Nulato, on the lower Yukon, and haul back with them on hand and dog sleds the bare necessities for existence, thus expending much time in unprofitable labor.

The cost of transporting freight from points where the steamboats may be able to land it on Innoko River to Ophir, by means of man-propelled boats, varies from 10 to 20 cents per pound, according to the distance it must be carried. At present it costs from $280 to $480 a ton for freight charges alone to have supplies brought to the Innoko diggings from the larger centers of supply on the Yukon. Besides this heavy freight toll, the initial cost of provisions in Fairbanks is much higher than at the ocean ports of Nome or St. Michael. By establishing reliable communication with St. Michael, the freight charge from Seattle may probably be reduced to about $70 a ton for goods delivered at Dishkakat, but the difficulty of carrying them from that place to Ophir will still remain. The writer was told that the charge for hauling freight with horses and sleds over the 55 miles of winter trail from Dishkakat to Ophir was about 7 or 8 cents a pound, so that the lowest estimate it is now possible to make with the figures at hand is a freight cost of $210 a ton for delivering supplies at Ophir from Seattle by way of St. Michael and the Yukon. This figure is based on the current freight tariffs, but there appears to be no reason why this cost might not be materially reduced by an organized and well-regulated effort.

There is no doubt that freight can be brought from San Francisco or Seattle to Bethel fully as cheaply as to St. Michael. At Bethel the river boats can be loaded directly from the ocean vessel, only one handling being necessary. The river boats can ascend the Kuskokwim and the Takotna to its forks without any difficulty, and from this vicinity the overland haul of about 35 miles to Ophir can easily be made by summer wagon road or winter sled trail, or by a light railroad if developments should warrant. There appears to be no question that the Kuskokwim route to the Innoko placer camp affords the most expeditious and satisfactory solution of the transportation problem; that even under present conditions there is no reason why supplies from Seattle may not be delivered at Ophir for $100 a ton; and that with good management the actual freight cost over this route may be reduced considerably below that figure.

WINTER ROUTES.

Distances by the winter routes from the lower Yukon to the Innoko are much shorter than by the summer water routes. The wide extent of flat, swampy country of the lower Innoko Valley is then frozen over, so that more direct courses may be followed from one place to another. It is about 57 miles by sled trail from Kaltag to Dishkakat, and about 55 miles from Dishkakat to Ophir, or 112 miles altogether. This trail is for the most part over flat-lying country, but between Dishna and upper Innoko rivers it crosses a low mountain range at an elevation of about 1,300 feet above sea level by way of a low, wide pass, with easy grades approaching it from either side. Kaltag is a military telegraph station and a regular post-office on the winter mail route from Fairbanks to Nome. During the winter of 1907–8 a moderate amount of freight was hauled over this trail by dog teams from Kaltag and Nulato to Ophir for 50 cents a pound. A number of personal outfits were hauled over it by means of hand sleds, and some new arrivals even hauled their provisions from Nome. A herd of reindeer of about 30 head was driven from Unalaklik to the Innoko and sold for the meat.

Another winter route to the Innoko leaves Yukon River at a small trading station called Lewis's, which is located on the north bank of the Yukon, about 15 miles below the United States military telegraph station called Melozi. The trail goes south from the Yukon up the valley of Yuko River, crosses the wide, flat pass at its head into the valley of the North Fork of the Innoko, and continues southward down this valley to a point on the Innoko 65 miles below Ophir. The route then follows Innoko River to its headwaters. Several parties traveled over this route during the winter of 1907–8, and a few dog-team loads of freight were hauled over it. The distance is estimated to be about 100 miles, and it is by far the shortest winter route for those who wish to go from Ophir to upper central Yukon points such as Tanana, Rampart, or Fairbanks. Under present conditions this route would be the shortest and most direct for a winter mail service to Ophir, as all the winter mail for western Alaska now passes down the Yukon from Fairbanks, but no service to Ophir has yet been established.

EFFECT OF HIGH TRANSPORTATION RATES.

It may be seen that the transportation of supplies to the Innoko placer district for a reasonable cost has not been accomplished and that the exorbitant operating expenses in this district are the direct result of poor and inadequate transportation. For this reason the present conditions and possibilities have been described in detail, as the transportation problem is of vital importance and its solution as soon as possible is imperative to the success of the Innoko placer district as a mining community.

During 1907–8 the prices of staple provisions at Ophir were as follows:

Flour	per pound	$0.30	Bacon	per pound	$0.65
Corn meal	do	.50	Ham	do	.65
Rice	do	.50	Butter	do	1.00
Rolled oats	do	.45	Cheese	do	.75
Beans	do	.50	Dried fruit	do	.55
Coffee	do	1.00	Canned fruit	per can	1.00
Tea	do	1.00	Canned vegetables	do	.75
Sugar	do	.50	Canned milk	do	.50

GEOLOGIC SKETCH OF THE INNOKO REGION.

The bed rock of the Innoko region is for the most part primarily of sedimentary origin, although the original condition of the older rocks has been greatly changed by metamorphic alterations, so that now they are mostly in the form of schists and slates, with some cherts and crystalline limestones. Associated with these metamorphosed sediments, more particularly with the slates, and making up considerable areas of the bed rock, are large masses of basic volcanic rock, principally diabase, that may be related with part of the slates as one or more extensive original effusive stratigraphic members, or may be distinct from the slates in a stratigraphic sense. In addition to this large amount of apparently extrusive igneous rock, in the form of diabase, both the schists and slates contain locally intrusive dikes of more acidic igneous rocks. These dikes may be considerably younger than either the schists or the slates into which they are intruded, and they have no purely stratigraphic relation with those rocks such as the diabases may have with the slates. All the rocks above mentioned, with the possible exception of the acidic igneous intrusives, are considered to be of Paleozoic age because of their lithologic and stratigraphic similarity to the Paleozoic rocks of the upper Yukon Valley.

Lying unconformably above the Paleozoic rocks are a series of unaltered sedimentary formations of Mesozoic age that consist principally of limy sandstones and shales. Along the Kuskokwim Mountains between the southern headwaters of the Innoko and Kuskokwim River there is a belt that shows past igneous activity of both extrusive and intrusive character. The effusive rocks appear to be lavas, for the most part of basic type, that were poured out over restricted areas during Mesozoic time, for they are interstratified with arkoses, shales, and other sedimentary rocks that show ripple marks with plant remains, giving evidence of formation along a shore. On Kuskokwim River, where it cuts through the low ranges of the Kuskokwim Mountains from Kolmakof to Kalchagamut, Spurr [a] noted a number of occurrences of old-appearing volcanic rocks that appear to be flows of lava contemporaneous with the Mesozoic sedimentary rocks which form most of the mountains in this vicinity. Spurr considers these interbedded effusives to be of Cretaceous age. Dikes are also of common occurrence in this range of mountains. In general they are of siliceous varieties, and most of them have a porphyritic texture. These dikes are considered to be of Tertiary age because they cut sedimentary rocks thought to be Cretaceous.

With the exception of a very small area of slightly consolidated clays and sands containing some lignite, seen on the lower Innoko, the writer knows of no sedimentary rocks within this area that he considers to be of Tertiary age, although there is little doubt that rocks of this age may occur. Besides the igneous rocks associated with the Paleozoic and Mesozoic formations, there are some fresh, young-looking volcanic rocks of andesitic and rhyolitic types and effusive aspect on the lower Innoko at the southwest end of the Kaiyuh Range. These rocks are probably late Tertiary in age and may be considered, through similarity and proximity, to be closely related to the Tertiary volcanic rocks that appear at intervals along the lower Yukon from Nulato to St. Michael.

Thus there appears to be evidence that this region has been the scene of volcanic activity, in the form of lava flows, during three distinct periods—the Paleozoic, Mesozoic, and Tertiary.

ECONOMIC GEOLOGY.

The only mineral of commercial value known to occur in the Innoko region is gold, in placer deposits and possibly in lodes. Up to the present time the only production has been from the placers. The principal gold lode discovered is being actively prospected, however, and its owners hope to prove it to be of commercial value.

[a] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 159-163.

KINDS OF PLACERS AND METHODS OF WORKING.

The placer-gold deposits of Alaska may be classed as shallow or deep. Each of these classes may be subdivided into those in a solidly frozen, partly frozen and thawed, or unfrozen state. The unfrozen deposits may be still further subdivided into those that are unfrozen throughout the year and those that are only superficially thawed during the summer. A permanently frozen condition of the alluvium is the normal state of most of these deposits throughout the greater part of Alaska.

No particular limit can be arbitrarily set to the depth in feet of shallow placer ground. In a broad, general way, shallow placer ground may be defined as that which can be most economically worked for its gold content by some kind of surface opening and the removal of all the dirt lying on the bed-rock floor. The methods of moving the dirt may be various—hand shoveling, ground sluicing, hydraulicking, horse or steam scraping, steam shoveling, derricking. and dredging, singly or in various combinations. Placer deposits 40 feet or less in depth may perhaps be called shallow, because this depth may be considered the average limit for dredging operations.

Deep placers may be considered to be those in which the valuable strata are so deeply buried under barren material that they can not be mined successfully by any kind of open surface works. The universal method of mining deep placers is by shafts and drifts, with or without thawing and timbering. In Alaska such works have been carried to depths of 200 to 300 feet.

The Innoko region affords no exception to the conditions found elsewhere in Alaska. All the gold-bearing deposits now known there are comparatively shallow, being not more than 35 feet in depth. They occur in a mixture of humus, muck, clay, sand, and gravel, in the various characteristic conditions as to frost already named. On their depth and condition depend the methods of working them that should be practiced. Most of the work that has been done in the region so far may be classed as that of merely prospecting the ground. This has included both the sinking of shafts to bed rock and the digging of open cuts, the methods usually employed in a new camp, by pick and shovel labor, aided by the use of a few small steam boilers for thawing frozen ground. The sinking and drifting method may be carried on throughout the year, providing the ground does not contain too much live water. Open-cut work is confined to the summer season.

WORKING SEASONS.

The climate of Alaska is such that it divides the year, both for transportation and for mining operations, into two working seasons—summer and winter. The summer season is the period of surface flowing water, and this directly governs cheap transportation (by water routes) and cheap mining (by hydraulic methods). During the winter season, from October to early May, practically all the streams are frozen over. So far as mining operations are concerned, the effects of the summer and winter seasons are not marked except where the gold-bearing gravels are of the class that can be worked only to the best advantage by open-cut or hydraulic methods. Many gold placers in Alaska can be mined throughout the year, but the local conditions vary in the different districts, and in some places may be so different on two adjacent creeks, or even at two localities on the same creek, that entirely different methods of working are used.

The average season during which hydraulicking operations may be conducted, providing there is a sufficient supply of water available for this method of working the gravels, extends from about the first of June to the middle of September. As a rule, sluicing may be commenced the middle of May and continued two or three weeks later than hydraulicking, because it does not require so large a quantity of water.

THE ECONOMIC AREA AND ITS BED ROCK.

The area of known economic importance lies near the headwaters of the Innoko, in a region of low mountains. It extends from a point about 5 miles north of Ophir up the Innoko to the divide between Ganes Creek and Takotna River and is about 20 miles north and south by about 10 miles east and west. It embraces that part of the slate formation that has been most intensely altered and in addition intruded to a moderate extent by siliceous dike rocks. Some of these siliceous dikes are altered and mineralized with pyrite. Secondary quartz deposited along the walls of one of these dikes is known to carry free gold. This locality is well up on the southeast side of the Ganes Creek valley, at the head of Carter Gulch, near the divide on the trail that runs from Ganes Creek to the Takotna. The residual quartz found on the surface along the outcrop of the dike carries good values in free gold. A shaft sunk 30 feet on the dike did not reach below the zone of surface weathering and disintegration, and up to this depth the lode is not very well exposed. At the time of visit the lower 10 feet of this shaft was filled with ice, so that little could be seen. The association of free gold in quartz with this siliceous dike is a good indication of the probable existence of lode gold deposits worth prospecting for and also of the probable original source of the placer gold of the district.

How far these slates extend to the northeast of the Innoko is not known. The writer did not visit that part of the valley, and few prospectors have been far in that direction. To the southwest the slates extend up Ganes Creek for about 15 miles, or throughout the lower half of its valley. The entire drainage basins of Little, Spruce, and Ophir creeks, which each average about 10 miles in length, are within the slate bed-rock formation.

Up to the present time paying quantities of placer gold have been found only at isolated places on Ganes, Little, and Ophir creeks. This gold occurs in the present stream gravels and in bench gravels.

TOPOGRAPHIC AND DRAINAGE CONDITIONS.

The topographic conditions of the placer-gold area and its immediate vicinity are those of relatively even-topped mountain ridges, whose highest parts stand at an elevation of about 1,200 feet above the Innoko Valley floor. These ridges occupy all the major interstream areas and appear to express the former existence of an old land surface that had a much less pronounced relief than the surface of to-day. The present drainage system appears to be directly inherited from a former one in which the streams occupied the same relative horizontal positions that they now occupy. There has merely been a change in vertical position with reference to the older surface, brought about by a gradual downcutting into the older, more shallow valleys to a depth of at least several hundred feet, followed during Quaternary time by a much more rapid downcutting by Ganes Creek and Innoko River of at least 75 feet.

The first, longer, and more gradual downcutting period of erosion was mainly preglacial in age. It is apparently indicated by the level-tops of the major interstream ridges and divides and by the moderately sloping upper sides of the larger valleys where they descend from the divides and continue down on the secondary ridges and spurs between the minor gulches, to break off abruptly into the present valley troughs as bluffs of bed rock from 50 to 100 feet in height. Many of the present streams are now cutting along the bases of these bluffs.

The second period of stream erosion, in which the downcutting has been more rapid, has taken place since the glacial activity that has been already described. It is expressed on Ganes Creek and Innoko River by canyon and rock-cut bluff topography, and on the secondary streams by gulch topography. These secondary gulches are deeply eroded well back toward the major divides. During this period the erosion has been so rapid that on the larger streams considerable areas of the preglacial valley-floor filling of gravels have been left perched on the present valley sides as bench deposits. In places these bench gravels occupy positions 100 feet or more above the present streams, but on the gold-producing creeks the benches are on an average about 60 feet above the stream grades. About the mouths of Little, Spruce, and Ophir creeks, where they merge with the much wider valley of the main Innoko, there are also some elevated bench deposits. These are not creek benches, but benches of the Innoko Valley.

The three producing creeks now known fall into two classes as a result of the topographic development of the country they drain. Ganes Creek is a large stream with an extensive drainage area, carries a good volume of water, and is in a class by itself when compared with the other streams of the district. Its topography is in strong contrast to that of the other two gold-producing streams—Little and Ophir creeks—for these are relatively small streams, whose valleys are small in area and whose water supply is scanty. Little, Spruce, and Ophir creeks do not show any canyon topography due to a large and sudden increase in their water supply with its attendant rapid downcutting. Their valleys are deeply eroded for their size and length, but are of the form that indicates a long period of more uniform erosion.

STREAM GRADES AND WATER SUPPLY.

The valleys of Little, Spruce, and Ophir creeks have an average cross section of the broad, open V form, and although the streams are not large and their grades are not steep, they appear to have had sufficient transporting power throughout their history to carry the detrital materials produced by their erosion out into the wide Innoko Valley without any marked clogging or accumulation of material within their own valleys. As a result, these valleys are comparatively clean.

On the other hand, the volume of water in Ganes Creek is large, and the stream has cut the bottom of its valley down to a rather low grade, especially below the canyon. This condition of low-stream grade on the gold-producing part of Ganes Creek appears to be shown by the wide, uniformly flat bed-rock cross section of the valley from the canyon to the mouth. The plan of this cross section is that of a wide, shallow rectangular trench cut down into the bed rock of an older, broadly V-shaped bed-rock floor. From the canyon down to the Innoko the present floor of Ganes Creek is covered throughout its width and length by alluvium, over which the stream meanders with a current of irregular velocity. At one place the stream is obstructed by a large beaver dam which causes a riffle, and there are other irregularities that accelerate the current for short distances and give it a velocity in some places of 4 or 5 miles an hour. In other places the stream runs more slowly, at a rate of only 2 miles an hour. Probably its average velocity is 3 miles per hour.

To sum up the situation so far as stream grades and water supply are concerned, it appears that on Ganes Creek there is ample water with enough head for hydraulicking if the supply is obtained at the upper end of the canyon and brought around to its lower end, but that the grade of the bed rock below the canyon, upon which lie the deposits that are supposed to carry paying quantities of gold, is not sufficient to afford a good dumping ground for hydraulic tailings, which would have to be elevated or disposed of by some other mechanical means that would add to the cost of operation. On Little and Ophir creeks the valley grades are not quite so flat and appear to be sufficient to afford dumping ground for the tailings, but the water supply that may be obtained within these valleys themselves does not appear to be adequate for conducting hydraulicking operations on an efficient scale. There may also be doubt as to the presence of enough pay gravel within these valleys to justify bringing water for hydraulicking from a considerable distance. In 1908, which was a dry year, the amount of water in Little and Ophir creeks did not appear to be more than enough for sluicing purposes.

Of course, final statements of this kind can not be made without thoroughly prospecting the gravels by determining their quantity and average value, actually measuring the average water supply, and carefully investigating the whole problem from an engineer's standpoint.

THE PRODUCING STREAMS AND THEIR PLACERS.

GANES CREEK VALLEY.

General description.—Ganes Creek may be considered the head of Innoko River, although it shares this distinction about equally with the unnamed headwater fork that is generally spoken of as the upper Innoko, which flows from the northeast and joins Ganes Creek to form the main river. The volumes of water in these two streams are about equal. Both streams can be ascended 10 miles or more in light poling boats.

Ganes Creek, which is about 33 miles long, heads in a large, strongly glaciated cirque that is surrounded by sharply irregular mountains 4,500 feet above sea level. It flows for about 5 miles in this mountain basin over and through a mass of large glacial bowlders composed of the hard igneous rocks that make up the mountains. A large percentage of these bowlders are varieties of porphyry. Near the lower end of this cirque Ganes Creek is joined by a stream called Idaho Creek, of about the same size and character and flowing from a similar cirque.

From the mountains Ganes Creek flows for about 12 miles in a northerly direction out across a wide basin that is now largely filled by morainal bowlders. Topographically this basin appears to have been a part of the head of Beaver Creek valley before glacial time. About 3 miles southwest of this part of Ganes Creek is another large stream parallel to it, called Last Chance Creek. This stream is of about the same length and volume as upper Ganes Creek, heads in the same mountains in a similar cirque farther south, and flows across the basin in the same manner. Ganes and Last Chance creeks are separated by a ridge which appears to have been a medial moraine during the period of maximum glaciation. This ridge, on its surface at least, is formed of morainal deposits, except near the middle of its length, where a large dome-shaped mass of cherty limestone bed rock outcrops. This dome is called Knob Hill. Last Chance and Ganes creeks join at the northern edge of the basin, at the head of the canyon that has already been described as occupying the middle course of Ganes Creek. Throughout the basin both of these creeks flow over deposits of morainal bowlders which, like those in the cirques, consist mostly of igneous rocks, derived from the glaciated mountains. From a point near the source of Ganes Creek to the head of Ganes Canyon, a distance of about 15 miles, the descent of the stream is about 500 feet.

In its middle course Ganes Creek now runs for about 6 miles in a box canyon across a low range of mountains, made up of slate, that form the divide between the Beaver Valley and that of the Innoko. This canyon is not much wider than the present stream, which here flows on bed rock.

Below the canyon the stream has cut a wide, shallow trench of rectangular cross section with rock-cut bluff walls in the slate formation. This rock-cut trench is about one-eighth of a mile wide at the lower end of the canyon and broadens out to a width of about a mile at the point where the Ganes Valley joins the Innoko Valley, about 10 miles below. The perpendicular rock-bluff sides of this trench rise nearly 100 feet above its rock floor at the mouth of the canyon, and these bluffs bound the valley for considerable distances at intervals below the canyon. The heights of these bluffs decrease gradually from the canyon downstream, their average height being probably about 60 feet. Their continuity as a rock wall is interrupted by the numerous short tributaries that come in through steep side gulches, most of which are cut down to the level of the main valley. The presence on the tops of these rock bluffs of remnants of the old stream gravel filling of the former valley shows that the latest period of downcutting was rapid. It is evident that to produce this wide, trenchlike valley Ganes Creek has performed considerable lateral cutting, while the grade of the stream has remained at practically the same level. The rock floor is covered to a depth of 5 to 30 feet with stream deposits of fine to medium-sized gravels, which are made up chiefly of slate, with some clay and a few bowlders 1 to 2 feet in diameter. The larger cobbles and bowlders consist of igneous rock derived from dikes in the slates to some extent but mostly from the morainal wash from the area above the canyon. Nearly everywhere the gravel deposits are covered by humus muck 10 to 20 feet thick, upon which is a thick growth of willows, alders, and other brush, with here and there a clump of spruce trees of fair size. Probably most of these valley-floor deposits are frozen, but the large percentage of porous gravel beds and the good water supply cause a considerable amount of live water to be present. This tends to keep a considerable proportion of the material in an unfrozen condition, at least for part of the year. The deposits have not been prospected thoroughly enough to determine the distribution either of the ground frost or of the gold values.

Stream deposits.—Locally the present stream deposits are loosely divided into "creek claims" and "creek flat bench claims." The creek claims embrace the lowest ground; the creek flat bench claims lie a few feet higher and are mostly situated along the bases of the low rock bluffs. The creek flat bench claims are essentially of the same character as the rest of the valley-floor detrital covering, but to some extent they may contain more of the detrital material that has sloughed down from the higher benches lying on top of the rock bluffs.

All the ground along Ganes Creek, from the morainal rock piles in the cirque at its source to the alluvial flats at its mouth, has been located as placer-mining ground. In the wider part of the valley, from the canyon to its mouth, besides the claims immediately along the creek, the valley bottom on either side that is not embraced within the creek claims is located as far back as the bluffs on the right and left. These side claims are the "creek flat bench claims."

The numbers that designate these claims run from about 58 below Discovery claim, which is 10 miles above the stream's mouth, to about 83 above Discovery. The ground along all the tributaries of Ganes Creek has been located, on most of them for their entire length. From claim "No. 40 above," on Ganes Creek, which is just above the head of the canyon, to the head of the creek, the ground located embraces nothing but glacial deposits. These upper claims were located in the winter, when covered by snow, under the supposition that the placer gold on the lower part of the stream had been brought down from its headwaters.

No work has been performed above claim "No. 40 above," on which several holes have been started. These holes are in coarse morainal material and, as might be expected, have yielded no encouragement. From this claim down through the canyon to claim "No. 13 above" no work of any consequence has been done. It is reported that on claim "No. 37 above" the bench rim gravel is about 10 feet thick, and that it contains coarse gold. There is not much gravel at this place, however. From "No. 13 above" down to "No. 29 below" prospecting along the creek has been carried on in a desultory way at different places. During the summer of 1908 there were only a few men working in the Ganes Creek bottom, and they were engaged in prospecting and in doing assessment work. Prospects of gold are reported at irregularly distributed localities from "No. 13 above," which is at the mouth of Spaulding Creek, a short distance below the lower end of the canyon, to "No. 2 below." Some open-cut pick and shovel work has been done on "No. 11 above," but no profitable returns are reported. On "No. 10 above," or on a fraction between Nos. 9 and 10, a shaft has been put down from which values are reported. During the winter of 1907–8, 26 holes were sunk on the boundary line between "No. 20 below" and "No. 21 below," 16 holes on "No. 21 below," and 9 holes on "No. 29 below," all with no results. "Nos. 22 and 23 below" have also been prospected unsuccessfully. The holes sunk in the creek deposits are from 18 to 30 feet deep, and the alluvium is found to be made up of 15 to 22 feet of humus muck on top of 3 to 6 or 8 feet of gravel.

A little work was done on several of the tributaries of Ganes Creek during 1908. Glacier Gulch, which is 3 miles long and is staked from its mouth to its source, comes into Ganes Creek about half a mile above Moore City, on the east side of the valley. A little open-cut work has been done on the lower end of claim No. 1, at the mouth of the gulch. Here the deposit is coarse washed gravel about 4 feet deep, in which a little gold was found. Above, on claim No. 2, an open cut was started, and here the alluvium is much deeper than at the mouth of the gulch. This cut penetrated about 20 feet of muck and sandy clay with a little gravel, but did not reach bed rock.

Carter Gulch is the next tributary of Ganes Creek on the east side below Glacier Gulch. On this stream just above its mouth one man was ground sluicing a trench down to bed rock with the aid of an automatic dam, in August, 1908. The cut was put down to a depth of 23 feet, in ground composed mostly of tenacious clay, without exposing gravel, bed rock, or a pay streak.

On Last Chance Gulch, the next tributary below, on the same side of Ganes Creek, another man was making an open-cut trench with the aid of an automatic dam similar to that used on Carter Gulch. This trench reached a depth of about 10 feet, mostly in tenacious clay, and a few colors of gold were found.

Work was done on these three gulches because they are thought to be favorably situated for the presence of gold. The reason for this supposition is that these gulches all head on the divide southeast of the Ganes Valley, in an area of slates that have been intruded by mineralized dikes with which quartz carrying free gold is associated.

Bench deposits.—The occurrence of bench deposits of stream-worn gravel upon the tops of the rock-cut bluffs of the Ganes Valley appears to show that before Ganes Creek acquired its large increase in length and drainage area as a result of the glaciation above its canyon it was a stream of the same character as Little, Spruce, and Ophir creeks are to-day. The preglacial valley of Ganes Creek was then wholly within the slate belt, which extends to the head of its present canyon, and there was a divide across the site of this canyon that separated the drainage of the Ganes Valley from that of the basin above, now glaciated. Apparently the gravels now found in the benches are what is left of the preglacial alluvial deposits that occupied the Ganes Valley before the invasion of the glacial waters. When the waters that had accumulated above the canyon first burst across the divide and flowed rapidly down Ganes Creek, they no doubt rewashed most of the preglacial valley gravels now found on top of the bluffs, and thus introduced some bowlders and cobbles of the igneous rocks from the glaciated mountains. But this condition did not last long, for the enlarged stream of water that came down the valley soon cut a trench valley below the grade of the older deposits and with its rapidly lowering level carried the largest part of them downstream, so that they now make up a considerable portion of the present stream deposits. It does not appear that any large amount of the glacial wash was transported through the canyon from the basin above, and therefore most of the present valley filling is made up of detrital material that has originated within the slate belt.

The placer gold in the present valley gravels of Ganes Creek is no doubt derived from that which may have been contained in the gravels of its preglacial valley, but this gold is probably not concentrated to the degree it was in the older valley gravels, because the new stream, having a very much larger volume of water, has performed more erosion and transported a large amount of loose material out into the Innoko Valley. The power of the present Ganes Creek is shown by the deep canyon it has cut down through the slates and also by the fact that only very small remnants of the preglacial valley floor now exist. These remnants consist of disconnected strips along the valley that have an average height of about 60 feet above the present stream and extend back from the edges of the bluffs for a few hundred feet. They are cut in the slate and this rock makes up the valley sides above them.

The alluvial deposits on top of these rock benches are essentially the same in composition as the present valley deposits. They extend along the right side of the valley from a point near Spaulding Creek, opposite claim "No. 13 above," down to about No. 5 below Discovery. On the left side of the valley some bench ground is found on "No. 16 below" and again on "Nos. 19 and 20 below." Thus it is evident that the high bench ground is very meager in extent. However, the production of placer gold on Ganes Creek in commercial quantities is practically confined to several of these bench claims. The Pelky and Discovery bench claims have given the largest production. Under present conditions it is hard to work these bench claims because of a scarcity of water. Barely enough water for sluicing can be obtained from the small streams that flow in the short gulches which have been cut down through the bench deposits at intervals. Two ditches were being dug in 1908 to bring water upon some of the bench claims, but neither had been used at the time of the writer's visit. One was to take water from Last Chance Gulch to the bench opposite "No. 6 above." The other was intended to bring water from Yankee Creek over a divide into Mica Gulch and upon bench claim "No. 3 above." The Pelky bench claim is on the east side of Ganes Creek opposite creek claim "No. 4 above." Here there is 6 feet of gravel covered by 10 feet of muck at a distance of 72 feet back from the edge of the bluffs. All of the muck and gravel is frozen. Three "laymen" worked this claim on a 40 per cent basis during the summer of 1908. They worked an area of seven cuts 20 feet wide and six sluice-box lengths, from 60 to 80 feet back from the edge of the bluff; in all about 11,200 square feet of bed-rock surface was uncovered. The tailings were dumped over the bluff. The gold is coarse and not flattened. It has considerable quartz attached to it. The largest nugget weighed 16 ounces, 7 pennyweights, and 8 grains. Discovery bench claim was worked during 1908 by four "laymen" on a 50 per cent basis, but the production was not as large as in 1907.

LITTLE, SPRUCE, AND OPHIR CREEKS.

Little Creek is a comparatively small stream about 10 miles long. It lies to the northwest of and in a general way parallel to lower Ganes Creek, into which it flows about one-half mile from the Innoko, in the river valley flat. All of the alluvial ground in the valley of Little Creek, from its mouth to its source, was located for placer-mining purposes in 1907. The claims next above and below Discovery claim are located in the form of association groups of 160 acres each, and are the equivalents in area of eight ordinary single placer claims. The ownership of Discovery claim on this creek was in dispute in 1908. Work was being carried on by means of shafts and drifts on the Fathergill association group, below Discovery, and about eight men were employed on open-cut pick and shovel operations at the lower end of the Gold Run association group, where it joins Discovery claim. In August there was hardly enough water in Little Creek for sluicing. Both of these association groups had a gold output during 1908. Several other camps of prospectors were located at intervals on this creek above the Gold Run association tract, and prospects are reported to have been found at several separated localities up as far as claim "No. 14 above."

Spruce Creek is the next stream northwest of Little Creek. It is of about the same character and length as Little and Ophir creeks, and all of its alluvial ground has been located. Little work has been done within its basin, and it has not produced gold in commercial quantity.

To the northwest of Spruce Creek is Ophir Creek, which is about 10 miles long and empties into the Innoko about 5 miles in a direct line below the mouth of Ganes Creek. Like every other stream in the region, Ophir Creek has been completely staked from its mouth to its source. There are two discovery claims on this creek, a lower and an upper. Eight claims are located below Lower Discovery claim, and they extend upstream to No. 12 above Lower Discovery. "No. 12 above" is the same as Upper Discovery, and upstream from this claim the numbers begin again with 1 and extend up to No. 23 above Upper Discovery. Thus there are 43 claims staked along the course of Ophir Creek. Besides the creek claims, there are also some side or low bench claims, but no work has been done on ground of this class. From claim "No. 8 below" up to No. 2 above Lower Discovery, no substantial development has taken place, only the assessment work having been performed. From No. 2 above Lower Discovery up to No. 3 above Upper Discovery, a length of 14 claims along the creek, more or less work has been performed upon every claim. On No. 4 above Lower Discovery 5,000 buckets of dirt are said to have been raised. The largest production, however, is reported from Nos. 8 and 9 above Lower Discovery.

Ophir, Spruce, and Little creeks are all of about the same length. They are parallel to one another and to Ganes Creek, in a general way. Their valleys are of about the same depth and grade and are separated by ridges of about the same width and height. The whole area drained by them is made up of the same slaty bed rock. They all flow into the Innoko from the southwest and have their sources on a low mountain ridge about 1,200 feet above the Innoko. This ridge extends in a southeast-northwest direction from the canyon of Ganes Creek to the lower course of Beaver Creek, a distance of about 15 miles, and lies between the upper Innoko Valley and the glaciated basin of Beaver Creek to the southwest.

The alluvial deposits in the valleys of Little and Ophir creeks are all of the same general character and are not very thick or wide. The depth to bed rock is from 15 to 24 feet, the lower 4 to 7 feet being gravel and the upper part silt and muck. The width of 600 feet that is embraced by an ordinary placer claim includes the larger part of the alluvial deposits along these creeks, although in many places so-called bench claims have been located to cover the more gently sloping portions of the valley sides. Practically no work was done on these side locations in the summer of 1908, and little is known of their real character. All of the alluvial ground is covered by a heavy accumulation of moss. There is also a thick overgrowth of brush and considerable scrub spruce in the valleys.

The gold from Little and Ophir creeks is, like that from Ganes Creek, coarse and rounded, with a good many nuggets.

SUMMARY.

The creek deposits of the Innoko are all shallow and are composed of muck, clay, and gravel, which are for the most part frozen. The gravel and gold lie mostly on bed rock, and so far as experience indicates there are no well-defined pay streaks—that is, the distribution of the values is irregular both horizontally and vertically.

The opportunities for profitable drift mining on these creeks do not appear to be so favorable as the possibilities for a comprehensive scheme of hydraulic mining, by which all of the alluvial material may be worked in a systematic manner and all the values in the whole body of gold-bearing material may be recovered, regardless of its condition of distribution. Such a method of working means an entirely different community of interests than now exists, and probably there is at present little hope of bringing this about. To work these deposits with the greatest possible profit would involve the thorough prospecting of all the gold-bearing ground under expert supervision, the bringing of water from a considerable distance, and the consolidating of all property interests.

AMOUNT OF GROUND LOCATED IN THE PRECINCT.

About 1,600 instruments have been recorded in the official books of the Innoko precinct. About 1,200 of these cover placer-mining claims, which are located on nearly every watercourse within the Innoko Valley, many of them being on streams far removed from the known gold-bearing area. In other words, there has been a maximum of locating and a minimum of prospecting done by those who have visited the region. Of all the ground located only that on Ganes, Little, and Ophir creeks may be considered to have been prospected.

GOLD PRODUCTION.

On Ganes, Little, and Ophir creeks about 25 claims have produced placer gold. The production of about four claims has exceeded $10,000 each in a single season, but none of the claims has reached a production of $20,000.

An estimate of the total production for the Innoko precinct for 1907–8, based on the most reliable information the writer has been able to obtain, gives a total of $85,200, of which the season of 1907 is credited with $13,100 and that of 1908 with $72,100.

The placer gold thus far found in the Innoko country is very pure, its fineness being about 0.915. The average refined value is about $18.50 an ounce, and at Ophir the unrefined gold passes in commercial exchange at $17 an ounce.

SOURCE OF THE PLACER GOLD.

The chief source of the placer gold is probably in the belt of slates that have been strongly metamorphosed and intruded to some extent by siliceous dikes. The slates occupy the lower half of the Ganes Valley and all of the area drained by Little, Spruce, and Ophir creeks. It is thought that all the gold comes from points within the slate area. The writer saw dikes cutting the slates in the Ganes Valley and on Little Creek, and other dikes are reported to occur within the basins of Spruce and Ophir creeks. Some of these dikes are known to be mineralized with pyrite, and it is presumed that more of them may be so mineralized. Vein quartz is found along the walls of some of the dikes and some of this quartz is known to carry free gold. Thus it appears from the evidence in hand that the placer gold now found in the stream gravels of Ganes, Little, and Ophir valleys has originated from the mineralizing activities brought about by the siliceous dikes that are known to cut the slates.

The placer gold appears to have been formed by slow concentration as a result of the long period of erosion to which this mineralized slate belt has been subjected by the streams that drain its area. The gold now found in the bench deposits of Ganes Creek was probably all formed before the canyon was cut across the former divide by glacial water, and the placer gold in the present stream gravels on Ganes Creek is undoubtedly derived from the former valley filling of which the benches are small remnants. Probably almost all of the placer gold in this district is of pre-Pleistocene age.

RECENT DEVELOPMENTS IN SOUTHERN SEWARD PENINSULA.

By Philip S. Smith.

INTRODUCTION.

The purpose of this paper is to describe the new work which has been undertaken, the previous work which has been recently completed, and the projects and tendencies which have been noted in the southern part of Seward Peninsula. As an account of the earlier developments has been given in former Survey publications,[a] a repetition of the facts there set forth is unnecessary.

In trying to cover so large an area as the southern part of Seward Peninsula, the writer has unavoidably overlooked many enterprises and given to many minor features undue prominence because they fell more directly under his observation. The mention of various properties is therefore not to be taken as evidence that they are the most important. In fact, many of the largest producers will not be referred to at all, for they are only continuing work previously described in some of the reports already cited, and their developments have thrown no new light on the larger problems of Seward Peninsula geology and ore deposits. On the other hand, some prospect hole without enough mineral exposed to warrant staking the ground may be significant as suggesting an important economic truth.

PRODUCTION.

Figure 18 shows in diagrammatic manner the estimated production of Seward Peninsula from 1897, the first year when any notable amount of gold was won, to the end of the open season of 1908.

[a] Brooks, A. H., Placer mining in Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 19-24.
Moffit, F. H., Gold mining in Seward Peninsula: Bull. No. 284, 1906, pp. 132-141.
Moffit, F. H., The Nome region: Bull. No. 314, 1907, pp. 126-144.
Smith, P. S., Gold fields of the Solomon and Niukluk River basins: Idem, pp. 146-156.
Smith, P. S., Geology and mineral resources of Iron Creek: Idem, pp. 157-163.
Brooks, A. H., The Kougarok region: Idem, pp. 164-179.
Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., Gold placers of parts of Seward Peninsula: Bull. No. 328, 1908.
Smith, P. S., Investigations of the mineral deposits of Seward Peninsula: Bull. No. 345, 1908, pp. 206-250.
Knopf, A., The Seward Peninsula tin deposits: Idem, pp. 251-267.
Knopf, A., Mineral deposits of the Lost River and Brooks Mountain region: Idem, pp. 268-271.
Knopf, A., Geology of the Seward Peninsula tin deposits: Bull. No. 358, 1908.

These estimates are based on statements from the different banks, post-offices, express companies, and custom-houses, and replies to schedules sent out by the Geological Survey. Unfortunately, the last-named means of acquiring information has not been very successful in Seward Peninsula, owing to the lack of cooperation on the part of some of the producers. It is hoped that in the future more of the miners will respond to the request of the Survey for information; otherwise the production which should be credited to Seward Peninsula may be attributed to some other district. In this way a wrong impression may be gathered by outsiders of the mining activities in this region.

As is represented by the diagram (fig. 18), the gold production of Seward Peninsula has shown a marked decline from that of 1907, being about $5,000,000 in 1908. This amount is about the same as that for each year from 1900 to 1905, inclusive—in other words, prac-

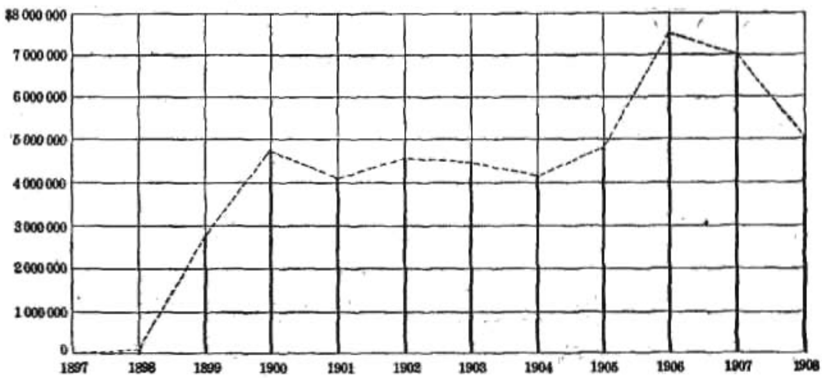


FIGURE 18.—Gold production of Seward Peninsula from 1897 to 1908.

tically the same as before the ancient beaches were discovered. Undoubtedly, many explanations could be advanced for this great falling off in the production of last year. Outside of more or less local reasons, there are three causes which have affected the region as a whole—the unsettled financial condition in the States, the mining out of the known bonanzas, and the unfavorable climatic conditions. Of these the second and third were the most important. The financial crisis had only a slight effect on the production of Seward Peninsula in 1908, but its influence will perhaps be felt more in the coming year, for the inability to start new enterprises in 1908 will be a decided drawback.

As placer mining progresses, the bonanzas that have given rise to the establishment of a camp become exhausted. It is inevitable that the production should show a decrease after a few years unless prospecting work keeps always ahead of the actual developments so that new deposits are discovered. After a camp has become well established, a uniform production from medium-grade placers is likely to replace the fluctuating production characteristic of the early bonanza stage. There can be no doubt that large deposits of low-grade gravel that can be economically exploited by competent management still remain in Seward Peninsula. The need of the region as a whole seems to be adequate prospecting and the development of the different enterprises on a sound business basis.

The unfavorable climatic conditions which prevailed in 1908 probably had a greater effect on the production than either of the other factors that have just been discussed. The unfavorable conditions were of two kinds—small precipitation and low temperature. An idea of the small amount of precipitation is afforded by a comparison of the stream discharges measured by Mr. Henshaw and Mr. Barrows in 1907 and in 1908, as stated on pages 370–401. All the streams show a marked decrease during the last year. But the figures themselves are not so impressive as the statement that practically no rain fell until the last week of July, and then the amount was rather small. Never, since the beginning of mining in the peninsula by whites in 1897, has so dry a year been reported. Many of the streams ceased flowing, and water, even for camp use, was often hard to find. Tundra fires were common, and everywhere along the railroad the sparks from the engine were starting new blazes each day. Thousands of the railway ties were burned and in places even the bridges over the creeks were destroyed. The aridity was not confined to any one section but was widespread throughout the peninsula. Its effect on mining was least marked in those places where the ditch systems derive their supplies from some large permanent source. Even in these places, however, it was not possible to work a full force. It should be pointed out, however, that a large part of the gold from the peninsula is won by winter mining, and that water for sluicing the winter dumps is generally snow water or is pumped by power.

Mining was retarded also by the fact that the opening of the season—that is, the arrival of boats from the States—was much delayed. It was the 15th of June before the first boat arrived, and one boat did not get in until the middle of July. Many of the mining operators were thus delayed several days in commencing work, and even a day's time in so short a season as that of Seward Peninsula may mean a marked reduction of output. However, a considerable proportion of the production is derived from winter work and was therefore not affected by the late arrival of the boats. It should also be noted that the season was not very late on land, but that the streams were flowing as early as usual and only the unusually heavy ice pack prevented the boats getting through. In addition to the time lost during the first part of the season, many more days were lost at the close on account of an early freeze-up. By the middle of September many of the smaller operators had stopped work owing to the freezing of the streams, and by September 22 or 23 all the large ditch lines that bring water from the interior to the vicinity of Nome had closed for the season. This year the ditches stopped delivering water at the earliest date that has ever been known in Seward Peninsula, except in the fall of 1905. The shortness of the season necessarily affected the production of the region, but just how much can not be determined.

NOME REGION.

GENERAL CONDITIONS.

Placer mining in the vicinity of Nome has been conducted on practically the same lines as in the past. No new bonanzas have been found during the year and much of the formerly known rich ground has been worked out. Nome, however, still leads the peninsula in gold production and the amount won probably exceeds that from all the other parts of Seward Peninsula put together. The causes which led to a great dropping off in other localities were not so strongly marked near Nome, because the large companies have already installed long ditches or mechanical devices for supplying water at a good head and in large volume. Nevertheless, none of the mines were able to work with full force all summer and the early closing of the ditches cut several days from the length of the working season. The snowfall near Nome was only about half that of other years, so that the supply of snow water for sluicing was available for only a few days.

To distribute the gold production of this region among the various types of placer deposits is impossible, owing to the fact that few replies have been received from the miners in response to schedules sent out by the Geological Survey. From the slight amount of information at hand it seems probable that about two-thirds of the entire production from the Nome region has been derived from the beaches and the other third from the creek and bench placers. The probable decrease in the ratio between beach and creek production for the year is believed to be due in a measure to the curtailment of work on the creek deposits by the shortness of the season and the lack of water. It should be remembered, however, that in actual amount the yield of the beach deposits has decreased proportionally more than that of the creek gravels. This falling off is due mainly to the low tenor of the beach deposits, because the conditions which affected the creek mining had only a slight effect on beach mining. This is true, first, because most of the beach is mined during the winter and therefore climatic conditions do not interfere, and, second, because the dumps from even the largest mines are sluiced in a very few days during the early part of the summer.

BEACH PLACERS.

Mining on the ancient beach lines has not undergone any notable reduction in costs during the present year. In fact, there has been a general tendency to mine more and more difficult ground, and this tendency has had the effect on the whole of increasing the costs. In one mine in particular work was being carried on by underground stoping in places where a perfect deluge of water was pouring through the roof. So much water was coming into the drifts that it could be kept down only by the use of very large pumps. Under such conditions a large part of the profits were consumed by fuel charges. At another mine the management, after having installed successively larger and larger pumps, finally decided to suspend operations, for the cost of working exceeded the income from the placer.

Most of these difficulties with water are encountered in ground where there is no permanent frost. There are many such areas which do not show any definite or constant relation to the present topography. Clumps of willows are taken as surface indications of thawed ground, but the more sections are exposed by prospecting the more irregular appears to be the distribution of the ground that is not permanently frozen. The presence of willows seems to serve little more than to point out the places where thawed ground is more likely to be encountered than elsewhere. They seldom grow on frozen ground, but on the other hand they are lacking in many places that are underlain by thawed material. Carefully drilled holes are probably the most effective and cheapest method of exploring an area to determine the physical character of the gravels in advance of actual developments.

A new beach placer or line of beach called the "submarine" has been discovered during the past year, and active operations have been conducted on it in at least two mines where large dumps were taken out during the winter of 1907–8. No accurate data on the value of the gravels were obtained, but it seems certain that the tenor is not nearly so high as that of the "third beach line." As this beach is a new discovery, and has not been described before in the reports of the Geological Survey, more space may be allotted to it than its output would perhaps warrant.

The easternmost of the properties on this beach is located on the coastal plain just west of Snake River and almost directly south of the pumping plant, a quarter of a mile north of the present beach. The ground has been opened by means of two shafts, the eastern of which has a depth of 69 feet and the western of about 65 feet. At this place the pay streak is 19.6 feet [a] below sea level and for that reason the beach is called the "submarine." The pay gravels in the

[a] Determined by Arthur Gibson, of Nome.

western part of the claim rest upon a true bed rock. Wherever this was seen it was a bluish-gray, somewhat calcareous schist, similar to that occurring in many other parts of the Nome district. The bed-rock surface slopes slightly toward the east, so that in the eastern part of the claim the values are found in material resting on a false bed rock of clay. The workable gravels have usually had a constant thickness of 3 feet. Not enough development work has been done to determine the direction or width of the auriferous gravels, but from the slope of the floor it is possible that their trend may be more nearly north and south than the present beach. Such a direction seems highly improbable, however, and it is much more likely that this slope is due to later deformation. Until the blocking out of the ground has gone further it seems unwise to accept any of the present deductions as to the direction in which the pay streak runs. As will be shown later, the occurrence of a similar layer of gravel at practically the same elevation on the adjoining claim to the west would strongly suggest that the general trend was east and west rather than north and south.

The unconsolidated deposits at this place consist of irregularly distributed alternations of gravel and sand, the latter usually forming the base of the section. Many of the sandy layers show abrupt terminations which seem to have been formed by faults, but none of these dislocations could be traced into the gravel lenses. In the gravel beds pebbles of all kinds of rocks were found. Numerous fragments of black slate, similar to that occurring in places as the bed rock of the "third beach" and in the hills back of Nome, were seen, as well as various schist and limestone pebbles. Feldspathic schist and greenstone fragments, however, form only a small percentage of the deposit. It is interesting to note in this connection that several blocks of granite were also found in the gravels. The significance of this lies in the fact that the granite fragments are similar to the granite of the Kigluaik Mountains, and the conclusion is practically inevitable that they must have been derived from this source. In the gravels some large blocks of quartz were found, some of them 2 feet in longest dimension. Their general outline was more or less angular, but their corners were well rounded and they had all the appearance of having been waterworn. No constant direction of the shingling of the gravel deposits was observed, and it would appear that deposition was effected by strong variable currents such as would be expected to occur near a shore line.

In the west end of the southern drift a series of ramifying streaks of a black peaty material cut in irregular directions across the layers of sand and gravel. Because of the difference in color these bands are far more noticeable where they cut across the light-brownish sand, but a careful search shows that they are almost equally numerous in the coarser gravel layers. Pebbles showing well waterworn outlines are scattered irregularly but not abundantly in these peaty seams. When first examined it was believed that they represented cracks which had been subsequently filled by material from the surface. Similar cracks are observed at the present time in many places where the melting of the ground ice allows settling and cracking of the deposit previously formed. In the light of more careful study, however, such an interpretation seems inadequate, for many of the seams taper off toward the top as well as toward the bottom, so that a connection with the surface is not indicated. It is believed that their occurrence is due in some way to the settling of the ground subsequent to the formation of a part at least of the gravel deposits, but the information concerning these seams is as yet too meager to allow an explanation of their origin. Although as the matter now stands an explanation of these seams does not appear to be directly connected with the economic problems, it is believed to be important, for everything which throws light on the physical conditions under which the coastal-plain deposits were formed should assist in determining the factors which led to the deposition of the economically valuable placers in this area.

In the north end of the eastern drift a layer of sand with a few pebbles scattered irregularly through it lies underneath a gravel deposit, only the base of which is exposed in the drift. This sand bed is interesting because it contains numerous shells that can be used in determining the relative age of the gravels at this point. The most abundant of the shells is one that is large and clamlike, but numerous other fossils also abound. All the shells occur in the sand layer, none being found in the overlying coarser gravel. The physical condition of these shells is interesting and, it is believed, throws some light on the relative age of this beach and the earlier known and previously described beaches. Practically none of the shells show water rounding or other evidence of having been subjected to the pounding of surf, but in spite of this almost all are broken into small bits or are so decomposed that it is almost impossible to remove them from the layers in which they occur. Such a condition would seem to indicate that they have undergone a large amount of decomposition and fracturing since they were laid down. When it is remembered that the shells found on many of the beaches farther inland, such as the "intermediate beach," are practically undecomposed, the suggestion that the "submarine beach" is much older than the others receives considerable support from the physical character of the fossils.

About a dozen species of fossils collected from the "submarine beach" at this place by E. M. Kindle and the writer were submitted to W. H. Dall for determination. From their resemblance to fossils whose geologic positions have been determined, he stated that these forms mark undoubtedly the oldest horizon that has been found in the unconsolidated deposits of the Nome coastal plain. This coincides closely with the decision that had been reached by the writer on entirely independent grounds, namely, the relation of the gravels containing the fossils to the overlying deposits and the greater amount of decomposition that had affected the shells. No final statement can as yet be made regarding the precise geologic age of the fossils from the "submarine beach," but there seems little room to question that they are at least as old as the Pliocene.

As far as exploration and development of the ground at this claim have gone, all the gravels are permanently frozen and therefore lend themselves to development by underground methods such as are in use in flat-lying consolidated deposits. Unfortunately, however, the contact between the sand and gravel layers is a plane of weakness, and frequently great pieces of the roof flake off along these division planes and bad accidents are likely to occur without warning. Practically no timber is used save in the main lines of underground communication. The shafts are well timbered and are equipped with power hoists. The ground is so dry that it requires very little expenditure for draining.

As is usual at the deep placer mines in Seward Peninsula, a dump is taken out in the winter and the gold is extracted during the early weeks of the open season. As the present operators are not the owners of the ground, they propose working throughout the year. In the winter of 1907–8 more than 10,000 yards of auriferous gravel was mined and hoisted to the surface. Foresight on the part of the operators caused them to place sluice boxes in position at the place where they proposed to make the dump of pay gravel. In this way, when the dump was sluiced in the spring it was necessary only to turn a hydraulic nozzle against the pile and the gravel was washed directly into the sluice boxes. This method resulted in a considerable saving in the cost of extracting the gold from the gravel and should be much more generally applied. Water for sluicing is furnished by means of a gasoline engine, which pumps water from Snake River, only a few hundred yards away. The tailings from the boxes are dumped over the steep bank which has been cut by Snake River into the coastal plain on which the shafts are located, so that an economical handling of the gravels is effected.

Only a small quantity of the gold won from this claim was seen and generalizations concerning its character may require modifications in the light of fuller knowledge. Most of the gold is fine, but the pieces average two or three times the size of those from any of the other beaches that have so far been discovered. It is of a bright color, practically no rusty pieces having been found. In spite of its bright appearance, however, it is not readily amalgamated. It is reported to lose considerable weight on melting, and this loss is attributed to the presence of arsenic. In the concentrates collected with the gold, magnetite and ilmenite form but an insignificant portion. Garnets are common. Sulphides are much more abundant than on any of the other beaches, and pieces of quartz with both iron and arsenical pyrite are common. The physical characters of the gold are such as to suggest that it has been derived from a near-by source.

Adjoining this claim on the west is another in which gold-bearing gravels have been found at practically the same elevation and are similar in all other essential respects to those of the claim just described. Because of this similarity it is supposed that the general trend of the pay streak is east and west rather than more or less north and south, as was suggested by the slope of the bed-rock surface, but in neither claim had the true direction been clearly demonstrated. No statement as to the value of the gravels per cubic yard was obtained, but it seems certain that it does not anywhere approach that of the "third beach" bonanzas.

The gold which is obtained from this claim is nearly the same as that from the one farther east, except that it is slightly coarser. So far as could be learned the largest piece of gold from this ground was worth between $10 and $12. Most of the pieces are flat, but some nuggets up to a dollar in value are found which have quartz attached and show, by their form, that they have not traveled far from the parent ledge. It is clear that the average of the gold is much coarser than that on the third beach. It is usually of a bright-yellowish color, but it is said to be greasy, so that it is not easily affected by mercury. On smelting it loses considerable weight, owing, it is said, to the large amount of arsenic. According to the owners the banks pay for the gold at the rate of $16.53 an ounce. Among the concentrates magnetite and sulphides form a considerable proportion. The sulphides are both iron and arsenical pyrite. Many large fragments of vein quartz and calcite in the tailings show abundant crystals of both of these sulphides. An assay by Ledoux & Co. of some of this vein material showed a gold value of nearly a dollar a ton. Garnet forms but an insignificant part of the concentrates.

The method of working the deposit is similar to that in use elsewhere in the underground mines of the coastal plain. Water for sluicing is delivered from Snake River by a gasoline pump, which is used for half a day by this claim and for the other half by the one to the east. The tailings are dumped directly from the lower sluice box over the bluff to the Snake River flood plain. None of the concentrates are saved, although it seems probable that the sacking of some of them would repay the additional cost. Seven men were employed in shoveling the winter dump into the sluice boxes, so that the cost of the spring clean up was much higher than on those claims where the dump is washed with hydraulic nozzles directly into the boxes.

Owing to the finding of values at this level 20 feet below the sea, prospecting has been carried on still farther west. It is reported that about an eighth of a mile beyond the last-described claim a beach has been found at the same level and that it carried some gold, but work at this place stopped so early that it is hard to believe that satisfactory indications were obtained. An eighth of a mile beyond there is still another shaft, but not enough work had been done here to indicate the value of the ground. It is said that the next drill hole that shows the presence of workable placers is about a mile beyond this point. According to current reports, however, even this place does not show a very encouraging deposit, and beyond this shaft no values have yet been found.

Another supposed line of ancient beaches, although it has furnished no production, is interesting as throwing further light on the complex movements that have affected the coastal-plain province, at least, and probably a large part of Seward Peninsula. Not enough is known as yet concerning this line, which has been prospected in a few widely separated places, to determine whether it is really a beach or not. Its supposed course nearly parallel with the present beach and the fact that the gravels of which it is composed seem to be of marine origin are the main features which have given support to the theory that it is a beach. This beach lies 300 to 1,000 feet inside the present one and may be called the "outer submarine beach" to distinguish it from the beach previously described, which may be called the "inner submarine beach." Around Nome both of these beaches are popularly called the "submarine," and the use of the terms inner and outer is suggested only to permit ready reference in the present paper. The elevation of the outer beach is reported to be 34 feet below mean sea level. No work was being done on this beach, so it could not be studied, but it is said to be rather crooked. The values obtained by the prospectors are low, but from their reports it appears that the ground can be worked. The pay streak rests on a false bed rock of clay at a depth of 60 to 70 feet, depending on the configuration of the surface, or at a nearly uniform depth of 34 feet below sea level. At a depth of 4 to 12 feet below the false bed rock, according to local conditions, is found the true bed rock on which, so far as is known at present, no values have been concentrated.

As there has been no production from this beach line the character of the gold has been determined only from small samples taken in panning. These samples are bright and, as a rule, finer than the gold from the "inner submarine beach." It is a fact of universal experience, however, that the samples obtained by panning are finer than the average found in the sluice boxes when the deposit is mined, so that a final statement as to the relative coarseness of the gold is not possible at this time. Perhaps one of the most notable features connected with the pay streak from this beach is the large amount of concentrates. It is roughly estimated that from a small clean up yielding a little less than 4 ounces of gold at least 6 pounds of heavy concentrates were obtained. A large proportion of these were sulphides. Arsenopyrite in perfectly formed crystals which have sharp outlines and are not waterworn forms a large part of the sulphides. Iron and copper sulphides are also abundant. Magnetite and ilmenite form a small proportion of the concentrates. Garnet, although represented by numerous fragments ranging in color from pink to deep red, does not form a notable part of the concentrates. None of the sulphides at this place have been proved to carry values in gold, but from their similarity to sulphides from near-by areas that have been assayed it seems probable that a considerable amount of gold may be locked up in these minerals, so that if sufficient quantities are obtained they should be saved for treatment.

OUTLINE OF THE HISTORY OF THE BEACHES.

Including the newly discovered inner and outer submarine beaches, there are now at least six beaches which have been recognized in the vicinity of Nome. Though data are not yet at hand to permit a detailed account of each of these beaches and their interrelations, it is certain that they represent marine conditions and mark periods of stability between successive movements of the land relative to the sea. It has been shown that the six beaches have the following elevations with respect to sea level: The "outer submarine beach" is 34 feet below sea level; the "inner submarine beach" is about 20 feet below sea level; the present beach is, of course, at sea level; the "intermediate beach" has an elevation of about 22 feet; the "second beach" has an elevation of 38 feet; and the "third beach" has an elevation of about 78 feet. Figure 19 shows in diagrammatic manner the position of these different beaches, both vertically and horizontally, relative to the present beach. Although there have been many oscillations the details of which are lacking, it seems certain that the so-called "second beach" is the next older than the present beach, because it is the only one showing by the topographic forms associated with it that it has not been subsequently covered by the sea.

From the present evidence it would seem that the earliest event recorded definitely in the history of the region is the formation of the "outer submarine beach." What the condition of the region was prior to this incident is not known, but it is probable that older coastal-plain deposits had been formed and were eroded by the waves to form this beach. After the outer beach had progressed to a certain stage, gradual depression with respect to the sea brought the shore line at the level of the "inner submarine beach." The amount of this depression must have been about 14 feet. Still later, further subsidence of about 42 feet brought sea level to the elevation of the "intermediate beach." The movement continued and the land sank with respect to the sea about 56 feet, so that the shore line was on the level of the "third beach." After remaining for some time in this position further depression took place and the sea attacked the schist and limestone bluffs which rise steeply about half a mile north of the "third beach." While each of the beaches was being formed by the sea, deposition was taking place on the sea floor, and sands and gravels brought down by the rivers and worn from the cliffs by the waves were covering the earlier beaches, thus producing a surface such as the sea floor of the present day might show if it could be examined.

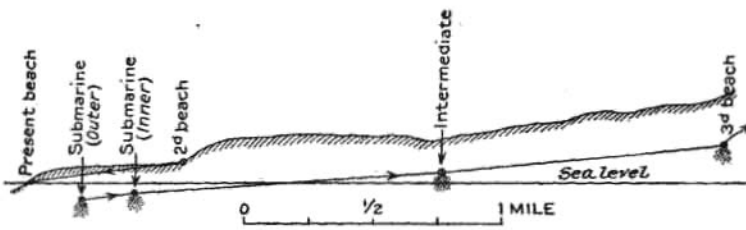


FIGURE 19.—Diagrammatic cross section showing beaches near Nome. Vertical exaggeration about 12 times.

After the shore line had taken a position landward of the "third beach" a change in the progressive depression of the land took place, and uplift began. The result of the uplift was to cause more and more land to emerge from beneath the sea. The uplift seems to have gone on at first without any interruption, for there are no signs of long halts and the accompanying formation of beaches on the surface of the coastal plain. At length, however, when the shore line was some distance south of the "second beach," a period of relative stability ensued and the sea gradually cut back into the coastal-plain gravels until a cliff, in places nearly 75 feet high, towered above the beach. This feature can be most plainly seen in the vicinity of Rocker and Martin gulches, a little east of Nome. When this stage of cutting had been reached an uplift of about 38 feet brought the shore line to a short distance seaward of its present position and then, in a period of stability, the sea renewed its cutting on the shore and formed the low cliff which rises from the present beach.

According to this interpretation the recognizable portion of the history of the coastal plain shows an earlier series of depressions amounting to between 100 and 200 feet, followed by an uplift of about 34 feet less. That there were oscillations in these movements can not be doubted, but that the sum of the changes of level was of the character noted seems obvious. The absence of all surface topographic forms characteristic of beaches, save in connection with the present, the "second," and the most inland beaches, seems to indicate conclusively that these three were the last ones formed and have not been subjected to marine erosion since their formation. Furthermore, the condition and character of the fossils already described would seem to substantiate this conclusion.

Even this interpretation of the past, however, is very incomplete, and the more remote history should be studied in order to understand the reason for the peculiar distribution of gold in the ancient beaches. It is suggested that the "third beach" is richest because there the greatest concentration was effected. It is highly probable that an earlier concentration may have been brought about in the vicinity of the "third beach" by former stands of the sea, and the reworking of this older deposit by the sea at the time of the formation of the "third beach" may have been the reason for the irregular distribution of the rich ground. That there has been greater reconcentration at this place is strongly suggested by the fineness of the gold. It is a well-known fact that the gold from the "third beach" is in smaller pieces than that on any of the other beaches except that of the present day.

CREEK AND BENCH PLACERS.

The lack of water has had a deterrent effect on the exploitation of new ground, and even the previously productive camps have been forced to curtail operations and work on a less extensive scale. During the season of 1908 creek and bench placer mining was done in practically the same areas as in the past. For this reason the region around Dexter, including by this term Dexter, Anvil, and Glacier creeks, is still the most important producer of gold from placers of these types. The result of this work, however, has not shed much new light on the geologic conditions at these places, and as the previously known facts have already been assembled and published, repetition here is not necessary.

Some new mining work has recently been undertaken on Osborn Creek, a tributary of Nome River from the east, 5 to 10 miles east of Nome. This region has long been known to be auriferous, but the tenor of its gravels had not been sufficiently well established to tempt extensive developments. A ditch was completed during the season and under normal climatic conditions a much greater production would have been expected than was actually achieved in 1908. Above Osborn Creek on Nome River a number of small outfits were mining. Not only was work in progress on the gravels of the main stream and its benches, but also almost all the larger side streams showed renewed prospecting. The production from this source, however, was small owing to the unfavorable season, but the activity seemed to point to a resumption of creek diggings.

In the Snake River basin the greatest mining activity was in the Anvil and Glacier creek basins. Creek and bench placers were being worked also on the tributaries above the junction of North Fork, where a number of outfits were employed. The most notable of these streams were Goldbottom and Grouse creeks, where several camps had been mining as uninterruptedly as the scarcity of water would permit. The production, however, was small.

On the other rivers practically nothing has been done except prospecting. On Stewart River two or three camps have been established above the mouth of Mountain Creek, but only a few men were employed at each and the amount of work accomplished was small. A little mining was done on Flambeau River, but the season was not profitable owing to the drought. A ditch started several years ago on this stream was continued for several miles this summer, but it was not used to any great extent.

LODE PROSPECTS.

In a summary of the lode developments up to the close of 1907 [a] the various veins which had been more or less prospected were enumerated. Only three of the number, however, were being actively exploited at that time. During 1908 work was continued on but one of these three properties, though one of the others was closed down because of lack of funds rather than absence of leads. Only two or three new localities of promise were brought forward. No producing ore bodies have been developed and the claims are simply in a prospect stage.

The prospect on which development work was continued last summer was a quartz vein carrying native gold located on the divide near the head of Goldbottom Creek. Earlier work at this place has already been described [b] and few new facts were gathered from the later work. At the time the prospect was visited the work of timbering the shaft was in progress and the underground developments could not be studied. The type of mineralization, so far as could be seen from the surface exposures, seemed to be that characteristic of the black graphitic slates rather than that of the limestone-schist contact. It is true that the limestone contact lies only a short distance east of the main shaft, but the rocks, although somewhat schistose in places, are, as a rule, slates of dark, nearly black color.

[a] Smith, P. S., Investigation of the mineral deposits of Seward Peninsula: Bull. U. S. Geol. Survey No. 345, 1908, pp. 231-234, 240-242, 244-245.

[b] Smith, P. S., op. cit., p. 233.

They are much jointed and veins and stringers of quartz are abundant but seem to have been formed later than or coincidently with the fracturing of the rocks. The veins, therefore, belong to the series which has been termed the later veins. Although the characteristics of this type of mineralization are its wide extent and the small thickness of the great number of small veinlets, there are many places along lines of movement where veins 2 or 3 feet thick are found. Such veins occur at the head of Goldbottom Creek, where the main lead on which the shaft has been sunk stands at a steep angle and seems to occupy a faulted zone in the rocks. The evidences of movement are very strong in the mirror-like slickensided slabs that are abundant on the dump. In fact, the main difficulty to be anticipated in developing this deposit will come from the dislocated character of the country rock.

Lithologically the vein quartz shows in places a little sulphide mineralization, but ordinarily sulphides are lacking and the quartz is milky white to glassy in color, with here and there darker bands that seem to be due to inclusions of the wall rocks. From the absence of sulphides or other sources of gold in samples which assay well, it is to be argued that the gold occurs primarily in native form. No accurate samples have been taken of the entire width of the vein, and, inasmuch as many of the specimens that have been assayed contained visible particles of native gold no approximate estimate of the value of the vein has been made. It seems evident, however, that it is to be classed as a low-grade ore body which will probably run below rather than above $10 in gold to the ton of rock.

No production has yet been made by this property. Apparatus for gold extraction was installed, but it has been taken up and will require modifications before it can be successfully operated. At present it is proposed to hoist the ore directly from the shaft and to dump it on the upper floor, whence it will be fed through a crusher and then pass to storage bins. From the bins the ore will be automatically delivered to the battery of gravity stamps and will then pass to a buddle or slime table. The tailings will be carried off by a sluice and then allowed to settle in a settling pond. A small amount of ore has been treated in this way, but as the underground developments have not reached the stage where a constant supply of ore could be delivered, the table has been removed and the mill is not now running. It would not, however, take long to put it into working condition.

From the surface indications it seems probable that the region is so faulted and the veins so greatly disturbed, that considerable expense will be involved in mining. This is perhaps the main difficulty to be anticipated for the immediate future, but mineralization is so widely distributed throughout the belt of black graphitic slates that even without a definite continuous vein it might be possible to mine the country rock with its network of small veinlets and crush and treat the whole material. If this is done, however, the presence of a large amount of carbon is likely to render the saving of the gold difficult. In other prospects carrying the same kind of material which have been brought nearer to the productive stage, it is found that the presence of graphite interferes greatly with the recovery of gold.

A new location that was reported last summer lies at an elevation between 400 and 500 feet on Newton Gulch. Several holes have been put down and some of them have penetrated for nearly 100 feet into a much-decomposed material lying close to the contact of a dark siliceous schist and the heavy limestone which forms the lower slopes of Newton Peak. The underlying rock that occurs most abundantly east of Newton Gulch is a dark graphitic schist; on the west of this gulch the underlying schist is silvery and micaceous. The dip of the rocks is northerly or into the hill, but they show intense crumpling and accurate interpretation of the structure is not possible, owing to the scarcity of outcrops.

Two or three men have been employed on this group of claims all summer, and it was proposed to do still further work in the winter of 1908–9. At the time of the writer's visit it was not possible to go underground in any of the deeper shafts, and a fall of several inches of snow so obscured the surface features that many of the facts which it was desired to learn could not be determined by direct observation. The mineralization that was seen showed abundance of sulphides now decomposed into limonite. All of the material thrown out on the dump was so badly decomposed as to afford little indication of its original condition. It seems probable, however, that the gold content is low, but only careful sampling can establish this matter and determine whether the deposit carries sufficient values to be profitably exploited.

A short distance above Specimen Gulch, on the western slope of the Anvil Creek valley, at an elevation of 25 to 30 feet above the stream, several holes have been sunk on a vein carrying a considerable amount of stibnite, or antimony sulphide. The rocks in this part of the valley are much dislocated and sheared. As a result of these movements fractures have been produced and many of them have been subsequently filled with minerals. In certain places veins 18 inches wide, consisting of stibnite nearly unmixed with other minerals, have been found, but as a rule the stringers are much narrower. Most of the stibnite is in rather massive aggregates, but in a few places radiating groups of the mineral show by their perfect crystal form and the unbroken lath shape of the separate plates that they could not have been subjected to any considerable amount of dynamic disturbance. This conclusion substantiates the previously expressed opinion that the mineralization has taken advantage of the fracture zones produced by an earlier period of diastrophism. No systematic work has been done at this place, but the surface indications warrant further development in order to allow more complete examination. From the fact that the vein filling has taken place after the period of great deformation, it seems probable that the difficulties of mining should be much less here than in the great number of Seward Peninsula veins that have been fractured and dislocated by these movements. The cost of treating antimony ores is so high and the market for the metal so well controlled, however, that it is questionable whether the ore can be worked unless it carries accessory values in gold. No assays of this ore have been made, but from the evidence afforded by samples taken from other antimony veins in the vicinity it seems highly probable that the ore does carry gold.

In other parts of the Nome region ledges showing mineralization have been brought to the attention of the Survey during the past season, but none of them have been developed by more than shallow pits that give but slight insight into the character of the leads. The two types already enumerated [a]—those in which the gold is free and those in which it is chemically combined with sulphur or some other element—seem to be the only ones which have been recognized, and of these only the veins which have been formed subsequent to the period of maximum deformation seem to be of sufficient economic promise to warrant much prospecting. Every year brings to light more and more evidence of the fact that throughout Seward Peninsula mineralization is very widespread, but it is this greatly diffused character which will reduce the number of workable ore bodies. It would seem that lode mines will be developed only in those places where especially favorable geologic conditions have prevented the diffusion of the mineralizating solutions and have confined them within certain narrow limits. That such places will be found can not be doubted, but that many failures are bound to precede the location of each productive mine is inevitable.

SOLOMON AND CASADEPAGA REGION.

COASTAL-PLAIN DEPOSITS.

The successful location of beaches in the Nome region has induced attempts to find other areas where similar conditions exist. In the Solomon region a coastal plain, in many ways similar to the one at Nome, stretches from the shore line to the foothills, a distance rang-

[a] Smith, P. S., Investigations of the mineral deposits of Seward Peninsula: Bull. U. S. Geol. Survey No. 345, 1908, p. 230.

ing from practically nothing at Topkok Head to 4 or 5 miles near the mouth of Bonanza River. Exploration for ancient beaches has been carried on at a number of points on this plain, and systematic work has been done between Spruce and Magnet (or Lillian) creeks, as already described.[a] In 1908 work on a small scale was continued, but the results, so far as finding placers of economic value was concerned, were not satisfactory. It seems clear, however, that marine material forms a large part of the coastal-plain deposits and that beach accumulation has taken place. The absence of gold may perhaps be due to the character of the bed rock that forms the old land from which the coastal sediments were derived. This rock is distinctly different from that back of the coastal plain at Nome, where abundant heavy limestones approach close to the old coast line. It is believed, however, that search for beaches in the Solomon region has been unrewarded so far because of the expectation that they will occur at levels identical with those at Nome. In the light of the complex history suggested on pages 277–278 for the Nome beaches, it is evident that discordance instead of accordance of elevation is to be expected.

In the winter of 1907–8 some prospecting was done 4 or 5 miles farther west, with a view to locating ancient beaches in the vicinity of Rabbit Creek, one of the many tributaries of Pine Creek. One shaft has been sunk at an elevation of about 200 feet on Rabbit Creek, a short distance above the point where the flume that leads water from the upper part of Uncle Sam Creek to Rock Creek crosses the stream. The bed rock at this place is reported to have been schist, which was encountered about 30 feet below the surface, or at an elevation above the sea of over 150 feet. The material in the upper part of the shaft is more or less shingly creek gravel, but lower down well-rounded quartz pebbles and sand indicate formation by marine agencies. The gold that was found in this lower gravel is bright and although all the pieces that were recovered by panning were very fine, none of them seemed to be very much worn and many had the spongy appearance of crystalline gold. No quartz or country rock was found attached to any of the pieces, but their form strongly suggested that the gold had not traveled far from the veins from which it had been derived. As the ground had been prospected only by this one pit no adequate idea of the tenor could be obtained. It was reported, however, that one 4-pan bucket had yielded 36 cents in gold. The gold, however, is irregularly distributed and the values found do not encourage development.

Farther up Rabbit Creek is a shallower hole in which the gravels are not as well rounded as in the lower pit and seem more like creek wash than beach or marine deposits. These gravels rest on a mica schist bed rock which is slightly calcareous and has a salmon color,

[a] Smith, P. S., op. cit., pp. 219–221.

owing to the stains due to the decomposition of the iron minerals. Some of the gold is rusty, as if it had not been subjected to recent movement. The rusty color undoubtedly is due in part to the character of the bed rock on which the gold has accumulated, for evidence of a considerable circulation of iron-bearing waters could be found at numerous places in the gravels. The gold occurs in thin plates, many of them with the edges bent over. Only small fragments were recovered in pan tests, the largest being worth about 1 cent. On the whole, the gold does not appear to have traveled far from its place of derivation and its shape is very dissimilar from that of characteristic beach gold, such as is found on the present beach at Nome or at other points in the peninsula.

West of this last-described hole, on the valley slope a little above the creek, at an elevation of approximately 250 feet above sea level, a hole 45 feet deep has been sunk without reaching bed rock. Thawed ground was encountered and the miners were driven out by the water. Northeast of this hole, on the eastern bank of Rabbit Creek near its head, two holes, 20 and 30 feet deep, were sunk to bed rock. In both, near the bottom, well-rounded beach wash was found. A section of one shaft showed in the upper part more or less angular slide or river wash, followed by sand and rather poorly rounded gravel, and near the bottom well-rounded gravel. In one of the holes the pebbles consist almost entirely of black graphitic slate, similar to that forming the country rock of Uncle Sam Mountain, but in the other the pebbles are almost all of white vein quartz. These pebbles, as a rule, are about an inch long and half an inch in the other dimensions. Under the gravels is a rather thin sand layer that rests upon a much-decomposed schist bed rock.

The values at this place occur in the sand underlying the well-rounded gravel and in the upper part of the decomposed bed rock. A selected pan from this material yielded 40 to 50 colors which together were worth about a cent. Some of the gold was iron stained, but most of it was bright. Apparently the gold derived some of the iron with which it is stained from the decomposition of the iron minerals contained in the black quartzitic slate pebbles. Not enough iron is present to form a cement at this place, but a short distance downstream another hole 36 feet deep passed through several layers of cemented gravel. Too small an amount of gold was seen from the upper hole to permit a final opinion of the character of the sand layer as a whole, but it would seem that the gold is much finer and in the main much more worn than that from any of the other holes already described. Although nearly all the ground is frozen, thawed areas are occasionally encountered so that the conditions of developing any productive deposit will be essentially the same as those surrounding the deposits of similar types near Nome.

CREEK AND BENCH PLACERS.

In the Solomon River basin the past season has been marked by greater activity in dredging work than in any of the other methods of mining. The dredge near the mouth of Johnson Creek has continued operation during the open season, a new dredge of nearly equal power has been constructed a short distance farther upstream, and an abandoned dredge near the mouth of Quartz Creek has been again put into commission. Along Shovel Creek the dry-land dredge is still in operation on West Creek and the steam shovel with its unique gold-saving device is working on the main stream near the mouth of Cadillac Creek.

A description of the dredge near the mouth of Johnson Creek on Solomon River recently published[a] gives some figures regarding the output of this dredge and its operating expenses that have not been heretofore available. According to this article the dredge cost originally $118,000 and was modeled after Exploration No. 2 dredge at Oroville, Cal. It has a capacity of 3,700 cubic yards a day, and the estimated cost of operating is about 10½ cents a yard. The total cost, however, including not only the actual operating expense but also items to cover depreciation, maintenance, and amortization of the capital, is 18 cents a cubic yard.

Although this statement of the costs of handling the gravel is of great interest, it seems wise to give a word of caution against the too general use of these figures for all dredging enterprises in Seward Peninsula. It should be remembered that such low operating expenses are possible only under particularly favorable physical conditions. All of the ground to be dredged was carefully tested in advance of actual mining and the area and extent of permanently frozen ground outlined, so that it could be avoided. Most of all, however, sufficient acreage was obtained to outlast the life of the dredge. By attention to this last detail the annual amortization charges were greatly reduced, for it is evident that such charges are much lower where the installation has a life of ten years than where only enough ground is available to support the industry for five years. The company working the dredge just described controls, according to Rickard, 4,000 acres, of which less than 100 have been dredged out in the three years that the company has been operating. Still another factor that has contributed to the success of the work at this point is the fact that the bed rock over the larger part of the area is schist, and is much more easily excavated than the hard limestone, which can be handled only by very powerful dredges.

The high cost of fuel is one of the most expensive items to be considered in dredging. At the plant just described more than 10 tons

[a] Rickard, T. A., Dredging on the Seward Peninsula: Min. and Sci. Press, vol. 97, 1908, pp. 734-740.

of coal are required daily. Where transportation is difficult it is evident that the success or failure of an enterprise may be decided by this factor alone. It was planned to build a ditch from Solomon River near the mouth of East Fork and to use the water thus derived to generate electric power for operating the dredge. Unfortunately this scheme was blocked by a controversy as to the ownership of the water right and has been, at least temporarily, abandoned.

Just upstream from this dredge another, operated by a different company, was installed last summer in the short space of about seven weeks. It is not new, having been originally in use near Hope, on Kenai Peninsula, but it has seen so little service as to be practically as good as new. Almost all the first part of the summer was occupied in assembling the dredge, and was thus unavailable for actual productive work. Mining began early in September and continued until the close of the open season, about the end of the third week of October, a large amount of gravel being moved. The opportunity of comparing this dredge, which is of the Risdon type, with the modification of the Bucyrus dredge farther downstream is exceptionally good and should afford considerable data for a determination of the efficiency of each type.

In operation the 5-foot buckets raise their load of gravel to the level of the upper deck of the dredge and dump upon an inclined plate which directs the material into a revolving trommel. The oversize from this trommel is discharged into flat pans which form a bucket conveyor, and the tailings are stacked at the rear of the dredge. The finer material that has passed through the screens is fed to tables covered with cocoa matting, on which are laid expanded-metal riffles. No quicksilver is used. Most of the gold is caught in the upper part of the tables, but the lighter material, after it has left the tables, is carried in a sluice with riffles, and a small additional saving may thus be effected. According to Rickard [a] the actual operating expense at this dredge, without allowing any charges for depreciation, interest, or amortization, is a little over 14½ cents per cubic yard. The ground had not been carefully prospected in advance of mining, so that no statement of the average tenor of the gravels is possible. It would seem, however, from the fact that the gold lies mainly in the lower layers and on bed rock, that the financial success of the enterprise depends on the efficiency of the dredge in cleaning bed rock.

Near the mouth of Quartz Creek an old dredge, which for the past two years has been lying abandoned near the mouth of Big Hurrah Creek, has been recently placed in commission. It is a small affair with 4-pan buckets. Power is furnished by a gasoline engine, the water being pumped by a 10-inch and a 3-inch pump. The larger

[a] Rickard, T. A., op. cit.

pump delivers the water for the main line of sluice boxes; the smaller is used on the so-called "slough over" from the bucket line. Hungarian or pole riffles are used in the boxes and most of the gold is caught in the upper half of the string. Unfortunately the machine is not strong enough for the work it is called upon to do, and more than half of the season was lost in making repairs. The bed rock in the eastern part of the claim is limestone, but in the western part schist predominates. Most of the mining is being done on the western part, for the dredge is not capable of cleaning the hard limestone. It is estimated that this dredge can handle 400 yards of gravel a day, but this maximum is seldom attained.

The fourth dredge in the Solomon-Casadepaga region is of a dry-land type and is in use near the mouth of West Creek, a tributary of Shovel Creek, which in turn joins Solomon River. Mining at this place was conducted on practically the same scale as in former years. The dredge is small, having a capacity of about 200 yards in ten hours, with not sufficient power to handle the large slabby pieces of limestone that are frequently encountered. This plant shows a rather unusual feature in that the sluicing water is carried by means of hydraulic hose to the dredge, where the gravels are washed, the tailings being discharged over the opposite side of the machine. It is not usual at this place to take up much of the actual bed rock, as the best paying material is found on a decomposed layer several inches above. It is expected that considerable values still remain in the bed rock, but according to the management it is not profitable under present conditions to attempt further recovery.

A short distance above the mouth of Jerome Creek, on Solomon River, some low bench gravels were mined to a small extent during 1908. The bed rock at this place is a few feet above the level of the river and is of a yellowish color and a somewhat limy character. It is overlain by about 12 feet of well-rounded, waterworn gravels, the largest pebbles of which are from 6 to 8 inches in diameter. All of the gravels are frozen except where exposed by surface stripping. Throughout the greater thickness of these gravels valuable, heavy minerals are almost entirely lacking. Near the base there seems to have been a slight concentration, and some gold-bearing gravel that can be profitably mined is found. Together with the gold in the concentrates is a large amount of magnetite and ilmenite and a small amount of garnet. Water for the development of this ground is delivered from the ditch on the east side of Solomon River, having an intake on Big Hurrah Creek, and is carried from this ditch by hydraulic pipe to the point where it is used. This place is interesting as giving an insight into the character of the gravels that form notable deposits along Solomon River as far upstream as Quartz Creek.

On Moran Gulch, a few hundred yards from Solomon River, a party of two men has been hydraulicking bench gravels which seem to be more closely allied to Solomon River than to Moran Gulch. In thickness they show considerable local differences, but the average is about 9 feet. The unconsolidated material consists, in the upper part, of muck and vegetation; this is underlain by layers of more or less clear ice mixed with muck, and this in turn by 3 or 4 feet of well-rounded gravels resting on a decomposed schist bed rock. Exploitation has failed to reveal any rich ground, but it is a question whether the slight returns may not be due to the mining methods practiced. No drain has been carried up to the workings, and it is frequently the custom to pipe the gravels into the sluice boxes through a large pool of standing water. Furthermore, bed rock is cleaned only with the hydraulic nozzle. It seems highly probable that owing to these two methods of work a share of the values is not recovered. Water is delivered to this ground from the ditch on the east side of the Solomon River valley, the intake being on Big Hurrah Creek. Work was in progress at this place only during the latter part of the season.

Between Shovel Creek and the mouth of Quartz Creek on the main river four camps have been working during the summer. One party of only two men was mining low bench gravels about a quarter of a mile above the mouth of Shovel Creek. Water for sluicing was delivered by a gasoline pump. The values of this ground are reported to be low and the returns, therefore, were probably small. Farther upstream, only a short distance above the mouth of Penny Creek, another party has been mining bench gravels west of the river. The gravels are about 10 feet deep and all of the upper gravel is well worn, so that the cobbles are smooth and rounded. Bed rock, so far as exposed, is limestone, which is much fissured as well as dissolved. In one place a pothole at least 8 feet deeper than the average level of the bed-rock surface has been dissolved in the limestone. Attempts to prospect this pothole have not yet been successful in reaching the bottom, but so far as it has been opened it has failed to reveal any gold. For the first 100 feet or so from Solomon River the gravels were entirely thawed and it was only after getting in about 150 feet that frozen ground was struck. So far as could be determined the upper gravels contain so small an amount of gold that for practical purposes they may be considered barren. Near the bottom, however, a pay streak of 1 foot of sand and gravel was encountered. The values are not limited to this thin layer, for gold has been found penetrating the cracks and crevices of bed rock to a depth of at least 4 feet. It is the practice at this place to sluice off the upper gravels and then to wash the pay-streak gravels and take up by hand from 1 to 4 feet of the bed rock. The pay streak is not only thin, but narrow, for its width is generally not more than 30 feet, and 15 to 20 feet would probably be about the average width. Water for sluicing is furnished by the ditch on the east side of Solomon River.

Half a mile below the mouth of Quartz Creek a party of five men has taken advantage of the exceptionally dry season to carry on mining in the bed of Solomon River. The river has been turned aside and small areas have been surrounded with sod dams covered with canvas to keep the water out. Bed rock in the eastern part of the claim is limestone, but toward the west side of the valley floor it is schist. The gravels are thin, nowhere exceeding 3 feet in thickness, and are probably more or less thoroughly set in motion each year by the stream. In consequence the values occur almost entirely on or within bed rock, so that it is necessary to take up by hand from 1 to 3 feet of the limestone to recover the gold. All of the gold from this ground is coarse and shows but slight evidence of having traveled far. In 1907 a $150 nugget was found and last year one worth $70 was taken near the bed-rock surface. The gold of the latter was not very bright and had a great deal of quartz and schist attached. From the character of the material associated with the gold it was evident that the nugget had been derived from one of the older series of much contorted quartz veins occurring in the chloritic schist which forms a part of the Nome group. The smaller pieces of gold are almost invariably bright and show no tarnish or rust. This character is in part due to the kind of bed rock on which they occur, for it is a notable fact that in a region where limestone forms the country rock the gold is, as a rule, not discolored.

East of the small dredge near the mouth of Quartz Creek, previously noted, bench ground has been developed on a small scale. Bed rock is limestone, in places much brecciated. The gravel here and there is 10 feet thick and this has given rise to some winter work by drifting. No well-worn gold is found on this ground, all the pieces being chinky and many of them of considerable value. The largest piece was worth $250. This heavy gold seems to occur near the contact of the heavy white limestone and the chloritic schist. At this locality part of the bench gravels are cemented. Both lime and iron form the cementing material and in a few places some placer gold has been found in the midst of the cement. Owing to the cemented character of a part of the gravel some gold is undoubtedly lost in sluicing, for no attempt to break up the agglomerate is made and so the pieces roll through the sluice boxes. Although the greater part of the gold on this claim is bright, much of that occurring in the places where iron-bearing solutions are prevalent is rusty and will not amalgamate.

Farther up Solomon River, between Quartz and Big Hurrah creeks, a bench deposit to the east of the river is being mined. Three men are engaged at this place in drifting from a vertical shaft. Water for sluicing is furnished by a small gasoline pump which takes water from Solomon River. The gold-bearing gravels are hoisted by a gasoline engine and the bucket is dumped by the man attending to the sluice boxes. Bed rock is a heavy white limestone, much fissured. In order to recover the values it is necessary to take up the bed rock to a considerable depth. No values are found in the upper part of the overlying gravels and as the ground is solidly frozen the drifting method is applicable. No statement could be obtained as to the tenor of the ground, but from the fact that the work has been continued at this place for several years it would appear that the results were satisfactory.

Hydraulic work has been continued on Big Hurrah Creek near its junction with Solomon River, but the unusual dryness of the season hampered mining to a marked degree and not so much was accomplished as was expected. On this ground there are three elevators, but only one is in use at a time. The bed rock for the first half or three-quarters of a mile above the railroad consists of black, somewhat graphitic, very siliceous slate, breaking into more or less rectangular blocks. A few narrow black limestone beds occur, but they are of slight extent. The bed rock is cleaned only with the hydraulic nozzle and is not hand picked. While this plan undoubtedly saves expense, there must necessarily be a considerable loss of gold. It is reported that the gold from this part of Big Hurrah Creek is bright and medium coarse. The greater part of it is flaky, but some small nuggets are found. Most of the values occur along the south side of the present creek floor. The northern part of the valley bottom is said to show only a small amount of gravel, the material for the most part being slide that carries but low values.

Few other localities in the Solomon River basin were actively mined during the past summer and the production from them may be considered as practically negligible. Outfits of one to four men each were working during a part of the season on Butte, Mystery, Kasson, and several of the other small creeks, but the lack of an adequate water supply caused suspension of mining until late in the season and the early freeze-up stopped work early in the fall. No new discoveries were made and what little mining was accomplished was along the same general lines and at approximately the same places that have been described in earlier reports of the Survey.

In the Casadepaga drainage basin the effects of the abnormal season were felt even more keenly than in the Solomon basin, for in the former few ditches have been built except from small local basins, so that no continuous water supply was afforded. When the region was visited in July no work was in progress, and later accounts from credible sources indicate that but little work — and that mainly of a prospecting nature—was done during the season in the whole Casadepaga region. Many miners who had been busy installing machinery during the previous season were forced to abandon operations and await more favorable conditions. A few additional notes on the Casadepaga and adjacent regions are given elsewhere in this volume, in a report on the Iron Creek region (pp. 333–337).

LODES.

For a long time the Solomon-Casadepaga region has been notable because in it was located the only productive lode mine in Seward Peninsula. Unfortunately a series of difficulties have arisen which compelled the suspension of operations at this mine during 1908. The closing down was not at all due to the quality or other characters of the ore, so that there is no reason to believe that work has been given up for good. Until the questions of management, etc., can be definitely settled, however, there is little prospect of work being resumed. It would seem that the developments already made justify a continuation of the work.

Practically nothing has been accomplished in this region during 1908 in the way of lode developments. Nearly all the lode prospects and exploratory work noted in a previous report [a] have received but scanty attention, and in many places not even the annual assessment work has been performed. A little new exploration has been undertaken on the north side of Big Hurrah Creek at a considerable elevation above that stream, but no shipment has been made. It might be possible by low freight rates to bring in supplies at a sufficiently low cost to allow the profitable development of some of the properties near the railroad. It should be remarked, however, that the diffused character of the mineralization throughout the various rocks suggests that only by a careful search for those places where the mineralization has been localized will a successful mine be established. That there are such places can not be doubted, for the Big Hurrah mine affords a conclusive example, but that many of the locations are on small stringers without any continuity in depth and without sufficient width to allow profitable mining must also be evident to anyone acquainted with this region.

COUNCIL REGION.

In the Council region the same adverse conditions that have already been noted as prevailing in other parts of the peninsula caused a great falling off in the production. This region was visited during the early part of July and a most discouraging impression of its activities was gained. From the data gathered at that time and from later

[a] Smith, P. S., Investigations of the mineral deposits of Seward Peninsula: Bull. U. S. Geol. Survey No. 345, 1908, pp. 234–238.

reports it seems certain that the production from this camp fell off nearly 50 per cent from that of the preceding year. The rich bonanzas that made the region famous in the early days have been more or less exhausted and no new ground has been opened by prospecting. That there are many rich spots still remaining, even on the known creeks, can not be doubted. It is believed that most of these places are those that have been overlooked in the earlier work and that they are not extensive. There are, however, many streams as yet practically untouched which would seem to warrant prospecting with good hopes of high returns. Rich ground must be found or a material reduction in operating expenses must be made if the future of Council is to be assured.

Of all the streams in the vicinity of Council, Ophir Creek still continues to be the most productive. Although this valley shows marked proof of failing to yield as much gold as formerly, nine-tenths of all the gold that comes from the Council region is derived from it. On one of the lower claims a dredge which has been located here for several years continued operations during 1908. Figures concerning the yield of the ground and the operating expense have recently been published by Rickard,[a] who states that the original cost of this dredge was $28,700 and that the annual charges for repairs are about $5,000. An interesting portion of Rickard's article referring to the work of this dredge is as follows:

During the season of 1907 this dredge worked for 110 days. The actual running time represented 69 per cent of the total time. The ground excavated represented 98,718 cubic yards. The total expenses were $31,672, and the value of the gold extracted was $83,144. Therefore the average yield was 84 cents and the average cost 32 cents per cubic yard. The season of 1908 will show about the same costs, but a better yield of gold. The fuel consumed is wood at the rate of 10 cords per day, at $10 per cord delivered. The total costs as given above include all repairs, equipment, and general expenses.

These figures are interesting as indicating the higher cost of dredging in a region not so easily accessible as the Solomon and Nome regions and for a dredge not of modern construction, but handled by an efficient management. Frozen ground is encountered more or less irregularly, and thus decreases the amount of gravel handled and materially increases the cost for repairs.

During the past season the largest organization operating on Ophir Creek, the Wild Goose Company, has moved its headquarters camp from its old position near the junction of Dutch and Ophir creeks to Discovery claim near the mouth of Sweetcake Creek. This change marks the beginning of the closing stage of the operations of this company on the upper part of Ophir Creek and is not a favorable sign for the district as a whole. Work was continued on several of the

[a] Rickard, T. A., Dredging on the Seward Peninsula: Min. and Sci. Press, vol. 97, 1908, pp. 234-240.

claims held by this company, but the main work was on the claims near Discovery. The unusual dryness of the season affected these claims less than it did those of the small operators who had not such extensive ditch lines. In spite of these long ditches, however, not enough water could be delivered to permit continuous mining and for a long time actual productive work was suspended. During these periods some prospecting was done, but no new developments of importance were recorded.

A short distance up Ophir Creek, on the same claim where, in 1907, an unsuccessful attempt had been made to use a dry-land dredge, a camp was established in 1908, and it was reported that the most productive work of the season was carried on there. Mining was done with scrapers and derrick, and a large crew of men was kept busy. No accurate data are available for a statement of the production from this claim, but it is believed that the success of the venture was not due to the richness of a small amount of ground, but to the fact that a large volume of medium low-grade gravel was handled economically. Some gravel of high tenor was found, but if previous explorations are to be trusted the rich areas were not extensive. The success must be attributed in large measure to efficient management.

Four or five other parties were more or less continuously engaged in mining above this claim all the way to the canyon of Ophir Creek. Many of these were using horse scrapers, but others were simply shoveling in. Near the mouth of Crooked Creek, however, a new enterprise that will be watched with considerable interest was started during the summer. This was the installation of a dry-land dredge similar in many respects to the dredge built on one of the claims nearer the mouth of the stream in 1907, but of much stronger pattern. The original intention was to use the dredge on Melsing Creek, and it was designed for the depth of gravels on that stream. For various reasons, however, it was decided to erect the dredge on Ophir Creek about 7 or 8 miles above the mouth. The gravels were reported to have a little higher tenor on this claim, but their depth was considerably greater than the dredge was originally planned to handle. A large part of the season was lost in getting the machinery which was shipped in from the States installed and in running order, so that it was in operation for only a short season. From all accounts the dredge seemed to be working satisfactorily. A dredge of this type, however, has yet to demonstrate that it can handle hard bed rock, and until this is proved it seems inexpedient to attempt mining of this sort except where the physical conditions are favorable. Fortunately the bed rock where this dredge is located is a much decomposed schist that can be easily picked up by the buckets.

Few other creeks in this region showed any notable production. On Melsing Creek work was in progress at the mouth and near the junction of Basin Creek, but there were few who gained much more than wages. Mystery Creek, which joins the Niukluk 5 miles east of Council, was the scene of some activity early in the season, but the long, continuous drought discouraged the operators and little was accomplished in the way of actual production. Above Ophir Creek little work was done on any of the tributaries of the Niukluk. A small production was reported from Warm Creek and also from Camp Creek, but the operations were not nearly so important as in previous years. The Casadepaga basin, which forms part of the Council precinct, has already been briefly discussed on page 292 of this report. It will be seen that the production from this area is not commensurate with its size and probably not with its latent resources.

KOUGAROK REGION.

Few of the claims in the Kougarok region were mined in 1908. This region is, even under most favorable conditions, hampered by lack of water, and when this normal character is exaggerated by unusual drought, mining is brought to a standstill. Though none of the larger companies have taken out much gold, many prospectors forced to earn a "grubstake" for the winter have gone back to the primitive rocker and were taking out a little gold. The amount won in this way was, however, too small to have a marked effect on the production. In consequence it may be said, without any disparagement to the future output of the region, that the amount of gold won in 1908 was far below that of preceding years.

On Quartz Creek and its tributaries, Dahl and Coffee creeks, some winter work was done, and the dumps were sluiced with the early run of snow water. Outside of this production little was accomplished. Mining on Dahl Creek was limited to three claims, and all of them were worked on a small scale. On Coffee Creek three outfits were located, but the work was mainly of a prospecting character. It is reported that a short distance up Kougarok River from the mouth of Quartz Creek some dredging ground was prospected, but no attempt was made to develop it. Although the summer was a failure in this drainage basin, the number of boilers that were placed in position at the close of the season promised considerable activity in winter mining. At least five parties were planning to sink shafts and prospect their claims on Dahl Creek.

Farther upstream, the next place where mining was done in 1908 was on Windy Creek, which joins Kougarok River from the west. Two claims were being developed on a small scale. The most interesting project on this stream has to do with gaining a water supply. The upper part of Windy Creek heads in a region of heavy limestone with practically no surface water. Lower down, however, near the contact of this limestone and the schists, numerous springs return to the surface the water that has been carried by underground passages in the limestone. These springs do not carry enough water to supply the needs of miners throughout the season. It is proposed, therefore, to dam up the springs and to allow them periodically to overflow during the winter. In this way a thick body of ice will be formed, which on melting during the summer will give a continuous flow. This experiment will be watched with interest, as it is practically the first attempt of its kind. Snow storage has not been successful, and it remains to be demonstrated that ice storage of this sort will fulfill the requirements. On Windy Creek there is also an enterprise on foot to build a ditch to Dahl Creek. A start on this ditch was made during 1908, but it will not be completed until the season of 1909.

Mining on the North Fork of Kougarok River has been carried on at three different camps. Most of the values that have been found occur in the benches on either side of this stream. The benches near the mouth of the creek seem to carry better values than those farther up the valley. Near the mouth of Eureka Creek bench ground showing a good gold tenor has been mined. One of the most interesting discoveries on Harris Creek has been the location of placer gold in limestone. Samples of this material were given to E. M. Kindle, of the Survey, by Mr. Kennedy, and have been examined by the writer. Though no minute study of these samples has been made, it seems certain that gold in particles that have all the appearance of placer gold occurs in the midst of the limestone. This rock is a dark, somewhat brecciated limestone, consisting mainly of calcite, but containing in addition rolled garnet grains and flakes of gold. The shape of the gold precludes the possibility that it was originally formed in the limestone in the condition in which it now appears.

Coarse Gold Creek is reported to have been mined by one outfit during the past summer. As there was no water until the first of August and as the freeze-up came about the first of September, no considerable production was to be expected. A few cuts were made and the gravel was sluiced, but it will be another year at least before any notable output is made from this stream. On Arizona Creek, which enters the Kougarok a mile and a half above Coarse Gold Creek, two men spent the season in prospecting. It was reported that minable gravels had been uncovered on the bench on the west side of Kougarok River near the mouth of Arizona Creek. The bench gravels lie at an elevation of about 70 feet above the stream.

Below Taylor Creek, on the main river, the past season has been spent mainly in preparing for future work. Considerable progress has been made in stripping and crosscutting the benches on both sides of the river, and everything seems to be in good condition to carry on mining actively when a normal season affords sufficient water. On Taylor Creek practically no work was done. The hydraulic elevator at no time had sufficient water, consequently it remained idle all the season, and no other work was started. On Homestake Creek some prospecting was done, but there was no productive mining. Above the Homestake Creek camp all the work was done on creek-bed claims. Five camps were operating claims on this part of the river, and several others were prospecting. The camps had crews ranging in number from 2 to 12 men each. No figures as to the production are available, but it seems probable that more than wages was made by the different outfits. The total production was probably greater than from any other summer diggings on the Kougarok. Prospecting on Macklin Creek is reported to have shown the presence of some minable gravels, but water for sluicing was lacking.

Developments on the tributaries to Noxapaga River that have been productive during former seasons were practically at a standstill during 1908. Prospecting work only is reported to have been done on Boulder Creek, and its production, therefore, can be considered as little more than wages. On none of the other streams in this section have there been any mining developments. In one place, however, plans have been perfected for more active work during the coming season.

PORT CLARENCE REGION.

PLACERS.

Gold mining in the Port Clarence region is confined largely to the valley of Bluestone River and its tributaries. There is also an extensive equipment on Sunset Creek and at a few other points in the region, but in the number of men employed and amount of production the valley of the Bluestone is the most important. When, however, this whole region is compared with the Nome or even with the Solomon region, its production is small and its industries seem to be on the decline. Such decrease is not to be accounted for entirely by the remoteness of the region. Supplies can be landed at Teller, the largest town, at even less expense than at Nome, and the routes into the interior are not much more difficult from one place than from the other.

A camp has been established on Bluestone River near the mouth of Ruby Creek, but little work was in progress except on some low benches on the west bank of the river. All of this ground is frozen and facilities for sluicing are lacking. A long ditch line has been projected, but its feasibility has not been demonstrated. It has also been proposed to build a ditch from the upper part of Ruby Creek, but when this creek was visited in the middle of August there was no water in the upper 2 miles of its valley. No other mining was in progress on any other part of the Bluestone proper below a point less than a mile from its junction with Right Fork. At this place the unusually dry season allowed work to be carried on for a short time in the actual river bed, which under ordinary conditions is inaccessible because the narrow canyon prevents turning the river aside. A small pocket of coarse gold was found and practically exhausted before the rains raised the river to such height that the miners were driven away. It is reported that all of the gold from this ground was coarse and chunky, fine gold being practically absent. In a lot of gold worth over $1,000 almost all the smaller pieces were shotlike in form and uniformly bright in color. Some wire gold was also seen, one piece being nearly 2 inches long. The largest nugget that was found was worth $72 and was roughly triangular in form. None of the gold showed signs of long travel and several pieces could have come only from near-by localities. It is not believed that the gravels in which this coarse gold was found are very extensive and the mode of occurrence would suggest local concentration caused by the peculiar physical conditions. There are strong indications of several levels of stream erosion on the walls of the canyon near this claim, and a detailed study of the evidence they afford would be necessary to determine the past history of the river.

Between the mouth of Right Fork and Alder Creek a little desultory prospecting on some of the bench deposits of the Bluestone was done. Hydraulicking of some of the bench gravels of the small stream north of Alder Creek resulted in a small production, but scarcity of water prevented any large scale operations. Above Alder Creek, on the tributary of the Bluestone known as Gold Run, several camps were established. A low channel on the west side of Gold Run was worked with a small force and productive ground developed. The material from the surface down to a depth of 5 to 10 feet is a dark slaty-colored muck showing in places distinct lines of stratification. It is solidly frozen and is reported to carry no values. Below this muck is gravel ranging from a few inches to several feet in thickness. This member and the underlying bed rock carry the gold. The bed rock is a dark schist much softened and decomposed on its upper surface. The gold is ordinarily bright, but tarnished and rusty pieces are by no means uncommon. Few large nuggets are found, but none of the gold is very fine. Pieces worth from 1 to 5 cents show but slight water rounding, though the finer gold is in general fairly well worn. In the concentrates ilmenite predominates over magnetite and there is very little garnet. Mining is done by ground sluicing off the overburden and piping the gravels through a series of bed-rock boxes. The tailings are discharged into Gold Run. A low ridge of rock separates the channel that is being mined from the present stream.

Southeast of the last-described property another outfit has been developing somewhat similar gravels. It is not to be inferred, however, that these two deposits are continuous, and as a matter of fact it seems probable from the difference in elevation that one succeeded the other only after a lapse of time. A section at the upper claim shows silts overlying the gravel deposits, but the stratification is not so clearly marked as on the lower claim. The pay streak rests on a somewhat calcareous schist that ranges in different parts of the exposed area from a foliated chloritic schist of greenish-gray color to a dark, nearly black siliceous slaty schist. The gold is coarse and several nuggets worth from $20 to $40 have been found. There is in addition a good deal of fine gold, but all is easily distinguished without the use of a lens. The actual mining operations are mainly hydraulic in character. Two nozzles are directed against the face of gravel and silt, caving the material, which is then washed into sluice boxes where the gold is recovered, the tailings being discharged into the main stream. Apparently sufficient water is available to meet the ordinary needs of the operators.

These are practically the only productive properties on Gold Run, but several prospectors on tributaries of this stream and the Bluestone are testing the gravels and producing a small amount of gold. On the head of Gold Run one prospector has continued the work of previous seasons on a small scale, owing to scarcity of water. On Bering Creek, a small tributary of Igloo, itself a tributary of Right Fork, a camp much handicapped by lack of water has taken out some good values considering the length of time devoted to mining. On Right Fork near the mouth another camp was engaged more or less actively in prospecting. On the divide between Gold Run and Canyon Creek the deep shaft mentioned by Collier[a] was visited last season and it is reported that further exploration work will be undertaken in the near future. From the character of the gravels, which at the base are made up largely of well-rounded granite bowlders derived from the Kigluaik Mountains, it seems probable that the old channel must have been formed by a river heading in those mountains before the glacial obstruction formed the divide between the Canyon Creek and Gold Run basins. It is believed that if this is the case the chances of finding economically important placers in this channel are not good.

Of the many small streams entering Port Clarence and Grantley Harbor from the north, Sunset Creek is practically the only one on which mining was conducted during the summer of 1908. Even at this place, which is equipped with a long ditch, not enough water was available to allow continuous work. In the winter of 1907 a shaft was sunk west of the creek and the gravels found were reported to be of low grade. The bed rock is a schistose greenstone, but farther east it is a dark-colored, somewhat calcareous schist. An open cut was also driven to the east of the creek with a view to prospecting

[a] Collier, A. J., and others, Gold placers of parts of Seward Peninsula, etc.: Bull. U. S. Geol. Survey No. 328, 1908, p. 279.

the bench gravels. The bed-rock surface rises rapidly away from the stream, but well-rounded gravel continues to an elevation of about 60 feet above Sunset Creek. The country rock at this place looks like black graphitic schist, but it is not quartzose and does not break into more or less rectangular blocks, and it gives a slight lime reaction. In places this schist is cut by greenstone and feldspathic schists. Mining has been done on Sunset Creek all the way from the mouth as far as Lombard Creek, the second small tributary from the north. After the first mile ledges appear in the valley slopes almost all of the way to the head. In places, especially near the mouth of Lombard Creek, the surface gravels are heavily iron stained.

At the present time the only work is being carried on about a mile from the beach. A hydraulic elevator was used, but the low gradient of the creek caused trouble in disposing of the tailings, and it may be necessary to use horse scrapers to clear away the accumulation at the lower end of the boxes. The gold is rather coarse, and the large pieces are dark colored. In the upper layers of the gravel some bright gold is found. Out of a collection of nuggets worth between \$200 and \$300 only one piece with quartz attached was found. Most of the gold does not have sharp outlines. No clue as to the origin of the gold has been discovered. Veins are common in the schists, and there is a good deal of heavy quartz float all along the creek, but none of it shows any mineralization, and assays that have been made indicate but a very insignificant gold tenor.

LODES.

In the Port Clarence precinct the lodes of especial interest are those in which the valuable minerals are cassiterite or wolframite. Investigations of the various localities where tin or tungsten has been found in Seward Peninsula has been recently summarized by Knopf.[a] None of the properties were examined by the Survey during last summer, so that there is no new information concerning recent developments. It is reported that near Tin City prospecting work was resumed early in the season. The placer-tin properties north of York were not in operation until late in the season. In the Lost River and Brooks Mountain region three locations were more or less prospected last season, but no ore was commercially extracted. As a whole, the prospecting for tin lodes was less actively pursued than for several years past.

Lodes of another class have been developed to some extent in the Port Clarence region on the north side of the Kigluaik Mountains, near Imuruk Basin. These are the graphite prospects. Mention has

[a] Knopf, A., Geology of the Seward Peninsula tin deposits, Alaska: Bull. U. S. Geol. Survey No. 358, 1908.

been made in another report[a] of the deposits of this mineral at many places in these mountains, and it has been shown to be of widespread distribution. Unfortunately, however, the graphite is so intimately mixed with grit and impurities that its extraction is difficult. Two or three separate outfits were engaged more or less continuously in developing the leads on the small gulches that lead to Imuruk Basin west of Cobblestone River. The graphite occurs in bands in a series of biotite schists rather closely associated with granitic intrusions. Dislocations and fractures make the stoping out of the ore more or less dangerous, and none of the holes have been run in more than a few feet. After the ore is broken from the ledge it is cobbed and hand sorted. In this sorting less than 25 per cent of the material is retained. This is sacked and slid down the steep slope of the mountains on sleds, made like a stone boat, to the flats surrounding Imuruk Basin. The sacks are then transported by horses to the shore, where they are put aboard a boat and taken to Teller for shipment to the States. Only a few tons of ore have been produced from this property. There can be no doubt that enormous quantities of graphite are present in the rocks in the Kigluaik Mountains, for large slabs have been found in the float all the way from a point east of Grand Central River to the head of Tisuk Creek, but it has not yet been proved that it can be separated from the accompanying grit and transported economically. In addition, the dislocated character of the rocks throughout the greater part of the region will make the following of the leads expensive when actual mining is commenced.

[a] Smith, P. S., Investigations of the mineral deposits of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 345, 1908, p. 250.

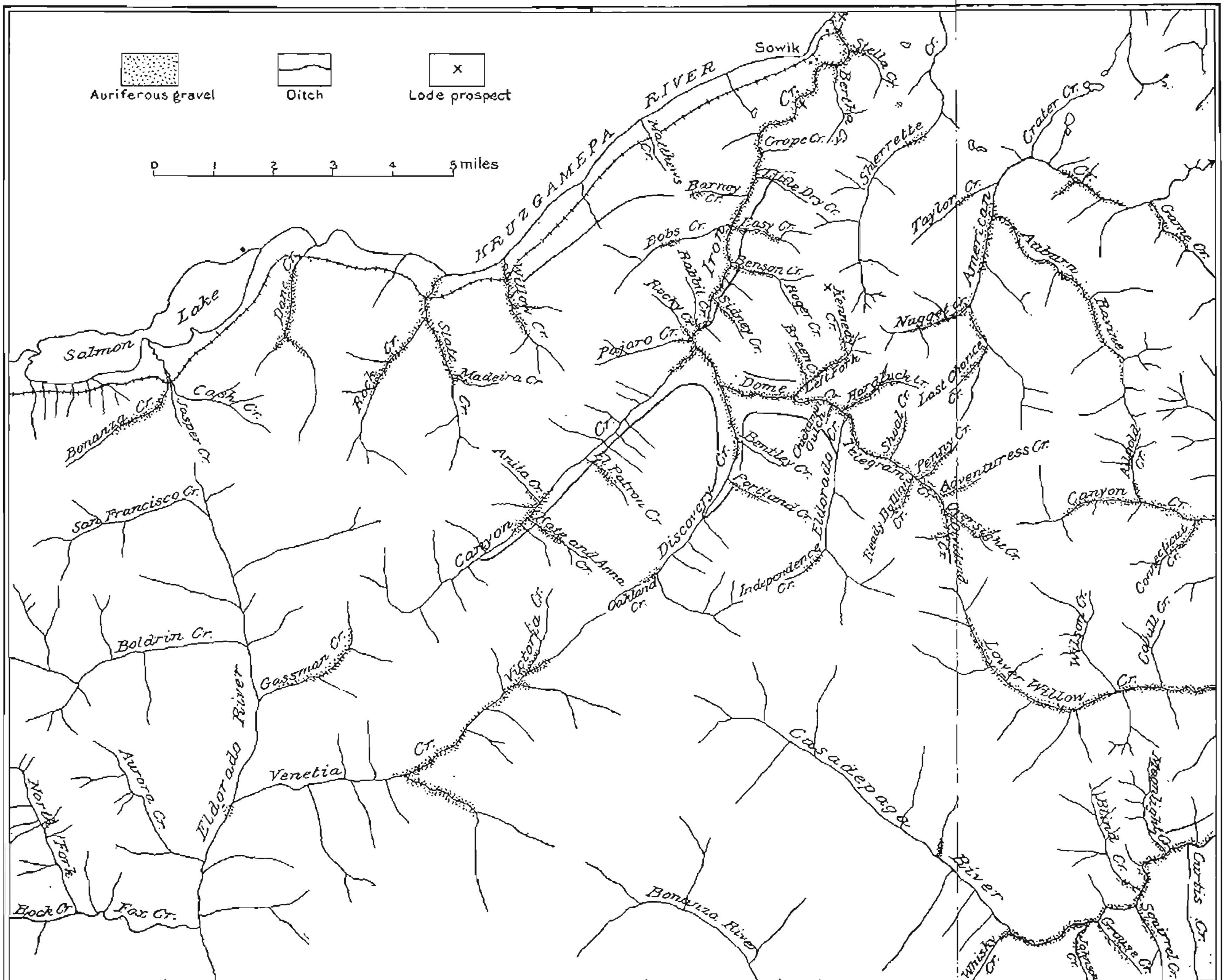
THE IRON CREEK REGION.

By Philip S. Smith.

INTRODUCTION.

In 1905 and 1906 parties from the Geological Survey mapped in detail the geology of a rectangular area extending from Norton Sound on the south to the crest of the Kigluaik Mountains on the north and from the meridian of Cape Nome on the east to a meridian 2 miles west of Nome on the west. In 1907 and during a few weeks in the early part of the field season of 1908 the mapping of the geology of another quadrangle was completed. This area is bounded on the south by Norton Bay, on the north by Niukluk River and the flats between that river and the Kruzgamepa, on the west by a north-south line 2 miles west of the town of Solomon, and on the east by the meridian of Topkok Head. Between these two regions only reconnaissance studies had been made. With the completion of the detailed investigations it became desirable to connect the two separated regions by study in the intervening area in order to see whether the various groups of strata could be correlated. Not only was such a closure desirable from the standpoint of the geologist, but it was recognized that the mining industry had developed in this area gold-bearing gravels that were similar to those in other parts of Seward Peninsula, and it was hoped that a study of these gravels might assist in explaining the origin and distribution of the gold gravels of the peninsula as a whole. This intervening area includes a large part of the basins of Bonanza, Eldorado, and Iron creeks, of which only the Iron Creek basin has been important as a placer region. It was not possible to complete the mapping of the geology of more than the Iron Creek basin and the northern part of the others, though some additional data were procured on the adjacent areas. Valuable notes were furnished by A. H. Brooks and F. H. Waskey and have been used in this report without specific acknowledgment, but the writer desires to express thanks for the assistance thus afforded, which can not be measured by reference.

Although it is the intention in this paper to direct the discussion mainly to the mining industry of the Iron Creek basin, it becomes



MAP SHOWING DISTRIBUTION OF MINERAL RESOURCES IN IRON CREEK REGION, SEWARD PENINSULA.

necessary, in order to establish certain broader generalizations, to include portions of the Casadepaga River and American and Sherrette creek drainage basins on the east and portions of the Eldorado and Kruzgamepa drainage basins on the west and north. This rather ill-defined area lying between the Casadepaga and Grand Central quadrangles, bounded on the north by Kruzgamepa River and on the south by Casadepaga River, is described here under the inclusive term "Iron Creek region."

Although situated only 40 to 60 miles from Nome, this region has not been extensively developed, and the number of miners who have exploited it has not been commensurate with the promise the area held out to the gold seeker. Even as early as 1900 gold had been found on the main stream and several of its tributaries, but the high cost of freight and the lack of adequate water supply discouraged permanent location. During the past year, however, the opening of a store, where supplies can be obtained at a rate of only a few cents a pound more than in Nome, and the completion of a large mining enterprise near the mouth of Iron Creek have assisted in the development and attracted attention to the district. The railroad which runs from Nome to Lanes Landing, or Shelton, as the inland terminus is called, has rendered the region easily accessible, and the high freight rates that prevailed when supplies had to be brought by team or dog sledge from Nome have been very sensibly reduced. In the early days, freighting of supplies often cost 25 cents a pound. The rate was reduced later to about 10 cents, and this price continued practically until the railroad was completed. Now, however, with a biweekly train service, freight, even in less than carload lots, is delivered from Nome at a cost of only 2 cents a pound.

In addition to the railroad there is a wagon trail connecting Nome and Iron Creek. The trail is long and hard, crossing five divides and winding from sand bar to sand bar as it follows the various creeks. Since the railroad was completed the wagon road has been practically abandoned, for it is a three days' trip, and as there are no road houses the traveler is forced to carry his own supplies or burden the prospectors along the line with his support. This road has not been laid out or graded; each succeeding team followed the wheel marks of its predecessors until an unusually soft stretch of ground impelled the driver to choose a new route. It is entirely feasible to make a good road for much of the distance; thus the traveler to interior points could avoid many of the vexatious delays and high charges incident to the often-traveled route along the beach to Solomon before striking inland.

GENERAL GEOGRAPHY.

The general geography of the region may be best understood by reference to Plate X. The Iron Creek basin is a triangular area whose divides form the watershed between the Kruzgamepa drainage, which flows westward into Imuruk Basin, the Niukluk drainage, which flows eastward into Golofnin Sound, and the drainage of Bonanza and Eldorado rivers, which flow southward into Norton Sound. In places the divides between the different rivers are sharp and well defined, so that the area belonging to the different systems is sharply delimited and easily recognized from afar, but in other places the divides are obscure, and one is uncertain of the course of the streams until they have been actually followed. Undivided drainage is particularly characteristic of the broad flat lying between Kruzgamepa and Niukluk rivers and shows an intricate past history which will be considered in more detail in a later portion of the report.

As already defined, the Iron Creek region includes the entire basins of the streams entering the Kruzgamepa from the south, from Dane Creek to Iron Creek. It also includes the headward portion of Sherrette Creek, which joins the Kruzgamepa 2 miles below Iron Creek, and the headward portion of American Creek, a tributary of the Niukluk. The eastern and a part of the southern boundary of the region are formed by the Casadepaga and its tributaries, the largest of which are Lower Willow and Canyon creeks. Eldorado River, with its numerous tributaries, forms most of the western boundary of the region, the extreme northwestern corner being formed by Bonanza, Cash, and Jasper creeks, which are tributary to Salmon Lake. At the heads of nearly all the larger streams are low, broadly open saddles that lead from one drainage basin to another.

The relief of the region is not great, few of the higher summits rising more than 2,000 or 2,500 feet above the sea. Viewed from a distance, the sky line is uniform and but few points project much above the general level. When the divides are studied in detail, at close range, however, the uniformity is not apparent, and though the suggestion of earlier writers that these divides represent an old erosional surface has not been disproved, it is not supported by any known facts. For instance, the tops of the ridges are practically devoid of gravels or deeply weathered rock, and the history of the surface that now forms the upland is undecipherable, because of the extent to which it has been changed by more recent activities. It would seem better, therefore, from the evidence now at hand, to attribute the present character of the sky line to headward erosion of subequally spaced streams. Such an interpretation would not preclude the possibility that the old surface in which these streams are intrenched was a nearly base-leveled plain that has been uplifted, but would indicate that such an explanation has not been made out from the existing features.

Although the relief is not very great, the slopes are by no means gentle, and descents of 1,000 to 1,500 feet from the ridges to the streams are not uncommon. The slopes show great variations in different parts of the area. Some of these changes are attributable to differences in the rocks, but many of the benches and abrupt descents are the result of the various movements that the crust has undergone—each bench or terrace representing a period of relative stability and each steeper slope a more active period of degradation. Many of the more resistant rocks may be traced for long distances by their topographic expression. The most resistant of the rocks are the greenstones and the limestones. Of these the limestones are particularly striking, for, because of their better drainage, they do not support vegetation well, and therefore their white color and steep slopes make them noteworthy landmarks.

Differences in the rocks have also an important effect on the streams of the region, for where the valleys are cut in a limestone bed rock the water seeps underground and is carried off in subterranean channels, so that running water is absent on the surface. One of the best examples of this condition is afforded by Auburn Ravine, a tributary of American Creek. For nearly 2 miles the valley is entirely devoid of surface water, except during periods of heavy rain. When this creek was visited, in July, there was not even enough water for camp use, and it was necessary to carry a supply from a small stream cutting across the limestone-schist contact. It is easy to see that under such conditions mining ventures which depend for success on a water supply are seriously hampered, if not entirely out of the question.

Even in those places where little of the rainfall is carried underground, the climate is such that water must be carefully conserved if it is to be used for mining purposes. No accurate data extending over a long period are at hand concerning the rain and snow fall of the region, but it has been shown [a] that the rainfall at Salmon Lake in 1906 was about 12 inches, from June to September inclusive, or about twice as much as at Nome. If the same proportion holds true during the rest of the year, the rainfall in the Iron Creek region is not over 20 inches, or about that of Wyoming or Colorado. It is evident, that under such conditions, this region should be classed as semiarid. As the precipitation comes mainly in the form of rain and during the four summer months, it gives the impression of being greater than it actually is.

[a] Henshaw, F. F., and Hoyt, J. C., Water supply of Nome region, Seward Peninsula, Alaska, 1906: Water Supply Paper U. S. Geol. Survey No. 196, 1907, pp. 9-10.

GENERAL GEOLOGY.

It is impossible to treat adequately the geology of the Iron Creek region without reference to many contiguous areas, and therefore in this report only the broader features of the subject will be described, the more detailed description being reserved for further discussion elsewhere.[a]

The geology of the region may be taken up under two broad subdivisions—the geology of the consolidated deposits, or, as they are sometimes called, the hard rocks, and that of the unconsolidated deposits, such as the sands and gravels. From the standpoint of the placer miner the latter class is, perhaps, more important than the former, but the question of the origin of the mineralization and the physical features which affect gold concentration are so closely associated with the geology of the hard rocks that a study of them must not be neglected. It should be noted that in this subdivision it is not proposed to include the cemented gravels under the term consolidated deposits.

CONSOLIDATED DEPOSITS.

There are a number of kinds of rocks in the Iron Creek region which differ from one another not only in physical character, but in age and mode of origin. Some, with more or less similar physical characters, differ in origin and age. It is not proposed to go in this paper into any great degree of refinement in the differentiation of the various rocks, but it may be broadly suggested that all the rocks were formed either as sediments or as the result of igneous activity. In many cases, however, it is difficult to assign a particular rock to its appropriate group without the most minute study. The changes have gone so far in many rocks that a determination of their original character is impossible and the decision as to the group to which they belong must be based on analogy or left unmade.

SEDIMENTARY ROCKS.

Of the unquestionably sedimentary or water-deposited rocks the limestones are the most abundant. Their distribution is somewhat irregular and affords many problems in correlation. Commencing near Solomon and extending in a slightly west of north direction is a heavy limestone which appears in the mapped area in the hills south of Casadepaga River in which Squirrel and Grouse creeks head. This limestone is cut by the Casadepaga and forms the ridge between that stream and Lower Willow Creek. To the north it persists as a

[a] This matter will be treated at some length in a report on the geology and mineral resources of the Solomon and Casadepaga quadrangles and adjacent regions, which is in preparation.

ridge separating Lower Willow Creek from the Canyon Creek of the Casadepaga drainage basin; farther north it separates the American Creek basin from that of Telegram Creek and, still farther north, Sherrette Creek from the tributaries of Iron Creek. Throughout this distance the limestone is practically continuous, and though it has been dislocated and fractured, its course is not interrupted. It forms a ridge except where it is cut across by one of the larger streams, such as Casadepaga River or Lower Willow Creek. Owing to the numerous fractures and the porosity of the limestone most of the water that falls upon it sinks underground and is carried by submarine channels so that the surface is dry. For this reason and also because of its steep slopes vegetation does not grow upon it and the bare white hills form striking topographic landmarks. Where this limestone is cut across by Iron Creek it forms a canyon of considerable ruggedness and the stream changes from its nearly due north course to one approximately northeast. Nowhere does this limestone appear to be less than 400 feet thick and in some places, where dislocation makes the structure difficult to interpret, an even greater thickness is indicated.

Apparently joining this limestone and continuous with it is a thick limestone which forms the ridge separating the Iron Creek drainage from that of Kruzgamepa River. It forms high hills on either side of Matthews Gap and cuts across the lower part of Willow, Slate, and Rock creeks as far as Dane Creek. In this part of the area its obvious continuation ceases, owing in part to the deposits of recent alluvium which mask the bed-rock exposures in the headward portion of Jasper Creek and Eldorado River. There is, however, another heavy limestone that continues from a point near the mouth of Bonanza Creek and forms the scarp south of Salmon Lake, where it may be regarded as the westward continuation of the limestone just described. There are few places in this distance where a thickness of less than 600 feet can be assigned to the limestone. No fossils have been found in it, and its stratigraphic position is assigned only on the basis of its areal relationships.

In addition to the nearly continuous heavy limestones there are other bands less regular in their distribution and ranging from beds only a few feet in thickness up to beds of several hundred feet. Some of the heavy limestones are probably the infolded equivalents of the limestone already described. A limestone of this character forms the ridge near the eastern margin of the mapped area, east of Allgold Creek, and extends westward, forming the divide between Auburn Ravine and Game Creek and being represented by the low limestone knob between the head of Stella and Bertha creeks and Sherrette Creek. Another heavy limestone of essentially the same character forms the ridge between Rock and Slate creeks and

Canyon Creek west of Anita Gulch and extends westward to the head of Gassman Creek. Smaller beds appear at various places along the middle and upper portions of Iron and Dome creeks.

Usually the thicker beds are but little metamorphosed, and the determination of the original characters is not difficult, but in certain places the various movements that the region has undergone have changed or metamorphosed the rock. In such places mica and other minerals have been formed and a schistosity or foliation has been developed, so that the original limestone becomes a calcareous schist. All gradations of these changes may be traced in selected localities up to those where the process has gone so far that the original character of the rock is lost and it is a schist with entirely new features. The passage from a true limestone to a calcareous schist can be seen on the hill forming the divide between Canyon and Eldorado creeks and Venetia Creek. Calcareous schists occur also on Dome Creek, where their relation to the limestone may be clearly seen and the intergradation between the two types recognized.

A second type of rock of sedimentary origin occurring within the region is a black, very quartzose rock that is in places graphitic or carbonaceous. It has a thick slaty cleavage and usually breaks into more or less rectangular blocks, owing to the jointing. Nowhere is a great thickness exposed, but it seems to have a course nearly parallel to the thick limestone that forms the eastern boundary of the Iron Creek basin. It is somewhat dislocated, but can be traced from the mouth of Sidney Creek southeastward to Hard Luck, thence more nearly southward to the mouths of Ready Bullion and Adventuress creeks, and thence into the Lower Willow Creek basin, where it forms notable outcrops for a couple of miles below the head of that stream. It continues southward along the west side of Blind Creek, and the last seen of it in the mapped area is on Johnson Creek; but it actually extends southward to the point where it is overlain by the coastal-plain deposits near Solomon. It contains numerous veins of quartz that have been formed in the joint and fracture planes. It appears that this rock has not suffered as great metamorphism as the others, and consequently, instances of a gradation from the quartzitic phase to a schistose phase are not common.

There are many other places in which rocks of similar character are found, but their relationships have not been thoroughly worked out, and it is not possible as yet to determine whether they represent the same or different horizons. Thus on Canyon Creek, a tributary to Iron Creek, black quartzitic slates occur near the mouth of Anita Creek, and float of the same rock is found on the divide between Kate and Anna creeks and Oakland Creek, a branch of Discovery Creek. It is also present on Boldrin Creek, 3 or 4 miles above the junction of that stream with Eldorado River, and on the hill separating Aurora and Boldrin creeks, as well as on the southwest side of Aurora Creek. In all these places this rock seems to have been brittle, and where subjected to stress it was fractured rather than sheared.

Underlying the less metamorphosed sediments are schists of different character and chemical composition. Some of them have been proved to be of sedimentary origin through investigation with the microscope, and the origin of others has been disclosed by their relations to other known sedimentary rocks. Their relations to other rocks and their physical characters show that these schists are among the oldest rocks of the region. They form the bed rock over the larger part of the area, and if the overlying sediments could be removed they would cover a still larger surface. Their composition differs in different parts of the field. In some places the schists are highly quartzose; in others the quartz component is relatively small and the larger part of the rock is calcareous. Chlorite is universally present in these schists and gives the greasy greenish color which is so characteristic of these rocks. Original structures have almost entirely disappeared, but under exceptionally favorable conditions an older structure different in direction and character from the more recent structure induced by metamorphism can be recognized. According to the earlier workers in Seward Peninsula geology, these schists form the Nome group, which is pre-Ordovician in age and probably younger than the rocks that form the Kigluaik Mountains to the north. To this group have been referred all the highly metamorphosed rocks of sedimentary origin. As the original character of the rocks in many places is impossible to determine, the group doubtless contains some rocks of igneous origin as well.

IGNEOUS ROCKS.

The igneous rocks of the Iron Creek region are all of basic type. Granites and other acidic rocks, although abundant only a few miles to the north, are not found within this area in place. In composition these rocks are high in alumina, iron, and soda and low in silica. The igneous rocks may be roughly divided into two main classes—schistose and nonschistose. The nonschistose igneous rocks, as the name implies, are rather massive rocks that are somewhat jointed and fractured, but not cleaved or foliated. Though having affinities with different kinds of rocks, they may all be grouped under the general term greenstones. Because of their massive character the greenstones form prominent knobs and ridges. The minerals usually visible in hand specimens are garnet, amphiboles, and lath-shaped feldspars. The microscope shows that the amphiboles usually consist of the soda-rich hornblende allied to the glaucophanes and that the feldspars belong to the plagioclases rich in soda and lime, having a composition about that of oligoclase. In areal distribution the unsheared greenstones are irregular but occur throughout the region in small masses. Where contact relations are clearly shown the greenstones appear to form dikes and sills in the sedimentary rocks. Greenstones are most abundantly developed in the ridge between Eldorado and Iron creeks which extends southward, separating Casadepaga River from the headward branches of Lower Willow Creek. Rocks of this type are abundant in the divide south of Slate and Willow (tributary to the Kruzgamepa) creeks. They are also widely distributed in the hills west of Eldorado River, forming prominent peaks and ridges south of Fox Creek, in the divide north of Aurora Creek, and between San Francisco and Bonanza creeks. They are among the latest rocks in the region, lying on top of or cutting the older formations.

Another series of rocks forming considerable areas of the bed rock in this region are the schists that show numerous feldspar crystals, which give the rocks a speckled appearance. Some doubt is felt as to the precise origin of many of the rocks of this character, but there seems to be small room to question that some are of igneous origin. In favorable localities it is possible to trace the gradational stages between the unsheared greenstones and the sheared feldspathic schists. It is therefore believed that in such localities the schists have been produced by the shearing and metamorphism of the igneous rocks. Though this explanation can not apply to all the feldspathic schists, it seems probable that a considerable part of them have been formed in this way and should therefore be separated from the schists of sedimentary origin. If this is the correct interpretation, these schists are younger than the others and the areal relations are very different from those that would be shown if they formed part of the sedimentary sequence. Feldspathic schists predominate near those places where greenstones are most abundant. There are many places, however, where although feldspathic schists are present few greenstones occur. This condition might be explained by the suggestion that in such places shearing has gone on to such an extent that none of the original greenstone is preserved.

Although the question of the origin of all the feldspathic schists can by no means by regarded as settled, it is unnecessary in this paper to pursue the details further. It remains only to point out the areal distribution of this group of rocks. It is a common occurrence that the feldspathic schists form the upper parts of the ridges and are absent in the valley bottoms. This suggests that they overlie unconformably or cut the sedimentary rocks. Such a condition is shown by the bed-rock geology between Canyon (tributary to Iron Creek) and Discovery creeks. Feldspathic schists are also commonly developed in the divide north and east of the Casadepaga and in some of the hills at the heads of Rock and Slate creeks. The ridge between the headward portion of American Creek and its tributary, Auburn Ravine, is made up in large part of the feldspathic schists. West of Eldorado River also there are many areas of feldspathic schist; especially in this region are they near the knobs of greenstone.

VEINS.

The veins of the Iron Creek region are of different ages and character and each type occurs under different physical conditions. On the basis of age the veins may be divided into two main groups, the older and the younger veins. These terms are purely relative, but roughly suggest the relation of the veins to the great period of metamorphism that affected the region. The older veins antedate this period; most of the younger veins were formed during or after it. The difference in age has caused many of the differences in physical character. Thus the older veins are knotted and irregular lenses and stringers, whereas the younger veins are more or less continuous. Moreover, the vein filling in the older series is smashed and recemented, but in many of the younger veins the filling shows well-formed original crystals.

The contorted and irregular veins are most typically developed in the chloritic or sedimentary schist series. They are younger than that series, for they cut across the structure, but they seem to be older than the heavy limestone, for as a rule they do not occur in it. Practically none of these veins are present in the areas occupied by the feldspathic schists and greenstones. Usually the older veins consist entirely of quartz with no sulphides or other visible metallic minerals. Assays, however, of samples showing no metals have yielded values in gold, so that this mineral undoubtedly occurs in them. Secondary minerals have been developed in some of these veins and show by their presence that the contents of the veins have received additions and subtractions of material in the long periods since their formation. Owing to the folding and deformation to which they have been subjected they are not continuous and few of them can be traced for any great distance.

The veins of the second or younger series usually have quartz for vein filling, but some contain calcite instead. The quartz veins are of two types, one showing sulphide mineralization while the other does not. The sulphides are usually iron pyrite, but here and there copper pyrite is found. The nonmetallic filling in such veins is almost invariably quartz. In a few localities the quartz forms perfectly terminated crystals with the sulphides nearer the wall rocks. The more common type of younger veins, however, does not show sulphides, the filling consisting entirely of quartz. Such veins are particularly abundant in the black quartzose slates, but they cut all the other rocks of the region, though as a rule they are relatively few in the areas where greenstone or feldspathic schist forms the country rock. Assays of these veins show that they, too, like the older veins, carry values in gold. It is evident, therefore, that the introduction of the gold that has formed the gold placers of Seward Peninsula took place at more than one period of geologic time. As the younger veins have not been so much deformed by the later movements, they are more continuous than the older veins and some of them can be traced for a considerable distance. The younger calcite veins are confined almost entirely to the large limestone areas, being as a rule absent from the adjacent schists. No well-formed calcite crystals have been reported and the filling appears to be material squeezed into the fissures caused by the deformation. So far as known no minerals of economic value have been found in veins of this type.

UNCONSOLIDATED DEPOSITS.

TYPES AND AGE RELATIONS.

The gravels and unconsolidated deposits of the Iron Creek region are of four main types—the present creek gravels, the bench creek gravels, the glacial deposits, and the gravel-plain gravels. While in many places the types are distinct and unmistakable, there are gradational phases between them which make the boundaries ill defined. In age the unconsolidated deposits range through a long time, but geologically they are very recent. The fossils that have been found throw no light on the age of the oldest of these deposits, but it is probable that none of them antedate the Pliocene. The absence of definite criteria prevents any statement as to the relation of the gravels of the Iron Creek region to those of the coastal plain with its ancient beaches, near Nome. Such a correlation could probably be effected by tracing the various deposits along the Kruzgamepa and Kuzitrin valleys until the coastal-plain province was reached. This correlation, however, would be more of theoretical than of practical value.

PRESENT CREEK GRAVELS.

The present creek gravels, as the term used in describing them implies, are those gravels which are now practically in process of formation by the existing streams. The materials which are being handled by the streams are of two sorts—those formed from the bed rock of the region and those made from the previously formed unconsolidated deposits. A stream that flows on older gravel deposits may be working on materials which are foreign to its drainage basin, and whose origin must be sought by reference to the previous history of the region. As an example of gravel of this type, formed by the intrenching of a stream in gravels of an older stage, may be mentioned the lower course of Sherrette Creek, which for a couple of miles above its junction with Kruzgamepa River flows on the unconsolidated deposits of the gravel plain, described on page 316. The gravels of Sherrette Creek are formed of rocks which do not constitute the bed rock of the creek valley, but which have been brought to their present position by a preceding series of activities and are being treated by the present stream as if they were deposits in place.

On the whole, however, the streams over the southern and larger part of the area are flowing on gravels that are made up of the same material as the bed rock of the basin. This is especially the case in the headward portions of the smaller streams, where it is evident that the gravels are directly derived from the underlying bed rock. As has already been pointed out, the region contains rocks of many different types, namely, the various limestones, black quartzites, greenstones, and chloritic, feldspathic, calcareous, or quartzose schists. In each area of a certain kind of bed rock pebbles of that kind of rock predominate in the gravels. This characteristic is in many places so strongly marked that the position of the contact between different formations may be closely approximated by noting the changes in the character of the gravels.

Almost all the present creek gravels are relatively shallow, few of the sections exposing more than 3 or 4 feet of material. Owing to the fact that these gravels are more or less constantly affected by the streams, decomposition has not proceeded far and the separate fragments are usually fresh and show but little effect of chemical decay. In shape the fragments vary much. The usual form, however, is the flat shingle so characteristic of normal creek wash; but this is typical only of the laminated rocks. Greenstones and the more massive limestones rarely exhibit the flat thin phases, but form pebbles whose different axes are more nearly equal.

Though the creek gravels are usually loose and unconsolidated, here and there, where the presence of water carrying large amounts of material in solution permits the process, the gravels are cemented. The two most common cements are lime and iron, and in the upper part of Iron Creek, near the black-slate contact, the iron cement is abundant. The iron of these cements is derived mainly from the decomposition of the sulphides that have been formed near the contact of the black slate and the thin-bedded limestones. Lime cement was seen in several parts of the field, but is of less importance than the iron cement, for it occurs at only a few places in the gold-bearing gravels and therefore does not cause as much trouble to the miner.

BENCH CREEK GRAVELS.

Bench creek gravels, the second type of gravel deposits occurring within the area, are of similar origin to the present creek gravels, but they have no longer their old relation to the stream by which they were formed. As a class these deposits, except under favorable conditions, are difficult to separate from the so-called gravel-plain deposits that form the fourth class. There are, however, many bench deposits which show so clearly their mode of origin that there can be no reasonable doubt that they have been formed by streams in the past. Since their formation movements of the earth's crust have permitted the ancient streams to cut down their valleys, and thus portions of the former flood plains have been left as benches on the valley walls.

Because the bench creek gravels and the present creek gravels have been formed under practically the same conditions, their general characters are the same, but the difference in topographic position shows that the bench gravels have been affected by certain activities to which the present creek gravels have not been subjected. The most notable difference is that of age. The bench gravels were formed at an earlier stage than the present creek gravels and it is by no means uncommon, in some of the older benches, to find many of the pebbles more or less decomposed and their soluble constituents leached out. The amount of leaching, however, is not at all commensurate with the amount that takes place in similar gravels in temperate latitudes, for the frozen condition of the ground and the absence of much ground water make the rate of decomposition slower than in a warmer, moister climate.

Benches occur along the lower courses of almost all the streams and many of them can be traced for considerable distances. In elevation they are in places a hundred feet or more above the streams. Although some benches occur at very much greater elevations, the creep of the surface cover and the greater length of time that they have been subjected to degradational processes render their form more and more obscure. So, although washed fragments of gravel are occasionally found high up on the hillsides, the deposits from which they came have been so commingled or rearranged that identification is almost out of the question.

None of the ancient bench creek gravels show any fragments of rocks foreign to the drainage basins in which the deposits occur, except in those places where gravel-plain or glacial deposits have been laid down and reworked by the streams that formed the bench deposits. Certain cases of this sort will be referred to elsewhere in this report (pp. 316–319). Though the bench deposits are numerous, sections are difficult to obtain except where mining operations have furnished fresh cuts. Interpretation of the sections thus afforded shows that in recent times the region has suffered a number of modifications, of which some were probably due to movements of the crust, but others were undoubtedly due to climatic changes that affected the conditions of precipitation.

None of the larger streams and few of the tributaries fail to have benches in portions of their courses. Instrumental leveling might give some clue as to the movements of the crust in the recent past, but no such work has yet been done, and widespread correlation of the benches at different elevations has not been attempted.

GLACIAL GRAVELS.

Glacial deposits form noteworthy superficial features in the Kruzgamepa Valley. There are two distinct types of these deposits—one in which the material was laid down by ice and the other in which, although the material had been carried by glaciers, the actual deposition was effected by streams or in bodies of quiet water, such as lakes. Each type is distinct and can be recognized by the usual criteria that apply to ice-laid or water-laid deposits. Although details of the history have not been worked out, it is definitely known that at a period not geologically remote glaciers occupied many of the valleys of the Kigluaik Mountains and extended into the Kruzgamepa Valley. In places the ice sent tongues through the low passes south of the valley, and, melting, discharged the water into the Norton Sound drainage area. Such a condition is clearly to be made out in the low divide at the head of Eldorado River, where morainic material and topographic forms due to glaciation are prominent.

The most striking of the morainic deposits are those which mark the closing stages in the period of glaciation. Consequently, the upper limit of ice advance is not well defined. It seems certain, however, that the region has not been entirely covered by ice at any recent time, for the character of the gravels and of the topographic forms affords conclusive evidence that the ice was more in the form of valley glaciers than of regional ice sheets. The deposits of a morainic character are usually formed of angular, unwaterworn fragments of rock that vary greatly in size, some of the larger blocks being several tons in weight. That the center from which the glaciers proceeded was the Kigluaik Mountains is clearly demonstrated by the lithology of the deposits formed by the ice. In these mountains the rocks are characteristically biotite schists and granites, whereas south of the mountains neither of these kinds of rock occurs in place. A good opportunity is thus afforded to differentiate the gravels that have been brought into the area from the north from those of local origin.

Though not all the material from the north has been brought by glaciers, almost all of it has been subjected either to the direct action of ice or to the indirect effect which the ice had on the previous drainage of the region. The intricate relation between the distinctly ice-laid and the fluvioglacial deposits makes the differentiation of the deposits to be assigned to each class nearly impossible, without artificially prepared sections.

GRAVEL-PLAIN DEPOSITS.

A consideration of the purely glacial deposits is intimately associated with that of the deposits of the gravel-plain type, and though the two are not always to be directly connected they present many points in common. Gravel-plain deposits are most characteristically developed in the Kruzgamepa Valley and in the broad flat which forms the northern border of the Iron Creek region between Kruzgamepa and Niukluk rivers. Very little is known about the gravel-plain deposits or about the floor upon which they rest, but from the few facts now available it is certain that their history is intricate, and that a number of factors must be considered in arriving at an adequate explanation. Natural sections of the gravel plain are extremely unsatisfactory, and but few artificial sections have been made. The few holes that have been sunk show that the gravels of which these deposits are formed are in places very deep. Near Sherrette Creek there has been a good deal of exploitation by the drill, and though the records are not complete they indicate a depth of gravel in places of more than 180 feet. A shaft sunk on Sherrette Creek a short distance above the first mapped tributary from the east showed a depth of gravel of nearly 70 feet. The section at this place consists of gravels containing heavy blocks of granite and other material from a foreign drainage basin, associated with limestones and schists, which occur within the Sherrette Creek basin. The bed rock exposed in this shaft was limestone and schist, the schist lying to the east and the limestone to the west, the shaft apparently striking the contact between the two rocks. The floor upon which the gravels were deposited seems to rise toward the west and to slope downward toward the east, or toward the center of the gravel plain. No data were available with regard to the slope in feet to the mile, but from the distribution of outcrops it seems certain that the gradient is high.

Elsewhere the same gravel plain seems to be a thin veneer of gravels over a high bed-rock surface. This condition is well illustrated by the flat between Iron Creek and Sherrette Creek near Kruzgamepa River. In this part of the area the main stream flows in a rock-walled canyon intrenched 50 to 100 feet below the surface of the gravel plain, and Iron Creek itself cuts across the plain in a canyon which in almost all places shows bed rock projecting in angular ledges that are covered by only a few feet of gravel and silt.

Here and there, however, ancient channels, whose depth exceeds that of the present streams, are found in the gravel-plain deposits. The most interesting of these ancient stream channels is well exposed by a tunnel that has been driven for mining purposes from Iron Creek to the Kruzgamepa near Sowik. Most unexpectedly the tunnel went for this entire distance through gravel. Four shafts were sunk to furnish ventilation and means of access, the collars being situated as follows:

Location of shafts near Sowik.

Shaft number—	Elevation above Kruzgamepa River.	Distance from Iron Creek.
	Feet.	*Feet.*
1	92	250
2	87	550
3	64	850
4	26	1,160

The following sections give the thickness and character of the various beds which were passed through in shafts 1, 2, and 3, from the surface downward:

Sections of shafts 1, 2, and 3 near Sowik.

SHAFT NO. 1.

	Feet.
Gravel, muck, and bowlders	40
Clear ice	2
Gravel	5
Sand	4
Gravel	9
Sand	4
Gravel	4
Sand	1
Gravel	8
	77

SHAFT NO. 2.

Sod	5
Clear ice	30
Gravel	2
Muck containing fragments of wood	8
Gravel	8
Loose sand	37
Gravel with large bowlders	28
Sand	2
Gravel	3
Sand	1
Gravel	4
Gravel with angular schist fragments	4
Hard schist bed rock.	
	132

SHAFT NO. 3.

	Feet.
Muck	5
Bowlders, muck, and gravel	6
Coarse sand	6
Fine loose sand	10
Gravel	10
Gravel and sand	6
Gravel	4
Sand	4
Muck	4
Gravel and muck	6
	61

Great variation in the character of the gravels prevails not only in vertical section, but also horizontally. This may most clearly be recognized by the following section made along the grade of the tunnel:

Section along tunnel near Sowik.

	Paces.
End of tunnel toward Iron Creek in coarse gravel.	
Shaft No. 1	41
End of coarse gravel and beginning of sand	14
End of thin sand layer dipping northwest and beginning of gravel	7
End of gravel and beginning of sand, which overlies the gravel	28
Shaft No. 2, in sand; dip in general flat, but strong cross-bedding	83
End of sand and beginning of coarse gravel	56
End of gravel lens and beginning of sand	7
Coarse gravel in roof, sand below, few pebbles in the sand	7
End of sand with strong dip toward the northwest and abrupt beginning of coarse gravel	26
Sand under coarse gravel with strong dip toward Iron Creek. Some of the gravel layers much iron stained and slightly cemented	6
Sand below and gravel above, alternating. All kinds of rocks from the pebbles of the gravel. At this place beginning of rise of sand toward the Kruzgamepa.	31
Shaft No. 3 in fine sand. Looks a good deal like blue muck. Irregular dip but predominantly toward the northwest	13
End of sand and beginning of coarse gravel. The sand goes distinctly below the gravel and dips northwest	11
Strike here seems to be nearly parallel with the tunnel	20
A sand interlaminated with the gravel commences and the gravel decreases in amount toward the northwest	31
Sand decreases and coarse gravel appears in roof, gradually increasing in amount toward the northwest	19
Shaft No. 4	60
End of tunnel on the Kruzgamepa side. All the way in very coarse gravel	43

Throughout these various sections granite and biotite schist fragments, most of which are well rounded, are found. On account of the prevailing slope of the beds toward the Kruzgamepa Valley it is believed that they were deposited by forces working from the east toward the west. If this explanation is accepted, however, it is difficult to account for the depth at which bed rock was encountered in the second shaft, for the bed-rock floor slopes from shaft No. 4, where it lies at an elevation of only a few feet above the Kruzgamepa down toward the east, to a depth of nearly 50 feet below the level of the river in shaft No. 2. Another objection to the theory is the fact that materials from drainage basins other than that of Iron Creek are present in great abundance in the gravels, so that it is not easy to understand whence they could have been derived by streams flowing from the east toward the west. On account of these objections, it has seemed most probable that the old channel here described was formed by a previous stream, antedating the present Iron Creek. The strong cross-bedding, noted in several places in the horizontal section, would seem to indicate the deposition of gravel, possibly as a delta-like formation in a body of standing water of no great depth. Such a lake might have been formed back of a temporary barrier such as an ice sheet, but strong water action is undeniably represented by the well-rounded character of most of the fragments, save in the extreme upper part of the deposit.

The general absence of forms due to glaciation on the surface of the gravel-plain deposits suggests that the formation of these plains took place at the close of the period of maximum glaciation. Here and there, however, as for instance at the mouth of Jasper Creek and the lower end of Salmon Lake, part of the glacial and gravel-plain deposits were contemporaneous. Furthermore, the change in the courses of some of the streams would indicate that some obstruction which has since disappeared, such as ice, must have existed after a portion of the gravel plain had been formed.

As has already been pointed out, there is no granite or biotite schist in the Iron Creek region, although both of these rocks predominate in the Kigluaik and Bendeleben mountains, which form the boundary of the gravel plain to the north. It is therefore believed that the upper limit of the float of these rocks on the south side of the valley indicates the height to which the old deposits, formed in part by the erosion of the land to the north, formerly extended. It was found that the upper limit of granite was at a fairly uniform elevation of 800 feet above the sea. This would correspond very closely with the elevation of Matthews Gap and the upper rim of the American Creek canyon, at both of which places granite wash, well rounded, is of common occurrence. Below this upper limit plains are developed at different elevations down to 450 feet. These levels, however, seem to be constructional rather than destructional in origin.

ECONOMIC GEOLOGY.

The economic resources of the Iron Creek region consist of placers, lodes, and water power and will be treated in the following pages in the order enumerated. Though these are the sources of wealth, the geographic position of Iron Creek determines the cost of supplies;

and many deposits that might be of value in more favorably situated regions can not be developed here. As transportation facilities increase with each succeeding year, the determination of just what ground can be worked to a profit is constantly changing. Even in the old days, when freight on supplies cost from 10 to 25 cents a pound, good returns could be obtained at many places. On the whole, however, the region has not been as thoroughly developed as the showing afforded by the prospects would warrant.

GOLD PLACERS OF THE PRESENT STREAMS.

It has been stated that the unconsolidated deposits of the region are of four distinct types. Each of these types, with the exception of the glacial deposits, has furnished gold in sufficient quantities to pay wages, but the present stream and bench gravels have undoubtedly proved to be the most valuable, and of these two the first have been more largely mined. In describing the different deposits, the placers of the streams tributary to the Kruzgamepa will be taken up from the west toward the east, commencing with Dane Creek and proceeding toward Sherrette Creek and its tributaries. The Niukluk drainage basin, which is represented in the area under discussion by American Creek and Casadepaga River, will be next considered, and then the streams tributary to Eldorado River, commencing with the northernmost and proceeding south.

TRIBUTARIES OF KRUZGAMEPA RIVER.

Dane Creek is the first small tributary to the Kruzgamepa from the south, east of Salmon Lake. It is only a little over 2 miles long and its stream gravels have received but scanty attention. These gravels are thin, but the relation of the stream to the country rock is such as to suggest the probability of finding workable placer deposits. No permanent camps have been established on this creek. In the lower part of its course the stream flows on gravel-plain deposits, consisting of a great variety of different kinds of rocks many of which are foreign to the Dane Creek basin. A low pass separates the eastern fork of Dane Creek from Rock Creek, the next tributary to the Kruzgamepa from the east, and it seems certain that in recent time there has been a discharge of either ice or water across this low sag. This incident has not affected the gravels of the middle portion of Dane Creek, although it probably has had some effect on those farther upstream.

Slate Creek enters Kruzgamepa River about 2 miles east of Dane Creek. Less than a mile above its mouth it divides; the eastern fork retains the name Slate and the western branch is called Rock Creek. Placer mining has been carried on in the past on both of these creeks, and A. H. Brooks states that 25-cent pans have been obtained on bed rock. This creek near its mouth is intrenched in a narrow canyon about 30 feet below an older stream floor. Farther upstream the canyon dies out and the stream flows on a gradient nearly coincident with the former valley, showing that the uplift that caused the intrenching is of recent date, as the stream has not yet been able to perfect its headward slope to fit the new conditions.

During the season of 1908 the only mining operations on Slate Creek were carried on from the junction of Rock Creek for about half a mile upstream. Two outfits were engaged in shoveling creek gravels into sluice boxes. The gold from both of these places was bright, and several small, rather sharp nuggets were seen. The ground lies near the contact of a heavy limestone and a dark-green feldspathic schist. Many heavy bowlders, some of them derived from ledges outside of the basin of Slate Creek, occur in the creek gravels. This stretch of the creek had already been worked over, and the values now obtained are those which were overlooked or lost by the earlier miners. The pay streak is narrow, and the gravels are in few places more than 3 or 4 feet thick. The gold is worth about $18.25 an ounce. The production is small, and but a few thousand dollars have been taken from the creek since its discovery.

The next tributary to the Kruzgamepa from the south, east of Slate Creek, is Willow Creek. During 1908 no productive mining was done on this stream. It was described in 1900 as follows:[a]

> Near its mouth this stream flows through a small rock canyon about 50 feet, above which is a bench on either side covered with gravels. This bench represents an old valley floor into which the stream has incised its present valley. The bed rock on which this creek flows includes limestone with interbedded quartz schists, which are of sedimentary origin. With it occur greenstones which are igneous. The strikes are nearly directly across the course of the stream and the dip south—that is, upstream. Gold has been found in limited quantities on this stream. On bed rock we know of pans yielding 25 cents. The dips being upstream and the rock often rather heavily bedded, the lodgment for gold is not so good as in regions where thinly laminated rock with downstream dips forms a natural riffle.

Willow Creek has been mined more or less continuously in a small way ever since its discovery. The small amount of water available for sluicing and the narrow pay streak have prevented any considerable development. The gold is similar in character to that from Slate Creek. In the canyon portion the gold is usually bright and rather well worn. Occasionally some larger pieces are found, which from their shape do not appear to have traveled far. Some foreign material is found in the gravels of the lower part of the stream, but the gold seems to be of local origin and more or less closely connected with the limestone and schist contact.

Three miles east of Willow Creek is Matthews Creek, which heads in the low divide separating Iron Creek from the Kruzgamepa. This

[a] Brooks, A. H., and others, Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900, a special publication of the U. S. Geol. Survey, 1901, p. 116.

stream nowhere cuts bed rock and is flowing on the gravels of the gravel-plain deposit. No gold has ever been reported from it, but on the other side of Matthews Gap streams flowing on gravel deposits of much the same type have yielded wages where water could be obtained by sluicing. There has, however, been but a slight amount of concentration, and although the bed rock in the neighborhood is of the same character as that which cuts the auriferous part of Willow and Slate creeks, the great depth of the gravel and the lesser amount of concentration will probably preclude the chance of finding economically valuable deposits along its course.

The next stream tributary to the Kruzgamepa is Iron Creek, which is economically the most important stream in the region. Although really continuous, Iron Creek bears three names in different parts of its valley. From its mouth to Left Fork, a distance of about 7 miles, the stream is called Iron Creek; above Left Fork as far as Eldorado Creek, a distance of about a mile, it is called Dome Creek; and from Eldorado Creek to the divide between the Willow and Iron creek basins it is called Telegram Creek. This confusion of names is due to the interpretation of the mining laws which permits the staking of additional claims on different creeks—that is, creeks having different names. In describing the placers of this basin the main stream from its mouth to head, considering Iron, Dome, and Telegram creeks as one stream, will be treated first, and then the tributaries.

In 1908 no mining was done on the main stream below Discovery Creek, but this stretch of the creek has been worked in the past, and there is no reason to believe that the gold content has been exhausted. In fact, a project of considerable magnitude is under way to handle the gravels of that part of Iron Creek above Bertha Creek where the gradient is sufficient. This scheme is based on the fact that near the settlement of Sowik Iron Creek approaches within 1,500 feet of the Kruzgamepa. At this place the difference in elevation of the two streams is 29.65 feet.[a] A tunnel (see pp. 317–319) with a low gradient has been driven to connect the two streams, and it is proposed to place sluice boxes within the tunnel and to sluice the gravels of Iron Creek through the flume and discharge them into Kruzgamepa River. A portion of the flume has been set in position, and by the opening of another summer the actual sluicing of the gravels should be well under way. The experiment will be watched with considerable interest, as it presents many features that have not been tried elsewhere in the region. It is proposed to sort out all the heavy, large bowlders and not to pass them through the flume. The amount of gravel that can be sluiced in this way can be decided only by actual practice, for the amount of reduction of velocity in the upper part of the flume, owing to riffles, can not

[a] Determined by Arthur Gibson, of Nome.

be foretold with accuracy. The problem of disposing of the tailings on the Kruzgamepa end of the flume is a serious one. At the present time this river, near the point of discharge, is divided into two branches. It is proposed to build a wing dam so as to throw these two streams into one channel and thus increase the transporting ability. It may become necessary to install a hydraulic giant near the discharge to help in keeping the material from choking the flume. Water, however, at the low elevation needed for the successful operation of the plan is abundant, and a scarcity need hardly ever, even in so dry a season as that of 1908, be apprehended.

No figures are available as to the tenor of the ground to be handled by the flume, but there are many indications which suggest that it is probably of low grade. Brooks, who visited the region in 1900, reported that colors were plentiful near the surface along the lower part of Iron Creek, but that at that time prospectors, after having gone down 5 or 6 feet, had been unable to reach bed rock on account of water. The fact, however, that this part of the stream long remained without any permanent miners suggests that bonanzas are not to be expected, and that a profit can be made only by handling a large amount of ground at a low cost. The gold that has been found in the creek gravels of the lower part of Iron Creek has been mainly fine flakes of a bright color, which have apparently traveled much farther than the dark angular gold characteristic of the upper part of Iron Creek.

In the past some mining has been done on the creek gravels from Easy Creek to Canyon Creek, but the amount of gold won from this part of the stream was not sufficient to counteract the high cost of labor and supplies, and this ground has lain idle for several years. Placers undoubtedly exist in this area, but the tenor of the gravels is probably so low that the deposit must be worked on a large scale if a profit is to be made, for the ordinary shoveling-in methods do not handle enough ground to pay much more than expenses.

Between Canyon and Discovery creeks on the main stream a small party, consisting of only two or three men, was mining the present stream gravels in 1908 by open-cut methods. At this place the creek floor is about 100 yards wide and the walls of the valley rise abruptly. The gravel is from 2½ to 3 feet thick and rests on a slabby calcareous schist. Several small stretches through this part of the creek have shown good values, but the richest pay streak apparently swings across the creek so irregularly that it is difficult to follow.

In 1905 renewed attention was paid to Iron Creek because of increased activities near the mouth of Discovery Creek. An expensive plant was erected at this point to handle the creek gravels with a hydraulic elevator, and long ditch lines were constructed.

The installation was completed in the fall of 1906 and a small amount of work was done. The venture was not successful, owing to a number of reasons, and a single pit partly cleaned out is all that remains of an investment of many thousand dollars. Near the mouth of Discovery Creek the pay streak is about 150 yards wide and the gravels are 6 to 8 feet thick. Only a little desultory work was done at this place during 1908, but the holders of the ground are expecting to do some work in 1909.

The concentrates from the gravel near the mouth of Discovery Creek show a variety of different minerals. Magnetite forms about a quarter of the entire bulk. Garnet, in rather angular grains, is perhaps the most common heavy mineral. In color it ranges from a light pink to a very dark ruby-red. In addition to the magnetite and garnet, a considerable proportion of ilmenite, the oxide of titanium and iron, is found. This mineral looks like magnetite but is nonmagnetic. It has no economic value as found in the black sands from placer workings. For the most part these three minerals are derived from greenstones and igneous schists, which occur to the south and west of Iron Creek. In addition to these minerals, which form the major part of the concentrates, iron sulphides are found. Much of the sulphide is altered into limonite, and in some of the larger specimens the outer portion is formed of limonite while in the interior still unoxidized sulphides may be recognized. The place from which the sulphide was derived is in doubt, for there are many veins carrying sulphide in the immediate neighborhood.

The gold is usually bright and in fairly coarse flakes, practically no flour gold being present. A few nuggets have been found, but they are relatively uncommon. No attempt was made to determine the exact tenor of the gravels, but they probably run between $1 and $2 a yard. Under the present scale of wages, etc., it is not feasible to work such ground in this district by pick-and-shovel methods.

Above Discovery Creek more gold has been taken out than in any other part of the basin, and here mining work is still in progress. When the region was visited in 1906 it was reported that between Discovery and Left Fork there was a fractional claim which had been worked during the two preceding years on a small scale. In 1906 from one to five men at a time were employed on the claim during the open season. The gold is coarse and easily saved. Both rusty and bright gold are found. The values occur in a thin pay streak on limestone and in the cracks and crevices in the bed rock. The small amount of ground held by these operators prevented any large-scale operations. At the junction of Left Fork two men were mining in 1906, but during the last year there was no work done and the ground has probably been mined out. The method used was to carry off the surface water by a bed-rock drain and then to shovel the gravel into sluice boxes. Several nuggets worth $30 to $40 each have been found in this place. The bed rock is a much shattered limestone with thin bands of schist both above and below. The relations of the various rocks through this part of the valley are very complex, owing to faulting. Near the mouth of Left Fork a fault with unknown displacement brings the limestone and schists into contact, the dips and strikes being practically accordant on the two sides of the fault plane. Along the fault plane calcite veins heavily impregnated with iron form a zone about a foot in width and may in part be the cause of the placer which occurs near by.

Iron Creek between Left Fork and Eldorado Creek, as has already been noted, is called Dome Creek. A short distance above Left Fork the largest nugget from the Iron Creek region was found, in 1904. It was a mass of gold with very little quartz attached, on the whole rather well rounded and weighing somewhat over 30 ounces. It was estimated that the gold contained in it was worth about $600. The gravel in which this nugget was found appears to be similar to that which predominates along Dome Creek. It is between 100 and 200 feet wide and from 3 to 5 feet thick. Steep slopes characterize the valley walls.

Work has been done on all the claims on Dome Creek and the returns have been satisfactory. This part of the stream was first worked in 1900 with rockers and every season since has seen some gold won from the gravels. When the region was visited in 1906[a] it was noted that "five or six men have been at work at this place, but as it is understood that this portion of the creek has already been worked over three times, it is doubtful whether subsequent work will be remunerative." The owners, however, are still able to rework the gravels at a profit, and this is practically the only part of Iron Creek where present stream gravels were actively mined during the season of 1908. At this place the stream flows through a rather narrow canyon with only a small strip of flood plain on the south side. The pay streak is from 25 to 30 feet wide and from 18 inches to 2 feet thick. This thickness includes 6 to 12 inches of bed rock which is taken up and cleaned. The overburden is stripped off by horse scrapers and the pay gravels are shoveled into the boxes. Numerous large bowlders of greenish schist and calcareous schist, which have probably fallen from the steep canyon walls, are found in the gravels and are troublesome for the miners to remove. Some of the talus from the walls lies on the creek gravels, and it is proposed to tunnel under it. Farther up Dome Creek the ground has been worked by open cut. The bed rock here is schist, similar to that occurring on the claims below. Large greenstone bowlders, which have probably

[a] Smith, P. S., Geology and mineral resources of Iron Creek: Bull. U. S. Geol. Survey No. 314, 1907, p. 162.

been derived from the high greenstone knobs south of Dome and Telegram creeks, are abundant.

The gold from Dome Creek occurs chiefly in the crevices of the bed rock. This condition is probably explained by the fact that in the earlier working of the creek, owing to the high cost of all essentials, the bed rock was not thoroughly cleaned, so that the values which were not recovered would naturally remain in the places most difficult of access. As a rule the gold is coarse and very dark colored. Some of the particles are so heavily iron stained that save for their weight they might easily escape detection. The dark color is almost invariably due to limonite. When a nugget of the dark gold is broken it is found that the limonite forms not merely a superficial coating but occurs in small particles throughout the nugget, with the gold in filaments. The gold thus forms a spongy mass with the oxide of iron in the interstices. It is believed that the limonite is derived from the decomposition of iron pyrites. If this is the case, the gold may have been deposited in the vein from which the placer was derived between the crystals of pyrite or as a mechanical mixture with the sulphide. Of these two explanations the former is believed to be the more reasonable. The gold from Dome Creek is worth from $18.25 to $18.45 an ounce.

In the concentrates garnet, or "ruby," as it is popularly called by the miners, is the most common mineral. With the garnet is a good deal of magnetite, usually in small grains. Ilmenite is also abundant, but the proportion between it and magnetite is apparently not as great as in the creek gravels near the mouth of Discovery Creek. Cinnabar, the sulphide of mercury, was reported by the owner of the claim to have been recognized in the concentrates from Dome Creek. None of the material was seen by members of the Survey, but there is slight reason to question the identification. Unfortunately, however, it is not known whether this mineral was derived from the Iron Creek basin or from a foreign drainage basin. The claims on which it was found have probably derived some of their gravel from the bench deposit into which the stream has cut, and as the level of the bench is not too high to have marked the 800-foot level already referred to, the possibility of a foreign origin is not precluded. The suggestion of a foreign origin is made because, so far as known, cinnabar is generally connected with intrusions of granite or with hot springs, conditions neither of which is fulfilled in the Iron Creek region, though they exist to the north, in the Kigluaik Mountains. The character of the gravels, however, does not suggest a foreign origin.

Above Eldorado Creek, on the portion of the main stream called Telegram Creek, only a little work was done during 1908, and the entire production probably amounted to only a few hundred dollars.

Several years ago, however, good values were obtained from some of the gravels, and it was currently reported that nuggets worth even as much as $100 each had been found in the upper part of Telegram Creek. The inadequate supply of water in the stream itself and the great expense necessary to bring water to such an elevation will hold back the development of this part of the basin. The gold that has been found is coarse but is not so heavily impregnated with iron as that lower down on Dome Creek. The lack of heavy limonite stain is probably due to the fact that the gold from this part of the creek either did not originate close to the contact of the black quartzitic slate or else has traveled somewhat farther from its source than the Dome Creek gold. Near the mouth of Ready Bullion Creek, however, where the bed rock is similar to that on Dome Creek, the gold has the heavy iron-impregnated spongy character noted on that stream.

The tributaries of Iron Creek, save in the upper part of the basin, have yielded but little gold. Such a condition is believed to be due more to inadequate prospecting than to the absence of profitable placers. Random samples taken on many of the streams show gold in sufficient amounts to warrant further prospecting, and it is believed that in the course of a few years many more camps will be established, and the existing camps will be worked on a much more extensive scale.

In the lower part of the Iron Creek basin the first tributary on which any mining work has been done is Barney Creek, which heads in Matthews Gap. No considerable production is reported from this creek. The common trouble of getting water at a sufficient elevation to handle the gravels is one of the most serious difficulties. The gravel from this creek shows a great number of fragments from foreign drainage basins. Garnets predominate in the concentrates to such an extent that the color of the gravel is distinctly reddish. Magnetite forms a much greater percentage of the iron mineral present than in the Iron Creek gravels, where ilmenite is much more abundant than the magnetic iron. The gold is chiefly in small flakes, not well rounded or smoothed, but as a rule not occurring in nuggets. The bed rock in the upper part of the creek lies at an unknown depth, but in places it is undoubtedly overlain by a thick cover of gravels.

Bobs Creek is the next stream above Barney Creek that enters Iron Creek from the west. The gravels are similar to those occurring on Barney Creek and like them have not been much developed. It is probable that with the completion of the ditch that has been in process of construction for the past two or three years some gold may be gained from this creek. All of the ground is frozen, and it is a very difficult problem to handle the gravels economically. The concentrates from this stream show a large amount of magnetite, with garnet as the most noticeable mineral. The gold is rather fine, although in no sense flour gold, and is invariably of a bright color. No productive work was done on this creek in 1908.

Easy Creek, which enters Iron Creek opposite Bobs Creek, is a small stream heading in the limestone ridge between Iron and Sherrette creeks. A camp was established near the mouth of this stream during the summer of 1908. Unfortunately, the operators were delayed in opening work until the middle of July. Mining at this place showed deposits of many different types, for in the course of development an old channel with a course approximately parallel to the present Iron Creek was discovered. After this old channel had been exploited for some time, work was transferred to a creek claim nearer the mouth of Iron Creek in order that the old channel deposit might be more effectively explored before actual mining work was commenced. Mining ceased before the end of September, so that owing to the late opening and the early closing, together with the time required for preliminary work, the season was not profitable. The owners are particularly fortunate in controlling a large spring, which affords probably 100 inches of water throughout the season. In addition to this supply, a ditch which taps Iron Creek above Sidney Creek gives an additional amount of water. Exploration is to be continued during the winter, and it is expected that with the information gained renewed activity will be shown in mining during the coming season.

Easy Creek has been worked in the past by different small outfits, and the gravels are reported to carry sufficient values to be worked at a slight profit even by pick and shovel methods. If this is true there seems to be no reason why a well-managed company with adequate water supply should not be able to develop a good paying placer. The Easy Creek gravels are not distinctly different from those of the other small streams in the immediate neighborhood. The bed rock consists of a dark, nearly black limestone and interlaminated schists in the lower part of the basin, with more limestone farther upstream, then more schists, and finally the heavy limestone that forms the divide. The dark limestone, which is much shattered, contains numerous veins, some of which are considerably mineralized with sulphides. Sulphides are also common in the concentrates, and it seems probable that a considerable part of the contents of the placer has been derived from very near by sources. Assays of some of the sulphides from Easy Creek show a gold tenor of a few cents to the ton.

Benson Creek is a tributary of Iron Creek entering from the east about half a mile above Easy Creek. The geology of the bed rock of this creek is complex, a series of limestones near the mouth being succeeded upstream by feldspathic schists, which in turn are succeeded by limestones. Gold placers on this stream have been worked more or less continuously since 1900. The various camps, however, have been worked on a small scale, and the production has hardly ever been more than enough to pay wages and leave a small margin of profit. Heavy bowlders, many of them from a foreign drainage basin, are found in the gravels and have to be rolled out of the way by undermining. The gold occurs usually in small grains of a bright color, though small nuggets are by no means uncommon. From the concentrates obtained on this creek it was seen that little of the gold was in thin plates or scales, but that even the smaller particles had subequal dimensions. The gold does not appear to have been worn smooth, but the thin edges of many pieces are bent back so as to form a ball. It seems certain that most of the gold has not traveled far from the place where it was formed. The placer contains a small amount of gold which is somewhat smoothed, and it is believed that this gold has been reconcentrated from the bench gravels through which the stream has cut its course.

Although Benson Creek, or Lulu Creek, as it is sometimes called, undoubtedly has good placer ground, the difficulty of obtaining water under sufficient head is sure to have a deterrent effect on its development. The creek itself has so little water that a supply must be sought from some outside area. None of the branches of Iron Creek from the east carry enough water to warrant ditch building, and the gradient of Iron Creek is so low that it would require a long ditch to tap it far enough upstream to give a good head. Besides this difficulty, the steep canyon walls would require a large amount of rock work and would necessitate so large an investment that it is a question whether the returns would be adequate.

On Hilliard, Sidney, Rocky, and Rabbit creeks, small tributaries entering the main stream below Canyon Creek, the ground has been staked and some work has been done. On the whole, however, none of these streams have yielded valuable placer deposits, although the geologic formation of some, as for instance Hilliard Creek, is similar to that in the vicinity of many of the productive placers. Concentrates from Rabbit Creek show characters very similar to those of the concentrates from Benson Creek, but the gold is finer and as a rule more flaky. Colors of gold, however, are abundant and all that were seen were bright.

Canyon Creek is the longest tributary of Iron Creek. It enters from the southwest near the abrupt bend in the main stream. For most of its distance it flows through a valley formed of feldspathic and chloritic schists, which do not seem to be favorable rocks for the formation of gold placers. Four miles above its mouth, however, the black quartzitic slates and limestones, near which the productive placers are usually found, form the country rock and the indications for placer deposits are good. Unfortunately no workable deposits have been found here, but this is to be explained in part by the lack of assiduous search. A small tributary which enters the main stream near this point has been productive, although no mining was done on it during the past summer. In fact, in the entire Canyon Creek basin no mining was done in 1908 except on El Patron, one of the small tributaries, where a single miner, much hampered by lack of water, has taken out little more than a "grubstake." The placer on El Patron is located near the contact of a limestone with the schists and the conditions seem similar to those prevailing farther up on Canyon Creek, already described. The gold from El Patron is coarse, slightly rounded, and as a rule of a bright color. Magnetite and ilmenite, with a rather smaller amount of garnet than is usual in the gravels of the Iron Creek basin, are present in the concentrates.

No work has been done in recent years on Discovery Creek, the next tributary of Iron Creek above Canyon Creek, save near the mouth. The character of the gravels is similar to that of Iron Creek gravels near this point (see p. 324) and both undoubtedly carry some gold. The bed rock at the mouth of the creek is the black slate that is closely associated with the limestone which occurs between Canyon and Discovery creeks. To judge from the character of the country rock, the probability of finding workable placers on this stream below the headward portion is not good. Near the upper part of the basin the stream cuts a series of limestones and placers might be expected, but in the middle portion of the basin feldspathic schists abound, and it is believed from experience in other districts that this is not a rock from which placer gold is usually derived. Small placer deposits have been reported on some of the eastern tributaries of Discovery Creek, but none of them are being worked and it is not believed that they will prove important.

Left Fork joins Iron Creek about a mile upstream from Discovery Creek. The bed rock consists of rather heavy limestones and schists, three limestones being separated from one another by schist bands. The creek in the lower part flows in a narrow rock-walled canyon, and where the bed rock is limestone the water disappears, to be carried by underground channels. Good placer ground has been found in the lower part of the valley, where the broken and shattered condition of the limestone has afforded natural riffles for the lodgment of the gold. At the present time, however, the ground on Left Fork has been mainly mined out and the only values that remain are those that have been lost by the earlier miners. It is so difficult to clean a hard limestone bed rock thoroughly that probably sufficient values remain to warrant reworking the ground. Such reworking, however, will not be attempted until some of the other more favorable spots have been exhausted. The pay streak was found to be rather irregular and to swing from one side to the other. No accurate estimate of the production from this creek has been made, but probably $20,000 has been taken from it. No mining was in progress in 1908.

Above Left Fork is Hard Luck Creek, which, with its tributary, Hobo Gulch, heads in the limestone ridge between the American and Iron Creek drainage areas. The basin of this stream is bounded by rock scarps and appears to be the remnant of an older drainage channel that has been dammed by talus, behind which alluvium has been deposited. This basin lies at an elevation of about 100 feet above Iron Creek. Angular black slate, with some quartz and greenstone bowlders, forms the placers in which the values occur. A number of the greenstone bowlders are as much as 18 inches in diameter, and some of the fragments are well rounded. Near the head of the basin, however, the greenstone is more angular and shows less water rounding. The angular gravel is about 2 feet thick. In parts of the basin the gold-bearing gravel rests directly upon bed rock, but in other places a thin layer of clay serves as the surface on which the placer was deposited. The floor of the deposits is irregular. Coarse gold is characteristic of this placer. It is usually of a bright color and the grains are well rounded.

On Eldorado Creek, which joins the main stream near the mouth of Hard Luck Creek, no profitable placers have been developed. The valley of this stream lies almost entirely within the area of feldspathic schists and greenstones, which, as already noted, are not the rocks from which placer gold is usually derived in this region. Near the mouth, however, the bed rock consists of the limestones, which seem to be more commonly associated with placer deposits. None of the small tributaries of this stream have yielded any promising placers. A little work has been done on Independence Creek, the branch heading in the low saddle leading to the head of Discovery Creek. The developments at this place, however, are not sufficiently satisfactory to warrant the continuation of the work.

Above Eldorado Creek a number of small tributaries join Telegram Creek. These are Shoal, Penny, Adventuress, and Oversight creeks, entering the main stream from the east, and Ready Bullion and Dividend creeks, coming in from the west. On all these creeks placer ground that is economically profitable has been discovered, and a good deal of work has been done on them in the past. The gravels are shallow and are more or less rapidly worked out. The country rock is similar to that occurring in the productive portion of Dome Creek and is the direct continuation of it. Coarse gold is common and many of the nuggets are of good size. During the past season practically no work was done on any of these deposits, although the ground is staked and the annual assessment work is being kept up.

Sherrette Creek is a tributary of the Kruzgamepa. The upper part of the valley lies in the high limestone ridge to the east of Iron

Creek, and in its lower course the stream flows in a valley but slightly intrenched below the gravel plain that forms the divide in places between the Kruzgamepa and Niukluk basins. Bed rock is exposed everywhere in its upper portion, but in the gravel-plain part of its course the stream has not cut down to bed rock but flows on the gravels. No placer mining has been done on the upper part of the creek, but in the lower mapped portion there has been some prospecting of the stream gravels. In 1908 one camp was established near the point where the trail leading from Sowik to American Creek crosses Sherrette Creek. Work at this place has been carried on mainly with the idea of testing the deep gravels of the gravel-plain deposit, but a little work has also been done in the present stream gravels. The results so far are meager. The creek developments, however, are very interesting, for gold-bearing gravels occur here intimately associated with bowlders of large size and angular outline, which must have come from a foreign drainage basin. The whole floor of the creek is covered with blocks of granite up to several tons in weight which could have been derived only from the Bendeleben or Kigluaik mountains. Indiscriminately mixed with these rocks are fragments that have clearly been brought from the head of the Sherrette basin. Gold is not known to occur in the Kigluaik and Bendeleben rocks, so the placer most probably owes its valuable mineral content to the near-by schists and limestones.

The auriferous material of this placer rests in some places upon thin clay layers in the midst of the re-sorted gravels, but in other places the gold is found throughout the gravel without the presence of any impervious layer on which concentration has been effected. Needless to say, those places where clay layers have served as floors for the concentration of the heavy particles afford the best returns.

All of the gold that was seen was in small particles worth from a tenth to three-quarters of a cent each. No flour gold was noted; all the pieces were easily distinguished by careful inspection with the unaided eye and further study with a lens failed to reveal any pieces that had not been previously recognized. In form the gold is in somewhat flattened flakes, but some of the larger pieces have a spongy appearance. Few of the grains are smooth or well worn. A bright color is common, and no rusty or discolored pieces were noted.

Among the concentrates very little garnet was found, which was rather remarkable, for ordinarily this mineral is abundant. Magnetite and ilmenite are present in about equal proportions. Sulphides of iron and copper were also recognized. The owners of the ground report finding fragments of copper ore in the sluice boxes. These fragments were undoubtedly derived from the upper part of the basin, where copper sulphides are known to occur in place in the limestone-schist series. The copper minerals found in the gravels are usually the carbonates, although some copper sulphide may be found where oxidation and weathering have not proceeded too far. The presence of the copper ores is one of the most definite proofs of the local origin of some of the material of which the placer is composed.

AMERICAN CREEK.

Heading between Iron Creek on the west and the tributaries of the Casadepaga on the south and east, American Creek flows northward, then makes an abrupt bend to the east, and finally joins Niukluk River a short distance upstream from the mouth of the Casadepaga. That this has not always been the course of the stream is shown by the continuation of the northward trend of the valley near the big bend by a channel only 50 to 70 feet above the present stream. This feature would afford material for an interesting physiographic study, but a discussion of it has no place here, for the placers that have been worked are all above this point. All of the headward portion of this stream is in the hilly country where outcrops abound, but the influence of the conditions which helped to produce the gravel plain is to be noted even in this part of the basin. It is well shown by the presence of waterworn gravels and angular fragments derived from foreign drainage basins up to an elevation of 800 feet, or well above the junction of Auburn Ravine and American Creek, or even above the junction of Auburn and Wade creeks and of Nugget and American creeks.

During the past summer the only mining done in this basin was on Auburn Ravine, but the abandoned camps seen on many of the other tributaries show that the ground has been more or less thoroughly prospected, and the numerous claim stakes indicate that even now almost all the available ground is held. Owing to the absence of prospectors practically no data were procured concerning past work. The headward portion of American Creek lies in a region of limestone and schists which in places are much dislocated. None of the black quartzitic slate is found in this part of the valley. Greenstones are rather uncommon. Some work of a prospecting type has been done on Last Chance Creek and also on Nugget Creek and its tributaries.

Auburn Ravine is one of the largest tributaries of American Creek. It enters that stream a short distance above the big bend. It heads in the low saddle that leads to a tributary of Canyon Creek, which in turn flows into the Casadepaga. The bed rock of the east side of the valley and of a large part of the creek is limestone; the western divide is formed for the most part of schists, both chloritic and feldspathic. Owing to the presence of limestone as the bed rock, most of the water escapes by underground channels, and the creek bed is perfectly dry except for a short time immediately after a heavy rain.

When this creek was visited in 1908 there was not even enough water in the bed of the stream to furnish a supply for cooking, and it was necessary to carry water from those places where the small side streams flowing on schist still afforded a little run-off. It is evident that under such conditions the difficulties in the way of economically handling placer gravels are almost too great to be overcome. At one of the claims a short distance below Jack Wade Creek, which was visited about the 1st of September, only enough water could be collected in an hour by damming the side streams to allow from five to ten minutes' sluicing. While the owners were waiting for enough water to collect, the larger bowlders were picked out and everything was done to utilize to the best advantage every second that the water was flowing in the boxes.

Fortunately, however, the gravels of Auburn Ravine all the way from the mouth up to August Gulch, the small headwater stream coming in from the west, carry gold. Two outfits were mining the creek during 1908—one located a short distance above Jack Wade Creek and the other about the same distance below. Work on the upper claim has been carried on for three years. The gold is all coarse, no fine flour gold being found. Whether this condition is due to the absence of fine gold or whether the fine particles are lost in sluicing is not known, but it is certain that the percentage of small nuggets found is very large. A nugget worth $11 was the largest piece found on this ground. It was of a dark color, but most of the gold from this claim is bright and exceptionally pure. Assays made by one of the banks at Nome showed the gold to be worth $19.53 an ounce.

No true bed rock is found in the creek, but instead the auriferous gravels rest upon thin clay layers, which serve as local floors on which concentration has been effected. As a rule, the clay layers have a dip toward the east, and it is believed by the miners that there may be an older, deeper channel to the east of the present stream. The indications, however, are not sufficiently conclusive to warrant such a determination. The gravels of the present creek bed consist of large angular blocks of limestone that have evidently been derived from the steep hills to the east. All these fragments are much corroded and the presence of solution lines shows that a large part of the angularity is due to chemical erosion. In one place there is a bed of clean, well-washed sand that does not look like ordinary river sand, but its origin is in doubt. Where this sand was encountered it was at least 10 feet thick, but as it seems to be missing in several of the near-by holes its areal extent can not be very great.

Samples of the concentrates from this claim proved to be very interesting and in a measure unique. Garnet, as is usual, is one of the most common minerals. With it are magnetite and ilmenite in about equal amounts. Much of the ilmenite occurs in particles up to half an inch in length. These two iron minerals have undoubtedly been derived from the greenstones and feldspathic schists that form the high hill between the heads of American and Auburn creeks. Most interesting, however, was the verification of the report of the miners that cinnabar, the sulphide of mercury, was occasionally found in the gravels. Of this statement there can be no doubt, for careful study of samples in the laboratory has determined the mineral as cinnabar. In view of this determination the statement that cinnabar is also found on Dome Creek, in the Iron Creek basin, seems entirely probable.

On the claim below Jack Wade Creek practically the same conditions are found as those already described. Work at this place, however, has not been carried on for so long a time, and consequently less of the ground has been explored. The bed of sand and gravel already mentioned is here seen to lie definitely below the present stream gravels. The material is almost clear sand, with here and there narrow layers of small pebbles. At the base of the section in the prospect pit angular, partly dissolved fragments of limestone are common. The pit at this point was about 12 feet deep. Attempts to sink it deeper were prevented by the caving of the walls, so that bed rock was not reached. From the character of the lower part of the gravels it seems probable that true bed rock would be encountered within a short distance. The owners, however, are intending to test the gravels with a drill, as they believe the depth to bed rock will be very great.

PORTIONS OF THE CASADEPAGA DRAINAGE BASIN.

The portions of the Casadepaga drainage basin that lie within the area mapped on Plate X are the main stream, from its head to Curtis Creek; Lower Willow Creek, from its head to Cahill Creek; and Canyon Creek, from its head to Connecticut Creek. Although these streams cover so large a territory, there are very few productive placer mines on them, and the places where gold-bearing gravels have been found or are likely to be found are confined within a comparatively small area. In the entire Casadepaga basin north of the main stream, from the head to a point below Curtis Creek, no mining was in progress during the season of 1908. Almost the whole of this area lies in a belt of greenstones and feldspathic schists, and the probability of finding placers of economic importance does not seem good. In the past a few placer miners have worked at different parts of the basin, but the early abandonment of the claims points strongly to the conclusion that the results of the prospecting were not satisfactory.

Lower Willow Creek, or, as it was formerly called, Left Fork, is a stream about 8 miles long, heading in the Iron Creek divide and flowing southward and then eastward to join the Casadepaga. In its headward portion it flows parallel to the dominant structure of the region, but where its trend is easterly it cuts across the structure, so that different kinds of rocks are exposed in different parts of its course. In 1900 Brooks reported that there was no mining on the main stream and only one of the small tributaries had been developed. Soon after that time, however, prospectors found good values in the creek gravels and in the adjacent benches, and mining work was pressed with some energy. Gold was discovered in Lower Willow Creek near the mouth of Green Gulch. Lower Willow Creek was not visited by any of the Survey geologists from 1900 to 1906, so that details as to its development during that period are practically lacking. The visit in 1906 was so near the freeze-up that most of the miners had closed down for the season. It was evident, however, that only a few outfits had been busy and that they consisted of only two or three men each.

In 1907 mining on Lower Willow Creek was more or less inactive. From a point a short distance below Cahill Creek to a point within a mile or so of the head of the stream, the ground has been pretty thoroughly prospected and some gold found. The gold from this part of the creek shows two entirely distinct phases; in one the gold is fine and in small bright flakes; in the other nuggets of coarse gold are common. It is reported that the nuggets are worth from $1.50 to $2.50 each. Both kinds of gold are found in the same pay streak. Although prospectors have proved the presence of auriferous gravels in many places along the creek, there was practically no production during 1907. In 1908 two outfits were at work on the upper part of Lower Willow Creek, one near the big bend and the other a mile or so farther upstream. Mining was not actively conducted, however, and the production of the entire creek did not amount to more than a few hundred dollars. The similarity of the bed rock to that of the productive portion of Dome Creek indicates a similar origin for the gold in the two places.

Of the tributaries of Lower Willow Creek, none were productive during last year, although several have yielded fair returns in the past. In the early days of mining in this basin a good deal of gold was found on Wilson Creek, which flows near the contact of the heavy limestone and the schists. Placers on this stream have, however, been nearly exhausted, and no work has been done for several years. Benches at a low elevation are present along Wilson Creek, and it seems probable that the pay streak is due in a measure to the reconcentration of the higher-level gravel deposits by the present stream. Not only is this true of Wilson Creek, but also of Cahill Creek and several of the other small streams tributary to Willow Creek.

Canyon Creek is the next downstream tributary of the Casadepaga that heads within the Iron Creek region. Mining is being done on the lower portion of this stream, but none within the area mapped. Prospects of gold have been found on many of the side streams and on the main stream, but the returns have not been sufficient to encourage development. On Allgold Creek, the small branch which heads in the low saddle leading to Auburn Ravine, a good many prospect pits have been dug. Colors of gold are almost universally present, but no heavy pieces of gold, such as characterize the Auburn Ravine valley, have been discovered. The valley of this creek is cut mainly on the feldspathic schists, and is therefore a rather unpromising location for productive placers. Some prospecting has also been done on the small stream that heads against the divide of American Creek, but work on this stream has long been abandoned. The small stream that heads in the low pass to Iron Creek cuts a series of heavy limestones, but its grade is so steep that it seldom carries water for more than a few days after a heavy rain, and it has not been prospected. Active water sorting has not allowed much concentration of the gravels, and it is doubtful whether profitable placer ground will be discovered.

ELDORADO RIVER AND TRIBUTARIES.

Only the headward portion of Eldorado River is included within the area mapped as the Iron Creek region. It is not an important producer of placer gold, and although in the past many of the small tributary streams have yielded a little gold, none of them have been profitably exploited except perhaps Venetia Creek, which rises in the divide at the head of Discovery Creek. This valley was prospected in 1900 by the gold seekers who, on finding the country near Nome staked, were forced to seek elsewhere for unoccupied ground. Since that time attempts have been made to develop certain claims, but the results have generally been unsatisfactory. Even in 1903 Collier noted that practically no part of the region was being worked except Venetia Creek. In 1906, when the region was visited by Moffit and Smith, no work was in progress. During 1908 the valley was not studied in detail, but it was learned that there were no camps on the entire upper part of the stream.

As Venetia Creek has not been mined in recent years, it is perhaps appropriate to abstract the main points concerning the geology and mineral resources of this stream from the report of Collier,[a] who saw

[a] Collier, A. J., and others, Gold placers of parts of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 328, 1908, pp. 221-222.

the creek when mining was most vigorously in progress. He states that gold was discovered on this creek in 1900, but that up to 1903 the production from the entire creek was probably only about $6,000. The lower portion of Venetia Creek is a sharply cut, narrow gorge with steep walls, which rise to elevations of about 100 feet above the stream. Farther upstream the gorge character disappears and the flood plain widens to 100 yards. The bed rock is limestone and calcareous and chloritic schists, which have very variable strikes and dips. Numerous small veins of quartz are universally present. Greenstone is also found in the float and forms intrusive sills and dikes cutting the other rocks.

Placers are not found in the canyon portion of the stream, but exist in those places where there are broad flood plains 3 or 4 miles above the mouth. All the deposits that have been mined are of the present creek gravel type, although terraces which give promise of yielding returns lie along the valley slopes. A large part of the gold is found in the crevices of the bed rock, and in many places it is necessary to clean the bed rock to a depth of 3 or 4 feet. In the lower claims the gravels and overburden have a thickness of 5 or 6 feet, but in the upper portion of the valley they are much thinner. Although the flood plain is locally 100 feet or more in width, the pay streak is usually narrow. In some places the auriferous part is only 10 feet wide, and as a rule it is not over 50 feet.

Mining has been done only by shoveling into sluice boxes. To make the productive ground available, the stream has been turned aside by wing dams and the water carried away by a ditch. Water for sluicing has been derived from Venetia Creek itself. Collier notes that the ditches are particularly well built and are practically sod flumes. Even during a dry season, such as that of 1908, there seems to be sufficient water in this stream to supply the needs of placer miners who use the water only for washing the gravels in sluice boxes. The gold that has been won from Venetia Creek is mostly fine, although nuggets worth several dollars each have been found. In general the gold is bright and, according to Collier, is characterized by flat pieces shaped like pumpkin seeds. Its assay value is said to be very high, $19.40 an ounce being reported. If these figures are correct, the Venetia Creek gold is one of the purest that is found on the entire peninsula. According to current report, the present creek gravels of the stream are exhausted, but the difficulty of thoroughly cleaning bed rock probably prevented complete recovery of the values, so that it would not be surprising if with a reduction of the cost of labor and supplies some of the ground were reworked.

BENCH PLACERS.

The placers occurring in bench deposits include the bench stream placers and the bench gravel-plain placers. As shown in the foregoing account, there are but few claims actively operated on the present creek gravels, where concentration should probably give the most profitable and most easily worked placers, and it follows that few of the bench deposits have been developed. Although benches that may afford placer ground of economic importance are known on almost every stream, the cost of obtaining water at a sufficient elevation above the streams has prevented developments of note. This condition is, of course, inevitable in the early days of a camp, for the high cost of supplies, the necessity of proving the ground to be actually auriferous, and the greater engineering requirements would induce the miners to develop the creek gravels first. Sooner or later, however, if the camp succeeds and the creek gravels approach exhaustion, attention is sure to be turned to the benches. It is believed that when such a stage is reached in the Iron Creek region placer reserves containing large amounts of low-grade ground will be found, and their exploitation will prolong mining activities for a considerable period.

From a general study of the benches that have resulted from the action of former creeks at a higher level, there seems no good reason for doubting that the gravels of the benches are identical in origin with the present creek gravels. If this is the case it necessarily follows that the bench gravels must in many places be auriferous. Although it is possible that some of the bench deposits may be as rich or even richer than the stream placers, it is safe to assume that, as a rule, they are not so well concentrated. Such an assumption is supported by the fact that in many places the gravels of the present streams are reconcentrated gravels derived from bench deposits. At such places the additional sorting of the gravels has generally resulted in the concentration of the heavier minerals.

Outside of the Iron Creek basin itself no bench placers are being operated, and even within this basin there are only one or two that are worthy of note. It must be remembered, however, that there are many bench deposits which only await exploration to become productive. Practically no stream in the entire Iron Creek region, a part of whose valley lies below an elevation of 900 feet, does not show terraces on its valley slopes. Many of these terraces have been formed by streams, and it seems probable that there is a larger gold reserve in these benches than in any other part of the region.

Some prospecting on the lower part of Iron Creek has shown that it is almost impossible to take a pan of gravel from the benches on either side of the stream without getting colors. This gravel, although undoubtedly modified by stream action, belongs typically to the gravel-plain deposit. The gold that it contains is probably derived from the quartz stringers and veins which are common near the limestone-schist contact, but so much of the material has been transported for long distances that any definite statement as to its origin is impossible. It is, however, probable that this material has not been derived from the rocks which form the Kigluaik or Bendeleben mountains.

In developing some of the creek gravels on Easy Creek (see p. 328) the miners uncovered an ancient channel in the bench deposits, which seemed to have been formed by a stream that was parallel to Iron Creek rather than to Easy Creek. The bottom of this channel has not been reached except on the western rim. Figure 20 shows in a diagrammatic manner the main features at this place. A good section is afforded by a bed-rock drain which has been driven to carry off the seepage water. Sluice boxes were erected and the gravel was shoveled in until a point was reached where the steep

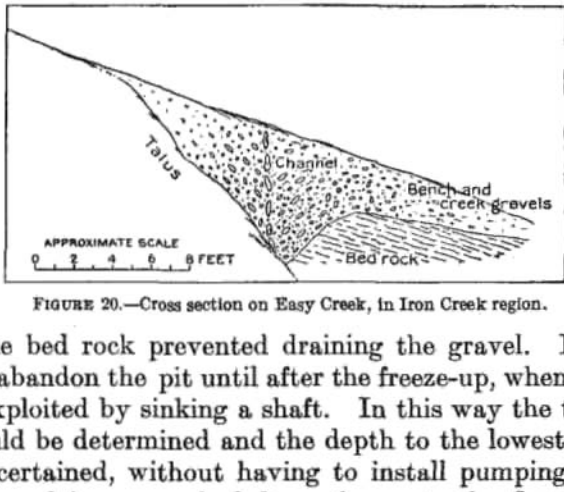


FIGURE 20.—Cross section on Easy Creek, in Iron Creek region.

slope of the bed rock prevented draining the gravel. It was then decided to abandon the pit until after the freeze-up, when the ground could be exploited by sinking a shaft. In this way the tenor of the gravels could be determined and the depth to the lowest part of the channel ascertained, without having to install pumping apparatus. As the channel is approached from the west, the floor of the cut exposes bed rock with a surface slope toward the west at a gentle angle. Overlying the bed rock is a thin layer of waterworn gravels, which are covered by the muck and moss that form the surface. This bench gravel has a slight dip to the west, but is essentially flat. Farther east the bed-rock floor abruptly changes its slope and descends rather steeply toward the east. Gravels of a variety of different kinds of rocks appear and increase rapidly in thickness. The bedding of these gravels seems to dip rather steeply more or less parallel with the slope of the channel rim and to strike approximately north and south. About 10 paces from the beginning of the descent of the bed rock toward the east there is a bed of pebbles which stands practically vertical. It was believed at first that this bed might represent the line occupied by the stream as the old channel was aggraded. Under this interpretation, however, the bowlders that mark the course of the stream should have their longest axes parallel to the direction of stream flow and their shortest axes vertical, whereas, in fact, their longest axes are vertical and their shortest axes horizontal. No suitable explanation of this phenomenon is suggested, for the preservation of bedding in this unconsolidated gravel shows that there can have been no deformation. The structure is evidently one of original stream deposition, but how it was produced has not been solved. Beyond this vertical layer there are indications that the gravel has a strong dip toward the west. This portion of the section, however, is badly masked by the accumulation of talus and slide which has fallen down where the gravels have been undermined. All of the gravel in the old channel is well waterworn, and there is no evidence of glacial action on any of the fragments. Near bed rock there are many slabby angular pieces that seem to have been broken from the surface of the rock but not to have undergone any transportation. As far as the explorations have gone, the gravels of the channel seem to be but slightly auriferous. It should be realized, however, that the greatest amount of concentration would not have occurred in the part of the channel exposed by the present workings, but in the lower part, which is still hidden.

Another interesting bench deposit has been discovered on the southern rim of Dome Creek near Chickamin Gulch, which enters the main stream from the south between Hard Luck Creek and Left Fork. This gulch scarcely forms a notch in the canyon walls of Dome Creek. A cross section near the gulch shows the main stream flowing on a small flood plain about 25 feet wide. Farther south a little talus forms an irregular deposit at the foot of an abrupt canyon wall. The cliff face is about 75 feet high and is formed all the way of rather massive limestone, dipping southwest. At an elevation of about 90 feet the cliff ceases and the surface rises gently southward, the slope steepening at a considerable distance from the stream as the ridge is approached. The gravels are found from the end of the limestone cliff for a distance of 150 paces southward, sloping gently away from Dome Creek. A little exploration has been done near the edge of the cliff, and the excavations afford a few fairly good sections. At this place the gravels are from 3 to 6 feet thick. They consist largely of fine sands with a few pebbles near the base and more angular material near the top. It is believed that the angular fragments are slide or talus that has been derived from the high greenstone hill between Eldorado and Discovery creeks. The surface of the bed rock on which the bench gravels rest is deeply corroded and everywhere shows the dissolving effect of chemical agencies. Into the irregular channels dissolved out of the limestone the sand and gravel have penetrated at many places for considerable distances. No accurate determination of the elevation of this locality has been made, but from aneroid readings it is probably about 800 feet above the sea. It has been stated that the elevation to which rocks from a foreign drainage basin were found along the south side of the Kruzgamepa Valley was about 800 feet. From the similarity of the two elevations it is suggested that the deposit noted on Chickamin Gulch may have been laid down as a result of the obstruction that formed this pronounced level elsewhere in the region. This suggestion is to be regarded only as a working hypothesis, for the data on which it is based are meager. The presence of the peculiar sand, which does not look like that formed by a small stream, is practically the only point, except the perhaps fortuitous similarity of elevation, which requires such an explanation. The occurrence of a similar sand in Auburn Ravine at nearly the same elevation, however, might be considered as throwing some light on this problem. Briefly stated, the suggestion which is made is that small lakes were formed near the heads of many of the northward flowing streams at an elevation of about 800 feet, on account of a barrier, such as ice, in the Kruzgamepa Valley, which formerly obstructed the normal drainage and has subsequently disappeared.

Prospecting on Chickamin Gulch has not been carried on to a sufficient extent to show more than the fact that these sands and gravels are auriferous. The gold is bright, no rusty pieces having so far been found. Only fine gold has been obtained, but as prospecting has not gone very far it is not at all improbable that coarser pieces may occur and will be recovered when active mining work is commenced. The few concentrates saved in the pan tests show the same heavy minerals as those noted in the present creek gravels. It will be a rather difficult problem to handle these bench gravels economically, as the amount of water available is small and the ground is unsuitable for ditch construction. If, however, the water right on Eldorado Creek from which the ditch previously noted takes its water could be obtained at a low price, a satisfactory solution of this problem would be effected.

LODE PROSPECTS.

As yet no lode mines have been discovered within the Iron Creek region. Search for lodes has been carried on in a more or less desultory way, but it has been hampered by the lack of capital and by the fact that many of the prospectors are holding more ground than can be exploited on the capital available.

In a summary of the recent lode developments in Seward Peninsula in 1907,[a] certain copper-bearing localities near Iron Creek were described as follows:

Between Iron Creek and the broad flat drained by tributaries of the Kruzgamepa and of the Niukluk there is a ridge of heavy white limestone underlain by chloritic and feldspathic schists. * * * The limestone would appear to be a continuation of the limestone * * * forming the western margin of the Solomon and Casadepaga quadrangles. In those areas the contact with the underlying schist seems to have been a zone of mineralization. In general, the mineralization is sparsely disseminated, but in places there are stringers of ore which tempt prospecting.

The greatest amount of prospecting for copper in this contact zone has been at the headwaters of Sherrette Creek, a tributary of the Kruzgamepa. At one place about 4 miles [south] east of the mouth of Iron Creek an inclined shaft has been sunk on a mineralized zone 5 feet in width. The foot wall is a silvery-gray chloritic schist destitute of feldspars. The hanging wall is ill defined and the width of the ore body would have to be drawn on a commercial basis. The foot wall is so poorly exposed that its character may be due to alterations effected by the mineralizing solutions, but it is believed that it is not a schist derived from an igneous rock.

The ore so far disclosed consists chiefly of malachite, but there are also some copper sulphides, mainly chalcopyrite, with only a subordinate amount of bornite. The stringers are very narrow and no commercial ore has yet been discovered. All over the hill, however, may be found fragments showing copper stains. This has given rise to the popular belief that the belt of mineralization is very wide. If, however, the interpretation that the ore occurs near the schist-limestone contact is correct, and if this contact forms a more or less flat surface, with local wrinklings here and there, it seems more likely that the width of the mineralized area is not very great, and therefore that the chance of finding valuable lodes is not promising except in those places where the mineralization, instead of being disseminated over a large area, has been more restricted.

All the float or ledges on the higher ground * * * [east] of Iron Creek which show copper carbonate stains carry that mineral in the form of malachite. Lower down the slopes, near the upper branches of Left Fork, a tributary of Iron Creek, there is a copper lead where malachite is almost wanting and where the copper carbonate occurs in the form of azurite. The reason for this difference in character is not known. At this place only a small amount of exploration has been done, and the ore so far developed is not found in commercial quantities.

During 1908 no new developments were made on any of the prospects described above. A controversy arose as to the ownership of the ground, and while this gave an impetus to the accomplishment of the annual assessment work it hampered the actual exploration of the deposit. Claims have been staked all the way from the head of Penny Creek, a tributary of Telegram Creek, to a point north of the head of Easy Creek, but on most of them the indications are so trifling they have no economic value. The multitude of corner stakes and location notices gives a false impression of activity.

In the report just cited[b] a galena prospect near the mouth of Iron Creek, on the Kruzgamepa, was described as follows:

[a] Smith, P. S., Investigation of the mineral deposits of Seward Peninsula: Bull. U. S. Geol. Survey No. 345, 1908, pp. 242-243.

[b] Smith, P. S., op. cit., pp. 246-247.

Three pits have been sunk on the southern side of the river. The easternmost one shows schist very much decomposed and somewhat out of place, with bowlders of yellowish-brown iron-stained limestone above. Twenty-five paces west of this pit there are a series of angular greenstone blocks which seem to be nearly in place and are probably frost-riven fragments from a ledge occupying essentially the position of the greenstone float. A second pit nearer the mouth of Iron Creek shows some galena with a few copper stains. No productive ore is exposed. The third hole, which is nearest the mouth of Iron Creek, is driven in limestone, and there is no schist exposed. In the cut was a lenticular body of galena about 4 feet thick. Most of this has been mined out, but no ore has been shipped. The strike of the limestone in this pit is N. 35° W., and the dip is rather steep to the northeast.

Across the Kruzgamepa and directly opposite these pits is another vein, openings on which show lenses of high-grade galena. This pit is in limestone, but apparently cutting across the bedding of the limestone is a band of feldspathic schist. The galena does not seem to conform to the general strike and dip of the limestone, but the rocks are considerably decomposed, and only the surface has been exposed in the excavations, so that accurate determination of the structural features was not possible. The structure is very complex, for within a distance of 150 paces the dip of the rocks changes twice from easterly to westerly. It seems clear, however, that the galena at this place occurs as a replacement deposit in limestone near the contact between a schist derived from an igneous rock and a limestone. Owing to the nearness of the exposures on the opposite sides of the Kruzgamepa it is suggested that the deposits on the south side may be of similar origin. If this is so, the decomposed schist lying under the limestone may have been derived from an igneous rock and the greenstone float noted between the first and second pits on the south side of the river may be in place and the equivalent of the more sheared feldspathic schists which on the north side are observed cutting the limestone. It should be noted that in addition to the galena there is also a little chalcopyrite scattered through the ore.

Exploration at this place was carried on during the season of 1908 only on the south side of the river, near the mouth of Iron Creek. A short adit was driven through the loose angular talus into the schists that occur east of the limestone. A heavy band of iron sulphide, in places 2 or 3 feet thick, was encountered. The pyrite was practically unmixed with other minerals. A sample assayed by Ledoux & Co. showed a small amount of gold. This ledge, aside from its gold content, contains no minerals of economic importance, but the occurrence seems to be significant as showing that considerable mineralization has taken place in this region. This lens is by far the most promising indication of mineralization in a workable vein which has been seen. As a rule the mineralization is so diffused that it is necessary to treat a large amount of country rock as well as the small ore stringers. Near the contact with the limestone the sulphides have replaced the country rock and a banded appearance has been produced. This is due to the greater permeability of the rock to the mineralizing solutions parallel to the lamination than in any other direction.

Sulphide mineralization, in the shattered limestone on Easy Creek, has already been noted. Here, however, the mineralization is so diffused that there is no probability of finding a vein which could be mined. Assays of some of the thicker sulphide stringers with very little of the country rock attached showed a slight gold value. Mention of this place is made not to suggest that a workable deposit may be found here, but to point out an example of a common type of mineralization near the limestone and schist contact. It is of particular interest as indicating one of the sources from which the gravel deposits received contributions of gold.

When the Iron Creek region was visited in 1900 a quartz vein was noted about 2 miles above the mouth of the creek. Some work had been done at this place, and it was reported that the vein had a tenor of $12 a ton in gold. A little desultory work has been done here at odd times for several years, but only the surface has been uncovered, and the indications are not very promising. The country rock is limestone, very much folded and shattered; a short distance downstream, underlying the limestone, is chloritic schist. The structure is synclinal. On the west side the dip is steep to the southwest, and on the south side the dip is nearly vertical, but slightly to the northeast. Sulphides are abundant, their distribution showing that the mineralization had taken place after the folding and fracturing of the rock. No well-defined leads were seen. This occurrence serves as another illustration of the rather diffused type of mineralization which is so commonly found associated with the contact of the limestone and schist throughout not only the Iron Creek region but also the rest of Seward Peninsula. No work was done on this claim in 1908, and it would appear that operations here have been abandoned.

Throughout the Iron Creek basin there are many sulphide-bearing veins which might warrant further prospecting, but so far as the conditions surrounding them are concerned they are similar to the types already described. In consequence, as they have not been prospected, it does not seem desirable to enumerate their positions on the different creeks. Suffice it to say that while evidence of widespread mineralization can be found almost everywhere east of Iron Creek, the mere fact that it is so widespread suggests that workable veins are few. The contact between the schists and the limestones is, in most places, a horizon of mineralization, but because this mineralization was diffused over so large a surface there has not been the concentration or localization which is essential for the production of a workable vein.

On some of the other tributaries of the Kruzgamepa conditions similar to those prevailing on Iron Creek and its branches have been observed, but to these places the same statement as to the improbability of finding workable lodes would apply. On Slate Creek, however, about a quarter of a mile above Rock Creek, mineralization of a different type was observed. A number of shallow pits have been put down, some inclined and some vertical, but after they have been sunk a few feet the difficulty of handling the surface water has compelled their abandonment. The country rock is a feldspathic schist and greenstone that appear to cut across the limestone, which forms the bed rock lower downstream. In the less sheared phase of the feldspathic schist or greenstone, sulphides in small particles are scattered throughout the rock and seen from their relationship to be original constituents. Some doubt of this conclusion is felt, however, for it is not proved that any unsheared rock exists within the area studied, and it is therefore entirely possible that the sulphides may have been introduced during the period of dynamic metamorphism. Under this hypothesis the sulphides were formed later than the inclosing rock. Whichever interpretation is correct, it is certainly true that throughout the region, where greenstones and the peculiar schists that are believed to be derived from rocks of igneous origin form large areas of the country rock, placers are absent. From this fact it would seem to follow that the absence of placers is due to the absence of mineral-bearing veins or other mineralization which could supply the valuable minerals. This conclusion seems to be supported by the field evidence, for veins are much less abundant in these areas than in those where numerous contacts of limestone and schist have afforded good places for deposition.

In amount the sulphides form but an insignificant portion of the rock. Assays made from selected specimens yield but a small gold value—so low that the rock could not be mined commercially under any conditions. Shearing planes are numerous throughout the exposures and have no pronounced trend, although the mean of a number of observations seems to be northeast and southwest. Owing to the number of planes of movement, the rock is considerably slickensided. This movement, however, does not seem to mark a considerable displacement along any one plane, but rather a series of small movements along a great number. At present it has been impossible to determine the sum of these movements. On many of the joint and shearing planes specular hematite, in bright and shining tabular crystals, has been developed.

In the American Creek drainage basin few veins were seen and no exploration had been undertaken. The difficulty of uncovering or tracing a vein is great, where the mantle of rock waste is as heavy as it is over much of this basin. If veins exist in this part of the region they will be located first on the ridges, and thence traced toward the moss and muck covered lowlands. The American Creek basin lies between two limestone ridges, at the border of which mineralization of the diffused type shown on Iron and Sherrette creeks is common. There are, however, not many distinct veins except the contorted and wrinkled quartz stringers and lenses occurring in the chloritic schists, exposures of which are few.

The part of the Casadepaga region that lies within the area mapped on Plate X has not been prospected for lodes to any great extent. Claims have been staked in many places along the southern continuation of the limestone belt to the east of Iron Creek, already described. Between the limestone and the schist there is a layer of rock, in places a foot or more in thickness, which looks like a silicified limestone. When this rock is studied under the microscope, it is seen to be composed almost entirely of quartz with no limestone or calcite. If, therefore, it has been formed through the replacement of the limestone by silica, the alteration has been so complete that not a vestige of the former condition is preserved. In the siliceous rock copper sulphides and carbonates appear here and there. The copper stains give the rock the appearance of containing a good deal of copper, but in reality the amount of this mineral is small and none of the pits visited showed any encouraging indications of workable lodes.

Near the eastern margin of the area mapped, north of Canyon Creek, numerous holes have been sunk at the lower contact of the limestone and the underlying schists. These holes have failed to uncover any promising leads, but seem instead to show the extreme complexity of the structure in the contact region. The mineral stains at this place also occur in a siliceous band from 1 to 2 feet thick that seems to be a limestone replaced by silica. The metallic minerals form but an insignificant portion of the rock, and there are no indications that profitable leads will be uncovered in the immediate vicinity of any of the prospect holes examined.

Near Whisky Creek, a tributary of the Casadepaga, a short distance above the big bend, a quartz vein, which is said to assay well, is reported. Work was done here two years ago, but evidently the returns were not satisfactory, for no further prospecting has been done. The prospect was not visited, but samples examined indicate that the vein consists of white, somewhat crushed quartz, with very little sulphide mineralization. It occurs in the schists, but is not very far from a limestone contact. This occurrence, however, does not seem to be at all similar to the diffused mineralization so common near this contact, but is in all probability a vein of rather recent date cutting across the schists. From the lithologic character of the vein filling, it does not look as if the vein could be worked under existing conditions. It should be noted, however, in connection with this class of veins, that the valuable mineral is usually in the form of native gold, and therefore even a fairly rich ore might escape detection unless assayed.

In concluding the portion of this report dealing with the lode developments, it may be well to state again that no leads have been discovered within the Iron Creek region which are more than prospects and that few of these prospects seem to hold out much inducement for further exploration. A few, however, are of sufficient promise to warrant the expenditure of a good deal of time and a little money in order to determine whether further outlay is justified. That there is probability of lodes being found can hardly be doubted, for the presence in the placers of large nuggets with quartz attached strongly indicates that they have been derived from quartz veins, and it is entirely inconceivable that all the veins from which these large fragments of gold have been derived have been eroded away. Such veins must have been filled from depth and not from the surface, and therefore their roots at least should still be preserved. It is not meant to suggest that the veins from which the placer gold was derived will show in all places large pieces of gold, for just as in placers hundreds of tons of gravel must be handled to find a large nugget, so in veins even a greater number of tons must be mined to find a large segregation of gold, because in the vein there has been no concentration by the washing away of the lighter particles.

WATER RESOURCES.

The water resources of the Iron Creek region may be divided into two classes—developed and undeveloped. A description of the former will include a statement of the ditches and flumes that have already been built, while under the head of undeveloped water powers a few examples of general application will be considered. All the figures relating to the volume of water in the different streams have been taken from reports of members of the Survey. The records for 1908 have not been incorporated in the following notes, but will be found on pages 382–385, in the paper by F. F. Henshaw.

DEVELOPED WATER RESOURCES.

Of the streams flowing into Kruzgamepa River, only on Willow and Iron creeks have ditches been built. The Willow Creek ditch is a small one, built to carry water from that stream across Matthews Gap to the small streams entering Iron Creek from the southwest below Canyon Creek. Measurements[a] on Willow Creek made about the middle of September, 1907, gave a discharge of 3.3 second-feet at an elevation of 900 feet. From the intake of this ditch for a considerable distance much rock work was encountered. After this difficulty was overcome, frozen ground was struck, which caused a great deal of trouble. Unless the ice is carefully covered with an impervious layer of sod or earth, the running water will quickly melt it and the ditch will be destroyed. In some places the water has cut

[a] Henshaw, F. F., Water-Supply Paper U. S. Geol. Survey No. 218, 1908, p. 59.

holes in the ice 20 feet or more deep. After the ditch was completed from Willow Creek to a point near Bobs Creek, it was found that not enough water was delivered to make mining profitable, and it was therefore proposed to continue the ditch to Slate Creek. According to the report above cited, Slate Creek, at an elevation of 900 feet, had a discharge of 11.3 second-feet on September 19, 1907. The continuation of the ditch to this creek would undoubtedly give a considerable increase in volume, but much of the work is expensive, and should be undertaken only after it has been definitely proved that the ground to which the water is being led has a sufficiently high tenor to repay the cost of installing the ditch as well as the operating expenses.

As yet but little of the Iron Creek water has been utilized. Several small ditches only a few hundred yards in length have been constructed, more for prospecting purposes than for the actual development of power. A small ditch has its intake near the mouth of Sidney Creek, but the head acquired is slight. As has already been pointed out, the walls of this portion of the valley consist mainly of rock and rise abruptly from the gravel-floored flood plain. Under such conditions it is difficult and expensive to construct ditches. To raise the water high enough to reach good ditching ground, expensive flumes are required to lead the water around the jutting ledges of bare rock. Measurements of the volume of Iron Creek below Canyon Creek on August 14 and September 15, 1906, gave a discharge of 17.1 and 26.1 second-feet, respectively. The mean discharge of Iron Creek at the same place for the month of August, 1907, was 48.5 second-feet.[a] There were many fluctuations from this mean, for measurements made on August 22 showed 99 second-feet, while from August 11 to 14 the discharge was only 33 second-feet. It is evident, however, that the supply is more than equal to the demands put on it by the present operators.

On Canyon and Discovery creeks there is the most extensive series of ditches within the region. Some of this construction is, however, only representative of wasted money. These ditches were constructed to bring water to the junction of Discovery and Iron creeks, where it was to be used in operating a hydraulic elevator. The longest ditch has its intake on Canyon Creek at an elevation of about 760 feet, or about 5½ miles from the junction of this stream with Iron Creek. According to measurements on August 13, 1906, the discharge at this place was 1.3 second-feet and on September 15, 1906, it was 1.1 second-feet.[b] This is certainly a small amount of water for which to build a ditch over 5 miles long. The ditch leads the water along the southeast side of the Canyon Creek valley and the south side of Iron Creek to a penstock above Iron Creek near the mouth of Discovery Creek.

[a] Henshaw, F. F., op. cit., pp. 58-59.
[b] Henshaw, F. F., op. cit., p. 58.

Another ditch has its intake on Discovery Creek, at an elevation of about 740 feet. At this place Henshaw measured discharges of 1.25 second-feet and 2.3 second-feet on August 13 and September 15, 1906, respectively. This ditch follows the north and west side of Discovery Creek. It is about 2 miles long and discharges its water into the same penstock as that into which the Canyon Creek ditch empties.

The third ditch of this system has an intake on Eldorado Creek at an elevation of about 750 feet and at a distance of about a mile above the junction of Iron and Eldorado creeks. The volume of Eldorado Creek, as measured near the intake of the ditch, was 4.5 and 5.6 second-feet on August 13 and September 15, 1906. This ditch follows the west side of Eldorado Creek and the south side of the Iron Creek valley as far as Discovery Creek. Thence instead of discharging the water into a penstock from which it could easily be piped to the elevator, the ditch is continued along the south and east side of Discovery Creek to the intake of the other ditch on that creek, and the water is carried by the latter ditch to the penstock between Canyon and Discovery creeks. In this way the water is carried an unnecessary distance of 4 miles along the creek, all the time losing elevation and for half the distance requiring additional ditch construction. Work on this system of ditches was begun late in 1905 and was completed in the fall of 1906. During 1907 the water was not used and the property passed into the hands of a receiver. In 1908 the water rights, ditches, etc., were sold, the price received being far less than the cost of construction.

Water for sluicing on Dome Creek is derived from a short ditch which discharges at an elevation of only a few feet above the stream. Measurements of the volume of this creek have been made by the Survey during both 1906 and 1907. On August 14, 1906, the discharge was 6.0 second-feet.[a] These figures do not include the discharge of Eldorado Creek, for the 5 or 6 second-feet carried by this stream were diverted by the ditch leading to Discovery Creek. In 1907, when none of the water was diverted by ditches, the following measurements were obtained near the same place: August 1, 26 second-feet; August 22, 37 second-feet; September 18, 22 second-feet. The mean daily discharge from August 1 to 18, 1907, was 24.5 second-feet, but good measurements of the low stages were not obtained.

Ditch building in the American Creek basin was confined to Auburn Ravine, and was not extensive. Several small ditches were built to collect water from Jack Wade Creek, but as has been noted in the section dealing with mining, it was often necessary to wait an hour to collect enough water to sluice for five or ten minutes. As the elevation of the ground to be worked is about 700 feet, it will be a serious problem to get water delivered, even at a small head. There

[a] Henshaw, F. F., op. cit., pp. 58-59.

is absolutely no chance of obtaining an adequate supply from this basin, and the distance from any basin furnishing a sufficient supply is so great as practically to preclude the possibility of building ditches or other conduits at a reasonable cost.

In the portion of the Casadepaga drainage area represented on the map (Pl. X) there are a few ditches, none of which are of any great length. On Canyon Creek a ditch takes water from the main stream a short distance below Allgold Creek at an elevation of 510 feet. It follows the north slope of the valley and discharges a short distance east of the margin of the area mapped. It is a small ditch, and during the early part of the season of 1908 was so choked with snow and ice that water did not run in it until July 6. On the upper part of Lower Willow Creek a number of short ditches have been built by small operators, but none of them are more than a mile or two in length, and the volume of water they carry is small. Much of the ground, especially on the east side of this stream, is very bad for building ditches, on account of the broken and fissured limestone ledges which form the bed rock. Limestone is about the worst ground in the peninsula for ditches, as seepage from it is very high. On the main Casadepaga River a short ditch about a mile long has been started from limestone springs on Moonlight Creek. Little more than an intention of utilizing the water has been shown here. Another ditch has its intake near the mouth of upper Willow Creek, whence the water was to be conveyed along the north side of the Casadepaga Valley at such an elevation that it would connect with the ditch from Moonlight Creek. Most of the line of the ditch, however, is marked only by a single furrow turned by a plow. As it has been in this condition for the past two or three years, the projectors probably intend to abandon it.

Two or three years ago there was considerable talk of building a ditch line from Eldorado River near the mouth of Venetia Creek over to Hastings Creek. Hastings Creek enters Bering Sea west of Cape Nome, and the length of the ditch as projected was about 30 miles. Measurements of Eldorado River near the proposed intake gave a discharge of 44 second-feet on August 14, 1906, and of 225 second-feet on September 17, 1907.[a] Work on this project, however, has not been commenced, and from the present indications it will be abandoned. Short ditches have been built on Venetia Creek and one or two of the other small streams tributary to Eldorado Creek, but none of them are in use and they have consequently fallen into ruin.

UNDEVELOPED WATER RESOURCES.

It is a difficult problem to present any adequate discussion of the undeveloped water resources of the Iron Creek region because of the uncertainty as to the place where the water may be used and the head

[a] Henshaw, F. F., op. cit., p. 69.

and volume that may be required. Before any satisfactory statement can be made as to what water powers can be developed for placer mining, it is necessary to determine the value and extent of the auriferous gravels to be worked, for on these factors depend the extreme amount of money that can be expended for water and other essentials. When the value of the land has been determined by careful sampling, the method of applying the water power can be considered. Measurements of the streams should be carried on carefully for several years, in order to ascertain the probable maximum and minimum flow available, and with these data the best methods of developing the natural resources may be determined. Only by carefully analyzing the problems in advance can the expenditure of money for development be safeguarded.

So far as the present indications warrant a suggestion as to where water will be needed in the immediate future in this region, the basin of Iron Creek seems to be the most important locality. This statement is based on the assumption that water is to be carried to the place where the power is needed. If, on the other hand, water power is to be transformed into electric power, the radius of operations is considerably increased. One project of this sort has already been commenced and practically abandoned. It should be said, however, that this project was given up not at all because of impracticability, but because of a contention as to the ownership of the water right. It was proposed to generate power by damming the outlet of Salmon Lake and utilizing the fall thus obtained. This lake, which is the head of Kruzgamepa River, discharges through a narrow gorge only 150 feet wide, where the stream has cut across a morainic deposit formed at one of the later stages in the retreat of a glacier. This gorge affords a remarkably fine situation for a dam. Henshaw, in the report already cited,[a] has discussed the bearings of the problem as follows:

Salmon Lake lies at the foot of the Kigluaik Mountains at an elevation of about 442 feet. It has a water-surface area of 1,800 acres and a drainage area of 81 square miles. Its principal supply comes from Grand Central River, which enters it at its west end. A number of small streams also enter the lake from both the north and the south, but with the exception of Fox Creek and Jasper Creek these are of minor importance. The outlet of the lake is through Kruzgamepa River.

This lake offers an excellent opportunity for a storage reservoir for power purposes and mining along Kruzgamepa River. The use of its water in the vicinity of Nome is practically prohibited, owing to its low elevation and the long tunnel which would be necessary to bring the water through the Nugget divide into the Nome River basin. By raising the water of the lake to an elevation of 500 feet, the shortest tunnel line would be between 5 and 6 miles long; and if any allowance be made for drawing on the storage, water could not be brought through to the Nome Valley at an elevation greater than about 450 feet. The mouth of the tunnel would be near Dorothy Creek, and the loss in grade between that point and Nome would bring the water so low that

[a] Henshaw, F. F., op. cit., pp. 53-54.

it could not be used to any extent for hydraulicking. Even if the water could be brought to the vicinity of Nome under a sufficient head for hydraulicking, the great cost and difficulty of building so long a tunnel would make the feasibility of the plan very doubtful. * * *

As it [Kruzgamepa River] leaves Salmon Lake the river flows through a narrow outlet having a width of 150 feet at the bottom and 500 feet at the top, offering an excellent dam site and location for a hydro-electric power plant. Plans for the construction of such a plant have been perfected by the Salmon Lake Power Company [1907], which intends to develop 3,000 horsepower to be used on dredges at Nome and Council and on Solomon River.

Salmon Lake at its present level, 442 feet, covers 1,800 acres; if raised to a level of 475 feet, it would cover 3,600 acres; and at 500 feet, 4,600 acres. The reservoir thus formed could be used for the storage of the water of the floods caused by the melting snow in the spring and the occasional heavy rains in the summer. The water thus retained would give a large minimum flow not only in summer but also during the winter months, when the natural run-off becomes small.

Kruzgamepa River seldom freezes over before the first of January, and it is probable that with proper installation, power could be developed throughout the year.

The mean discharge from Salmon Lake from June 15 to October 5, 1907, inclusive, was more than 600 second-feet. This discharge, with a fall of 50 feet, would yield approximately 2,700 horsepower. It is evident, therefore, that to dam the Salmon Lake outlet and use the fall for generating electricity would be a simple way of obtaining power at a relatively low cost and in such a form that it could be transmitted without regard to the slope of the surface of the ground. The radius of transmission would greatly exceed that possible by any other application. It is unfortunate that this scheme has been so hampered by antagonistic claims of ownership that almost no work has been done on the water right since 1907.

During the past summer a number of miners have discussed the possibility of bringing water from the Bendeleben Mountains across the broad lowland to some of the valleys, such as that of American Creek, which head on the south side. Although it must be admitted that a large amount of water could be procured in these mountains, it seems clear that without a very thorough examination of the costs and the technical difficulties of construction such a plan should be avoided. Without going into too much detail, as the data are not sufficient for an elaborate discussion, it may be pointed out that much of the ground which could be developed by this water lies at elevations between 500 and 800 feet above sea level. The broad flat across which it would be necessary to pipe the water in an inverted siphon lies between 200 and 300 feet above the sea in its lowest part. It would therefore be necessary, in parts of the line, to have the pipe under such tremendous pressure that the construction would need to be of extraordinary strength. Such a line would cost a large amount of money, and careful consideration should be given to the question whether the returns would allow for the interest and amortization of the capital within the life of the ground which it was intended to work. It may seem unnecessary to call attention to such obvious conclusions, but the fact that similar or even more evident conditions have been overlooked in the past makes such a warning not amiss, especially to those who, though not conversant with mining, desire to invest rather than to speculate.

For many of the places where gold is known to occur in placer deposits there is slight chance of obtaining water under head at a reasonable cost by means of ditches. In such places it will be necessary to search for water-power sites where the energy may be transformed into electricity or where a large volume of water under low head may be utilized to pump a small volume to a great height. So far in Seward Peninsula these two methods have received but slight attention. The use of the hydraulic ram has, however, been effective in other mining regions, and an inquiry into its availability for certain localities might offer a solution to the problem of obtaining a water supply at a sufficient elevation.

Where water for mining occurs in sufficient quantity within the basin in which it is to be used, ditches afford a ready method of transporting it; but where the water must be carried from one creek to another, there are few, with the exception of Iron Creek, which have a sufficient volume to make the cost of ditch construction feasible. Water from the Kigluaik Mountains can be delivered at an elevation of 600 feet only by means of a long inverted siphon, having a pressure in the center of 200 or 300 feet. Iron Creek water to be effective for use on Sherrette Creek must be delivered by a ditch with an intake near the mouth of Discovery Creek. If the ditch were lower it would not furnish the water at a sufficient elevation to treat the known gold gravels; if it were higher it would encounter much bare limestone, which would make construction extremely expensive. To bring Iron Creek water to American Creek would require a higher intake and a longer ditch, which would be almost all the way in broken fissured limestone without a covering of vegetation. Water could not be taken from Iron Creek to the Casadepaga or its tributaries, or from the Casadepaga Basin to Iron Creek, except at such an elevation that the volume would be insignificant. No water could be obtained from Eldorado River for Casadepaga River or Iron or American creeks. Eldorado River might receive water from some of the streams rising in the Kigluaik Mountains, either by inverted siphons across the Salmon Lake and Kruzgamepa lowlands or by a tunnel a couple of miles long through the Jasper-Eldorado divide. Either of these plans, however, would give water at a low elevation, which could be used only on the main stream, and, as has already been pointed out, the gravels of Eldorado River do not seem to be sufficiently auriferous to warrant any extensive construction work.

MINING IN THE FAIRHAVEN PRECINCT.

By Fred F. Henshaw.

INTRODUCTION.

The Fairhaven precinct was examined by Moffit in 1903,[a] but had not been visited by any other member of the Geological Survey until 1908, when the writer spent about seven weeks in this region. The studies of the placers and mining conditions were incidental to stream-gaging work, so that the following notes are not as complete as could be wished. They will, however, give a general idea of conditions in this extensive area and of the recent mining developments.

The Fairhaven district has been developed mostly by the efforts of the miners themselves, for hardly any outside capital was invested in it until 1906. Since that time a considerable amount of money has been spent, in ditches and mining equipment; it has, on the whole, been wisely spent, and the chances seem good of clearing a considerable net profit from the mining operations in the precinct. A sketch map (fig. 21) has been prepared, showing the location of placers, ditches, and points of stream measurements.

INMACHUK RIVER BASIN.

The basin of Inmachuk River was the scene of the discovery of gold in the Fairhaven precinct, the first finds having been made on Old Glory and Hannum creeks in the fall of 1900.[b] Considerable mining was done during the next summer, but in the fall most of the miners joined the stampede to Candle Creek. In 1903 a number of them had returned, and since that time mining and development work have steadily progressed. Prior to 1903 most of the work had been done on the smaller streams, but since that time a large part of the production has come from the Inmachuk itself between the mouth of Pinnell River and the point where it leaves the hills and flows across the coastal plain.

[a] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 247, 1905.

[b] Moffit, F. H., op. cit., p. 49.

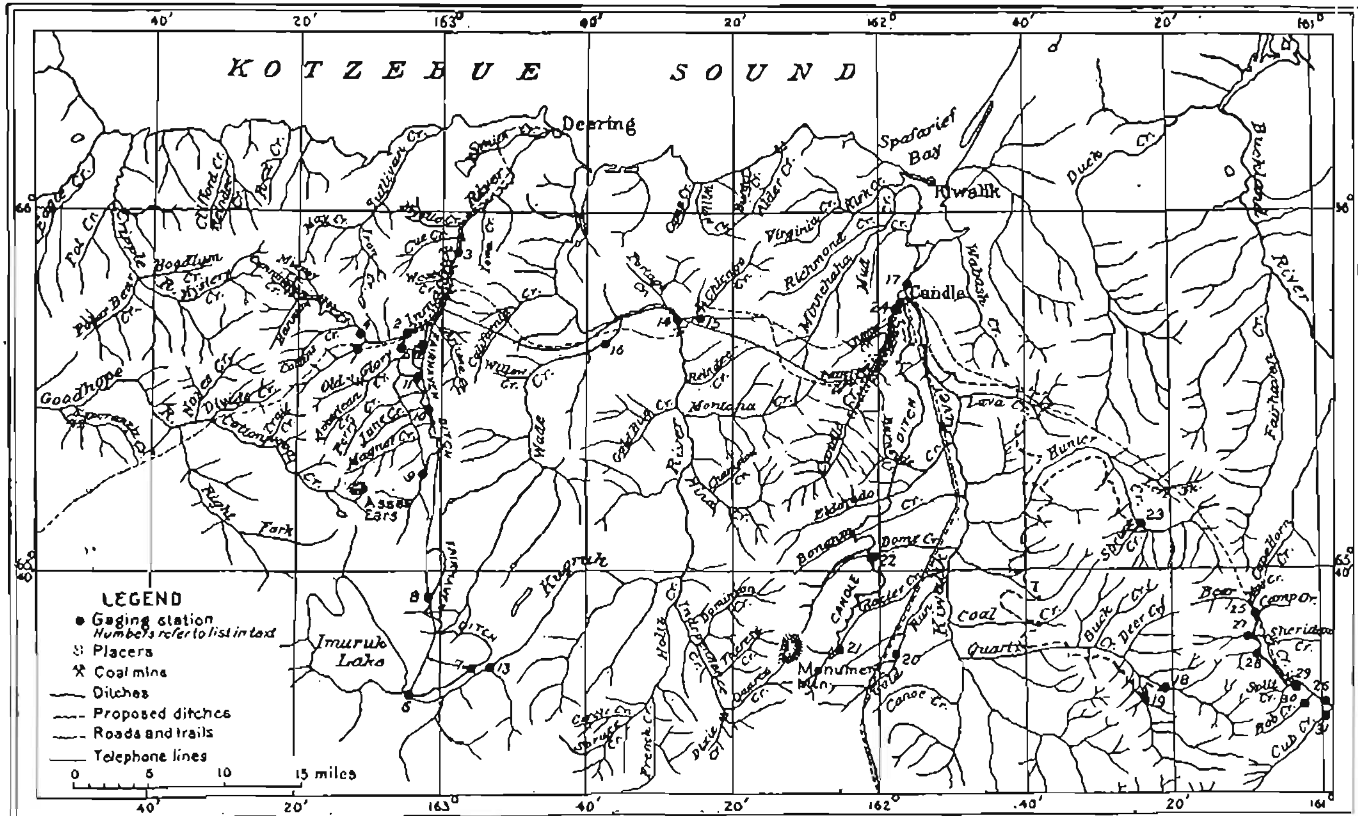


FIGURE 21.—Sketch map of part of Fairhaven precinct.

PINNELL RIVER.

Practically no work was in progress on the Pinnell in 1908, as all the old workings on Old Glory and the adjoining creeks had been abandoned.

HANNUM CREEK.

A ditch built on Hannum Creek in 1907 to furnish water for hydraulicking has its intake at the mouth of Cunningham Creek and extends for 5 miles along the right bank of the creek to a point a short distance above the mouth of Collins Creek, where a pressure of 200 feet is obtained. The ditch was built 4 feet wide on the bottom and has a grade of 4.2 feet to the mile. The character of the ground is very unfavorable for ditch construction, as there is much ground ice, containing little sediment and covered with only a few inches of moss and muck. There are also many places where the ground is fairly solid, and these conditions cause an unequal settlement in the bottom and banks of the ditch. In 1908 only about 2 miles of the upper end of the ditch were in use, from the intake to Milroy Creek. The water was being used to strip the muck from the ground lying on the right bank of Hannum Creek. Some work has been done in the stream bed at this point in previous years, mostly by shoveling into boxes.

INMACHUK RIVER ABOVE PINNELL RIVER.

Little mining has been done in the part of the river above the mouth of the Pinnell, and in 1908 the only development work was a little prospecting just above Hannum Creek. The depth of the gravel in the stream bed is here about 6 to 8 feet and the width not over 200 feet. Prospects were found, but nothing rich enough to pay to shovel. It was reported in the fall that practically all the ground from the mouth of Pinnell River to the springs on the upper Inmachuk had come under one control and that a ditch would be built to bring water from the springs for hydraulicking. It may be possible to reduce mining costs in this way, so that much of the ground can be profitably worked. The springs furnish a constant supply of water of about 8 second-feet,[a] and a pressure of about 150 to 200 feet can be obtained on most of the ground.

INMACHUK RIVER BELOW PINNELL RIVER.

The 7 miles of Inmachuk River below the mouth of the Pinnell have contributed a large share of the production in this basin, the total amount to date, as nearly as can be learned, being from $400,000 to $500,000, nearly all of which has been taken out by winter drifting. The gravel flat in this part of the river is from 800 to 1,200 feet wide

[a] The second-foot is equal to 40 miner's inches as used in the Fairhaven district. It is defined on page 372.

and the depth to bed rock varies from 15 to 30 feet outside of the river channel. The greatest depth, 25 to 30 feet, is in the upper portion, on claim "No. 1 below Pinnell;" below the mouth of Washington Creek the ground is shallowest, being 12 to 15 feet deep. The channel thaws to bed rock in summer, and as the gravel is mostly fine and loose, being called by the miners "chicken feed," there is a large underflow of water which has hindered open-cut work of any kind. In the winter the river is filled with the ice formed by the overflow of the water from the springs, and under these conditions the ground has been drifted, the ice being used as a roof. In some places enough light came through this cover to make candles unnecessary.

The bed rock is schist with interbedded limestone. The limestone seems to have served as a natural riffle and carries most of the gold. It lies in large, irregular slabs cemented together with clay, and is very hard to handle in drifting or open-cut work. Gold is sometimes found in the gravel, but only in the lower 2 or 3 feet.

Operations were being carried on at three places in the summer of 1908. The first, which has been a large producer, is claim "No. 1 below Pinnell." Here the values are on the left bank of the river. The surface of the bed rock is wavy, its depth below the surface varying from 20 to 30 feet, but the pay streaks seem to occur only at points where this depth is 24 to 26 feet. Some very rich spots have been found; one, 75 feet square, is said to have produced $33,000, or about $6 a square foot. In 1908 the river was turned to the left near the upper end of claim "No. 9 below Hannum" and a cut and drain were excavated in the thawed ground of the river channel in the hope of finding an extension of this pay streak that could be worked in the summer. The drain discharged on claim "No. 1 below Pinnell" and extended upstream for over 2,000 feet. Bed rock was reached in several hundred feet of the upper portion, but it was schist and carried no values.

On the Utica group of claims, about 2 miles below the mouth of Pinnell River, some ground was worked by drifting in the winter of 1906–7, but the operations of the past season were confined to hydraulicking with elevators, water being obtained from the Fairhaven ditch. This ditch takes its water from Imuruk Lake, which lies at an elevation of about 950 feet above sea level. A dam 500 feet long and 5 feet high has been built to form a storage reservoir, and this will hold the total inflow at the lake for two years if necessary. The ditch is in three sections; the upper section, 17 miles long, lies on top of the lava and extends from the lake around the head of Wade Creek to the divide between Wade Creek and Pinnell River. Here the water is dropped into a channel emptying into a sink hole in the lava, which seems to be connected by an underground passage with Wade Creek. The water is diverted from this channel into Pinnell River by the middle section of the ditch, which is 850 yards long. The water runs about 6½ miles between the upper and lower ditches and the drop is estimated at 140 feet. The lower section of the ditch extends from the intake on Pinnell River along the left side of the valley to a point a few hundred feet below Logan Gulch, a small tributary of the Inmachuk above Arizona Creek, and has a length of about 19 miles, making a total of 36½ miles of ditch.

The ditch has a grade of 4.2 feet to the mile and was built 11 feet wide on the bottom, 1 foot in cut at the lower side, and with a 4-foot lower bank. The removal of 1 or 2 feet of the upper moss and soil put the bottom of the ditch into ground ice and muck, much of the ice being fairly pure. This material thawed when the water was turned in and a large part of the bottom of the ditch has settled at least 2 feet and has widened in many places to 15 to 20 feet or more. As the upper bank thawed the material was thrown against the lower bank to protect it and keep the water from getting under it. Practically the whole of the upper ditch and at least three-fourths of the lower ditch, including all the upper 6 or 8 miles, is built in frozen ground of this character. Where the lower ditch is built around the steep gulches that carry the eastern tributaries of the Pinnell the northerly slopes of the gulches are covered with muck, but the southerly slopes are made up of a more solid clay and decomposed mica schist. Along the upper ditch lava bowlders are present in the muck from the surface to bed rock. At some places the material encountered was composed of angular fragments of lava with little soil between them. Above and below Snow Gulch, the lowest tributary of Pinnell River which the ditch crosses, there are short pieces of rock work. The rock is much shattered and could have been loosened with picks if it had not been frozen. Much difficulty was experienced in making the rock work water-tight on account of the lack of good sod, as the surface covering is commonly decayed moss or peat containing much fibrous matter, with little earthy material to give solidity, and will generally float even though saturated with water.

The ditch was built under contract and construction was begun early in 1906. The upper section and more than half of the lower section had been built by October 12, when work had to be suspended for the year; it was completed in July, 1907. Water was run through the ditch for a short time in September, 1907, and from July 1 to September 21, 1908, except for a few hours when it was turned out on account of breaks. About 12 second-feet were used in July and 25 to 35 second-feet in August and September. The ultimate capacity of the ditch when some low parts of the bank are raised will be about 100 second-feet. The pressure pipe leading from the penstock below Logan Gulch to the mine has a total length of 10,600 feet.

The elevation of the ditch above bed rock on the Utica claim is 530 feet, a greater head than that of any other ditch in Seward Peninsula, but the water is dropped into a second penstock 200 feet below the ditch, so that the pressure on the nozzles is that due to a fall of about 300 feet when allowance is made for frictional loss.

A diversion dam and waste ditch were built in 1907 to carry the surplus water past the mine. The dam was laid on top of the river bed, so that there is a large underflow, which seeps into the elevator pits. The first pit was sunk in July, 1908, at a point in the river bed where the gravel was about 15 feet deep. Two water lifts were required to handle the seepage, which amounted to about 4 second-feet, and it was found impossible to set the elevator more than 2 feet into bed rock. The gravel is moved to the door of the elevator very easily, as it is loose and well rounded. The bed rock encountered in 1908 was a very heavy limestone. All of it had to be taken up by hand, as the large slabs would not pass through the door of the elevator and could not be sledged to pieces and driven in with a giant because of the flat grade in the pit. The equipment consisted at first of a light hydraulic elevator with a 9-inch throat and a 14-inch upcast pipe, using a 3½-inch nozzle and lifting 32 feet vertically. A second elevator was set with a lift of 35 feet and the first one reset to raise 38 feet. One giant with a 2½ to 3 inch nozzle was used in each pit. The pits worked were about 250 to 300 feet square, a small size in ground of such depth. It will probably be found more satisfactory to use larger and heavier elevators and a larger stream on the giant, and to set the elevator deeper into the bed rock. Much larger pits can thus be worked and the bed rock can be run through the elevator.

Below the Utica lie the Dashley group of five claims, the Polar Bear group of four claims, and the Homestake group of eight claims, all of which have yielded considerable gold. They have been mined by winter drifting, outside coal landed at Deering and costing $60 a ton at the mine being used. Values as high as 5 to 8 cents to the pan—$7.50 to $12 a yard—for a pay streak 3 to 4 feet thick are said not to be uncommon for small areas; but as the gold is irregularly distributed and lies mostly in a creviced limestone, similar to that found on the Utica claim, mining is difficult and costly. The profits from these operations have not been large, and the plan of most of the owners seems to be to wait until the whole river bed can be worked on a large scale with water from the Fairhaven ditch.

The only plant operated in 1908 on this section of the river was below Washington Creek and included a steam scraper and derrick. At this point the gravel in the river bed is about 6 feet deep; but only the lower 2 or 3 feet is gold bearing. This material rests on a blue clay that is easily cleaned. The overburden was removed with a bottomless steam scraper handling half a cubic yard and operated by a double-drum hoist. The pay streak was then shoveled into buckets 3½ by 2½ feet by 20 inches, holding half a cubic yard, which were trammed to the derrick on short pieces of track and hoisted to a dump box about 18 feet above bed rock. Sluice water was pumped by a 12-horsepower gasoline engine lifting about 100 inches. The river water was carried by a channel scraped out on one side of the stream bed, and although this channel had a sufficient capacity for the low water of 1908, with a heavy rain storm it would have been quickly flooded. The seepage water that collected in the pit, amounting to about 20 inches, was handled by a large China pump run by an engine. Ten men were shoveling into buckets in the pits at the time the claim was visited in August, and it was stated that about 150 cubic yards of gravel was handled daily.

KUGRUK RIVER BASIN.

GOLD.

Though there has been considerable prospecting for gold in the Kugruk basin, it has not been very fruitful of results, and in 1908 the only camps in this region were those along the Fairhaven ditch and at the Chicago Creek coal mine.

The only mine that has produced any considerable amount of gold is on Discovery claim, on the Kugruk, a short distance above the mouth of Chicago Creek. At this point the river valley has a width of about a mile and the channel, which lies on the east side of the valley, is about 200 feet wide. The depth to bed rock on Discovery claim is only 12 to 14 feet, including the overburden. The pay streak is crescent shaped in outline and nearly a claim length from end to end. At the points of the crescent the gold is fine; in the middle it is coarse. The production from this claim during the winters of 1903–4 and 1904–5 is said to have amounted to $150,000. Its success led to much prospecting in the vicinity and over 100 holes were sunk to bed rock without finding any values. One hole, three-fourths of a mile from the river and a short distance above Discovery claim, is of interest in showing the great depth of ice and muck sometimes found in this part of Seward Peninsula. The following section was furnished by the prospector:

Section three-fourths mile from Kugruk River, near Discovery claim.

	Feet.
Clear ice	26
Muck	60
Reddish gravel	8
Muck	3
Bluish gravel	10
Schist bed rock.	

COAL.

Moffit has described the coal-bearing rocks of Kugruk River as follows:[a]

Sandy and shaly sediment interbedded with thin limestones were noticed at several localities in the valley of Kugruk River, especially in the vicinity of Chicago Creek, where they are associated with deposits of lignitic coal. These beds are folded and much jointed, but have not been altered to the same degree as have the neighboring schists. They have the same north-south strike and high dips common in the highly metamorphic rocks, and, when weathered, their altered surfaces present an appearance very similar to that which would have resulted had they been burned. Such outcrops were noticed on Kugruk River near the mouth of Chicago Creek and for several miles to the south, also on Chicago Creek one-half mile above the Kugruk. A rather imperfect cleavage was observed at one locality, where the difference in strike of cleavage and bedding amounted to more than 30°.

Lignitic coal was discovered on Chicago Creek in 1902 by men who were prospecting in the creek for gold. Some development work was done in that year and in the following winter, but it was not until the discovery of gold values in the second and third tier of the benches on the left side of Candle Creek, which had to be worked by winter drifting, that any considerable market was found for the coal. Since then the mine has been operated each winter and the Chicago Creek coal has proved an important factor in the development of the Candle Creek placers.

The Chicago Créek coal mine is operated only during the winter months, and the writer was fortunate in being able to examine it on the only day for several summers when the workings have been ventilated and made accessible.

The coal seam strikes about N. 8° W. and has a westerly dip of 53°. The strata in which the coal is included are soft and crumble easily. As nearly as could be determined from the exposures in the mine, the coal bed is 88 feet thick, with no partings except a few thin layers of bone and sandy shale. Drillings made during August, 1908, revealed the presence of the coal bed one-half mile N. 12° W., at a depth of 69 feet below the surface. An inclined shaft that follows the coal bed exposed on the left bank of Chicago Creek is 330 feet long and slopes downward at an angle of 18° to 36°. The shaft reaches a depth of 144 feet below its mouth and the bottom is more than 200 feet below the surface of the ground perpendicularly above it. The coal is solidly frozen to this depth. The incline lies 20 to 30 feet from the hanging wall down to a point near the lowest level, where the irregularity of the dip of the coal bed brings them nearly together.

The mine has been worked on four levels at approximately 33, 80, 100, and 144 feet below the shaft house. On the upper level a cross-

[a] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 247, 1905, p. 25.

cut 55 feet long was run in 1903, but did not reach the foot wall. On the lowest level a crosscut 104 feet long exposes the whole width of coal. The bed is here at least 85 feet thick, but appears to be somewhat thinner than at other points. On the upper three levels the coal has been taken from the portion of the seam lying within 20 feet of the hanging wall, which yields the solidest and most desirable fuel. Most of the coal mined in the last two years has been stoped from the area between the shaft and crosscut and discharged by chutes into cars in the crosscut. The coal at the lowest level appears to be more uniformly good than it is higher up, where only the part of the bed nearest to the hanging wall was worked.

The coal is of a lignitic character; it burns easily with a bright flame and leaves a small amount of white ash. Several samples of the coal from different parts of the mine were analyzed with the following results for the mean:

Analyses of Chicago Creek coal.

[Sample as received.]

Proximate analysis:	
Loss on air drying	33.59
Total moisture	37.73
Volatile combustible	24.14
Fixed carbon	29.27
Ash [a]	8.86
Ultimate analysis:	
Sulphur	.80
Hydrogen	6.77
Carbon	37.61
Nitrogen	.63
Oxygen	45.33
Calorific value:	
Calories	3,441
British thermal units	6,194

All the coal is frozen as it comes from the mine and must be allowed to thaw and dry to give the best results. A large percentage of it is seamed, and checks and crumbles when exposed to the air. This quality is objectionable when it is used under boilers, much of the coal being lost through the grates. Nearly half of the coal hoisted has been left in waste piles at the mine. As it requires about 2 tons of Chicago Creek coal to produce as much steam as 1 ton of Wellington coal, the native product can be sold low enough to compete with that from the outside only at mines on Candle Creek and Inmachuk River, where it can be delivered cheaply. For a greater length of haul the less bulky fuel is less expensive.

[a] There was considerable variation in the amount of ash from different parts of the vein; the mean for the 60 feet nearest the hanging wall was 4.13; for the next 12 feet, 7.08; and for the last 32 feet, 17.36.

An investigation was made during the past summer of the possibility of using the coal for generating power at the mine, to be transmitted electrically to some of the placer districts of Seward Peninsula. The development of dredging and other mechanical means of hoisting gravel will probably go forward rapidly in the next few years and will cause a large demand for power. One of the most important points to be considered in the discussion of this plan is the possibility that water powers which would compete with such a steam power plant may be developed.

KIWALIK RIVER BASIN.

CANDLE CREEK.

Candle Creek, although it has never been a bonanza like Anvil Creek and Snow Gulch in the Nome district, shows a wide distribution of values. Gold has been taken from practically every creek claim for over 10 miles and is found in the benches on one side or the other for fully one-half of this distance, in some places extending into the third tier. The total value of the production to date has been estimated from the best information available at $2,245,400, distributed by years as follows: .

Estimated value of gold production of Candle Creek, 1901–8.

1901	$70,400
1902	250,700
1903–4	181,500
1904–5	321,200
1905–6	542,400
1906–7	609,200
1907–8	270,000
	2,245,400

Placer gold was discovered in July, 1901, on Jump Creek, a tributary of Candle Creek, about 2 miles above its mouth. The creek bed was mined by rocking and shoveling during that and the following summer, but by 1903 the easily worked gravels had been nearly exhausted and the miners began to turn their attention to the benches. Gold was found in the benches on the left bank in the following winter, and since the season of 1904–5 they have yielded approximately $1,200,000, over half of the total production of the creeks.

The term "bench" is commonly applied to any claim outside of the stream channel. The claims lying adjacent to the creek claims are designated "first tier," those next above "second tier." Bench placers have been defined by Purington[a] as "placers in ancient stream deposits from 50 to 300 feet above the present stream."

[a] Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905, p. 27.

So far as is known the bed rock on the left side of Candle Creek shows no rim or escarpment but slopes uniformly to the present stream. The gravel deposits seem therefore to belong more strictly to the hillside placers, which lie intermediate between the creeks and benches and show no indication of the benching of their bed rock.

On bench claims No. 18 and 19, just below the mouth of Patterson Creek, the pay streak lies in the first tier, only a few feet above the level of the creek, and is possibly an extension of the old Patterson Creek channel, mentioned on page 366. On bench claim No. 17 it lies in the second tier and from No. 16 to No. 12 values have been found in both the second and third tiers. The bed rock at the lower end of the pay streak is probably higher than at the upper end. The gravel is thin, varying from 6 inches to 2 or 3 feet; in some places it is lacking altogether and the gold lies entirely in the bed rock. In one such place a narrow bed of gravel, evidently from a side stream, runs across the pay streak. Near Patterson Creek and above Jump Creek the bed rock is a decomposed mica schist. Between claims Nos. 12 and 17 it is a granitic dike, which can be traced by outcrops for a much greater distance. These facts are noted as showing some of the unusual features of these placers, but point to nothing conclusive concerning their origin. The writer spent only one day late in the season in studying the mining operations on Candle Creek, so that the developments in 1908 can only be outlined.

Four creek claims between Jump and Patterson creeks were being operated. An open cut on the side of the creek at claim No. 5 and a small steam hoisting plant on claim No. 14 were not visited. On claim No. 16 a cut was ground sluiced across a bend of the stream, and the gravel was thawed by steam and shoveled into boxes. On No. 17 a large hoisting plant had been installed, with buckets holding three-fifths of a cubic yard. The pay streak cuts across a bend in the creek. A shaft 35 feet deep was sunk to reach it, and as nearly as could be determined the bottom of the shaft was about at the level of the bed rock in the present channel. There are 8 to 18 feet of gravel, and gold was said to be found in the portion lying within 6 inches to 3 feet of the decomposed schist bed rock.

Mining on the benches has been confined mostly to winter drifting, and a little prospecting is about the only summer work on most of the claims. Bench claim No. 19, first tier, has been worked by open cutting, the water of Patterson Creek being brought through a short ditch for stripping the overburden and the gravel being then shoveled into boxes. This is the largest open cut on the stream. Four smaller pits were worked during the summer as much as the meager water supply permitted.

The only benches on the right bank of Candle Creek where values have been found are in the second tier, near the mouth of the creek, on what is known as John Bull Hill, where a considerable area of auriferous gravels was blocked out in 1907 with a keystone drill. Here the bed rock has an elevation of 10 to 90 feet and slopes toward the Kiwalik with a sufficient grade to carry the tailings into the river. In three holes the bed rock is limestone; in the remaining fifty, which are on or near the pay streak, it is a decomposed schist. The gold is mostly well worn and rather coarse. The depth of gravel and overburden is greater than on the benches on the left of Candle Creek.

The sections found in the drill holes are summarized below:

Mean sections of drill holes on benches of Candle Creek.

Material.	Thickness (feet).		
	Greatest.	Least.	Average.
Ice and muck	60	15	35.0
Barren gravel	18	0	4.2
Gravel carrying values	25	0	6.7
Total gravel	29	1	10.9
Bed rock carrying values	13	0	3.1

The only tributary of Candle Creek on which any considerable mining has been done is Patterson Creek, which enters from the left about 7 miles above the settlement of Candle. Gold was first found on this stream in the winter of 1907–8. In September, 1908, claims Nos. 6, 7, and 8 were being operated, and later reports indicate that the pay streak extends from No. 4 to No. 11, inclusive. As developed, it lies about 50 feet to the left of the present creek on claims Nos. 7 and 8 and crosses to the right near the upper end of No. 6. The bed rock is 5 or 6 feet below the present stream. At a depth of 12 to 15 feet below the surface there are 6 inches to 2 feet of flat gravel, not well worn, covered with ice and muck.

Several small ditches have been built to supply water for sluicing purposes on Candle Creek. The longest is the Jump Creek ditch, which extends up Candle Creek on the left bank as far as claim No. 7. It is 3½ miles long and 3 feet wide at the bottom. A ditch 2 miles long and 4 feet wide on Patterson Creek supplies water for stripping and sluicing on a bench on Candle Creek, just below the mouth of Patterson Creek. A slightly longer ditch takes water from Candle Creek near Blank Creek. There are also two or three short ditches from small tributaries. All these ditches depend for their water supply on the rains and the melting snow in the spring. In a dry summer like that of 1908 they can be used for only a few days.

The Candle ditch was built by the Candle-Alaska Hydraulic Gold Mining Company in 1907. It has its intake on Glacier Creek and extends for 33½ miles along the left bank of Kiwalik River to John Bull Hill, opposite the mouth of Candle Creek. Of this length nearly

3 miles is made up of three siphons—2,250 feet of 28-inch pipe across Dome Creek, 912 feet of 30-inch pipe across Bonanza Creek, and the big 12,580-foot siphon across Eldorado and Burnside creeks, composed of equal lengths of 35½, 37½, and 39½ inch pipe. The lateral to Dome Creek consists of 3½ miles of 4-foot ditch, making a total of 37 miles. The ditch is 6 feet wide at the intake, increasing to 9 feet at the lower end. It has a grade of 3.7 feet to the mile, a capacity of 20 to 30 second-feet, and an elevation at the penstock of 249 feet above Kiwalik River. A cut of 9 inches was made on the lower side. This gave a rather low ditch bank in places where the ground was solid, but in the frozen muck the ditch bottom has settled from 1 to 2 feet. The material encountered varied greatly. Near the upper end there were 2 miles of decomposed mica schist; below Burnside Creek there was some rocky ground with too little sediment to make the ditch tight without a great deal of work. Repair work in such places was difficult on account of the general lack of good sod. The portions of the ditch built over the muck gave the least trouble. A berm 1 foot wide was left on the lower bank between the cut and fill, and formed a protection for the inside of the bank when the bottom settled. An extension of the ditch at Gold Run, requiring 8 miles of ditch and a siphon, will probably be built eventually, as the measurements of 1908 show that the flow of that stream was about two-thirds that of Glacier Creek. The mining operations in 1908 were confined to stripping the overburden from the bench on John Bull Hill.

During the summer of 1908 operations on Candle Creek were handicapped and for weeks sluicing was stopped altogether by lack of water. The creek was dry at its mouth from the middle until the end of July and there was a scarcity of water all through the season, except for a very few days late in the fall. A drought has occurred every summer for the last three or four years, though operators have usually been able to sluice for at least a month at the end of the season. The fact that nearly $2,500,000 in gold has been extracted under such difficulties indicates the value of the ground and its possibilities if a good supply of water can be obtained.

Conditions are such as to make the hydraulic method the most feasible one for handling the gravels. Most of the producing claims lie along the benches, high enough to dispose of tailings without elevating. The overburden is ice, with little sediment, and can be removed by exposure to the air, assisted by a little water. The gravel on some of the claims carries gold in several feet of its depth. The builders of the Candle ditch were confident that its construction would revolutionize mining conditions in this region, and make it possible to hydraulic all the ground where drifting had been the only method available. The season of 1908 showed that the water supply that can be counted on throughout the season is only a small part of what had been expected. A summer as dry as that of 1908 may not occur again for years, but it is hard to see how Gold Run, Glacier Creek, and Dome Creek, having an aggregate drainage area at the ditch intakes of only 28 square miles, can furnish 30 second-feet even in a year with considerable rain. Two other ditches have been proposed. One, intended to bring the water of Quartz and Hunter creeks into the Candle Creek valley, would require about 65 miles of ditch and 14,000 feet of pipe, besides a distributing ditch on Candle Creek. The great cost of such an enterprise and the uncertainty of the water supply make its feasibility very doubtful. The other proposed ditch was to bring water from Imuruk Lake to the head of Candle Creek. It was shown by a preliminary survey that this ditch would require 65 miles of open ditch and over 20,000 feet of siphon, besides a long tunnel.

The most practicable method to obtain an adequate water supply would seem to be to pump it from Kiwalik River by electric power. It would require about 2,400 horsepower to pump 50 second-feet to a height of 300 feet, where it would cover all the ground of proved value on Candle Creek. There are two principal sources of power within a reasonable transmission distance of Candle Creek. The first is at the Chicago Creek coal mine, 15 miles distant, where the possibilities of power development have already been noted. The second is on Kugruk River, below Imuruk Lake. The Fairhaven ditch will probably never use more than one-half the inflow into the lake. About 90 second-feet of surplus water should be available for one hundred days, and can be carried in a ditch to a point about 4½ miles below the dam and then dropped into the canyon 500 feet below, developing nearly 4,000 horsepower. The power plant would be 40 miles in a direct line from the mouth of Candle Creek. The relative cost and advantages of these two plants can be determined only after an examination by an experienced engineer, but they present possibilities that may well be considered before any more long ditch lines are attempted.

GLACIER CREEK.

Glacier Creek, the only tributary of Kiwalik River besides Candle Creek on which gold has been found, lies about 25 miles north of Candle in an area of interbedded schist and limestones. The limestone springs in its basin give the creek a fairly well sustained low-water flow, so that there is always enough water for sluicing. These springs remain open during the greater part of the year; in the winter the water flows for about a mile and then freezes, forming a large "glacier" or ice bed. The ice prevents the growth of vegetation and leaves the gravel under it free from muck or other overburden. The depth to bed rock is only 2 to 4 feet, and the gravels thaw as soon as the ice is gone. The intake of the Candle ditch is just below the lower end of the "glacier." Colors of gold had been found in this part of the creek, but no prospecting was done until August, 1908, when two men who had been working on the Candle ditch ran an open cut and uncovered an area of high bed rock at the mouth of a small tributary from the left. They located a pay streak about 20 feet wide and it was reported that they took out nearly $200 by shoveling seven hours each; moreover, a much greater width is said to be rich enough to be worked at a profit by shoveling. This discovery caused a stampede to the creek and will probably lead to much prospecting in the hope of finding gold in benches and in creek claims farther downstream. It should also lead to more careful examination of the other western tributaries of the Kiwalik—Dome, Bonanza, Eldorado, and Burnside creeks—which have hardly been prospected.

BUCKLAND RIVER BASIN.

Bear Creek, the most easterly of the gold-producing streams of the Fairhaven district, is a tributary of West Fork of Buckland River. Gold has been found on lower Bear, Sheridan, and Cub creeks, and some mining has been done each year since 1901, but no extensive developments were undertaken until 1907, when the Bear Creek ditch was built to furnish water for hydraulicking. The ditch has its intake below May Creek and extends along the right bank to Split Creek, picking up the waters of Eagle and Polar creeks, which are its principal feeders. The ditch is 5.8 miles long and 4 to 6 feet wide on the bottom. It has a grade of 4.2 feet to the mile and the pressure obtained is nearly 200 feet. On account of lack of water no actual mining was done in 1908, operations being confined to prospecting on Bear Creek at the mouth of Split Creek. Here the gravel is loose with little fine sediment; the gold is bright and flaky, and lies in a bed rock of seamed and fractured eruptive rock, which will have to be moved to a depth of several inches in some places to recover all the values. There is also a small ditch for ground sluicing, which takes its water from Split Creek.

GOODHOPE RIVER BASIN.

Goodhope River is the westernmost of the larger rivers that drain into Kotzebue Sound. Little prospecting was done in its basin until the winter of 1907–8, when a party of Laplanders discovered gold near the mouth of Esperanza Creek, a small tributary from the south. The values were reported to be good and the news of the discovery caused a stampede from all parts of the Fairhaven district in the late summer of 1908. There will probably be much prospecting during the winter. Esperanza Creek lies about 25 miles in a direct line from the mouth of Rex Creek, which is the most convenient landing place for supplies.

WATER-SUPPLY INVESTIGATIONS IN SEWARD PENINSULA, 1908.

By Fred F. Henshaw.

INTRODUCTION.

SCOPE OF WORK.

The operation of the gold placers in Seward Peninsula had by 1906 reached such a stage of development that their future success was largely dependent on the possibility of mining large bodies of relatively low grade gravel. The most common method of working such ground has been by hydraulicking. For this method a large and steady supply of water under a high head is a necessity. To obtain such a supply a large number of ditches have been built, many of them long and constructed at great expense. There has been a great tendency to push forward their construction without first making sure of the primary requisite of their successful operation, an adequate water supply. The results of such a policy were forcibly shown during the last three summers, particularly in 1908, when in some parts of the peninsula the severe droughts caused much loss and inconvenience to mine operators.

In the whole of Seward Peninsula, as in most of the interior of Alaska, the climate is comparatively arid, except in small mountain areas. The total yearly precipitation ranges from 10 to 25 or 30 inches, and as much of this comes in the form of snow, which melts and runs off in a few days in the spring, the discharge of the streams becomes very small in an ordinarily dry summer. Too much stress, therefore, can not be laid on the importance of procuring stream-flow data, covering not one but from three to five years. The low-water period generally lasts only a part of the season, and the water supply is usually sufficient at other times, but in view of the other unfavorable conditions—the shortness of the season, the frozen state of the ground, the distance from base of supplies and consequent high cost of transportation—a reduction of even two or three weeks in the working season may mean the difference between profit and loss. The cost of the useless machinery and ditches which can be seen in some parts of Alaska amounts to hundreds of thousands of dollars, and most of this loss could have been saved by a preliminary investigation of conditions by a competent engineer.

Hydraulic developments have been carried farthest in southern Seward Peninsula, which has been an important producer of placer gold since 1899. Investigations of stream flow were begun in this area in 1906 by John C. Hoyt and the writer. In 1907 they were continued and extended into the Kougarok region in central Seward Peninsula. The results of these two seasons' work have been published,[a] and the present report is supplementary, bringing the statistics up to date. During the past season the more important stations in the Nome, Grand Central, Kruzgamepa, and Kougarok basins were maintained and the field of work was still farther widened to include the Solomon and Casadepaga drainage basins and the Fairhaven precinct. The writer was assisted in the work by A. T. Barrows, who spent his time in the southern and central portions of the peninsula.

The work in the Fairhaven precinct was in the nature of a reconnaissance, as the field season was so short that the writer was able to spend only about seven weeks in this area, from July 23 to September 9, and to make only two round trips over it. The report on this area should, therefore, be regarded as only preliminary, and can not be taken as indicating the normal conditions, for the drought of 1908 was without precedent since the beginning of mining operations in Seward Peninsula.

COOPERATION.

It was possible to cover this large area properly and to obtain daily records of flow only through the hearty and intelligent cooperation of mining operators, ditch companies, and others. Acknowledgment is due for gage readings to the employees of the Miocene Ditch Company, Wild Goose Mining and Trading Company, Pioneer Mining Company, Canyon Creek Gold Mining Company, Kougarok Mining and Ditch Company, Candle-Alaska Hydraulic Gold Mining Company, and to Messrs. Frank H. Waskey, W. L. Leland, F. F. Miller, C. F. Merritt, J. B. Gilvrey, A. Martell, and C. O. Mason.

METHODS OF WORK.

The methods of carrying on the work and collecting the data were substantially the same as those previously used for similar investigations, but were adapted to the special conditions found in Seward Peninsula. These have been outlined in the previous report.[b]

[a] Henshaw, F. F., and Covert, C. C., Water-supply investigations in Alaska, 1906-7: Water-Supply Paper U. S. Geol. Survey No. 218, 1907.

[b] Henshaw, F. F., and Covert, C. C., op. cit., pp. 9-12.

In the consideration of the water supply for any mining or other industrial project, it is necessary to know the mean discharge, its fluctuation throughout the season, and the causes which govern these variations. Several terms are used, such as "second-feet," "miner's inch," "gallons per minute," etc., to describe the quantity of water flowing in a stream, the one selected depending on the use to be made of the data.

"Second-feet" is in most general use for all classes of work, and from it the quantity expressed in other terms may be obtained. It is an abbreviation of cubic feet per second, and may be defined as the rate of discharge of water flowing in a stream 1 foot wide and 1 foot deep at the rate of 1 foot per second. It should be noted that to obtain the actual quantity of water it is necessary to multiply the second-feet by the time.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly, as regards both time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is expressed in depth in inches.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage problems.

The "miner's inch," the unit used in connection with placer mining, also expresses a rate of flow and is applied to water flowing through an orifice of a given size, with a given head. The head and size of the orifice used in different localities vary, thus making it a most indefinite and unsatisfactory unit. Owing to the confusion arising from its use, it has been defined by law in several States. The California miner's inch is in most common use in the United States and was defined by an act approved March 23, 1901, as follows: "The standard miner's inch of water shall be equivalent or equal to 1½ cubic feet of water per minute, measured through any aperture or orifice." This miner's inch corresponds to the so-called "6-inch pressure" and is one-fortieth of a second-foot. The inch in most common use in Seward Peninsula is the "old California inch," which was the standard in that State prior to the passage of the above-mentioned act, and is equivalent to 1.2 cubic feet per minute, or one-fiftieth of a second-foot.

HYDRAULIC DEVELOPMENTS.

The developments of the past season showed a marked decrease of activity in ditch construction from the three or four previous seasons. This was due largely to the financial depression in the States, but two other influences contributed—first, the appropriation of practically all the available water that can be conducted by gravity to proved mining ground, and, second, the growing caution of capital in taking up ditch projects in Seward Peninsula. The fact that unfavorable conditions outside of Alaska could practically stop construction work on nearly every big project after the large gold output of the two previous seasons shows how dependent the country is on outside capital. In a survey of the whole peninsula it is difficult to see where more than two or three new ditches could be built that would have a chance of success. The failure of many of the waterways already built, from the lack either of an adequate water supply or of values in the ground, has at last begun to make investors realize that investigation should be made before rather than after a large amount of money is spent. Another unsatisfactory feature is the looseness of the laws concerning water rights, which has led to many disputes and lawsuits and has hindered the development of many feasible projects.

The more progressive mining men of the region have begun to turn their attention to the possibilities of pumping water by hydroelectric power. There are seven or eight power sites in Seward Peninsula, reasonably near to important mining fields, where power could probably be generated economically. The best of these sites are on Kruzgamepa River at Salmon Lake, Kuzitrin River above Lanes Landing, and Kugruk River below Imuruk Lake. At all the points the low-water flow could be reinforced by storage, and the aggregate power on a continuous basis for a mining season of one hundred and twenty days could be at least 25,000 horsepower.

Little ditch work was carried on in Seward Peninsula in 1908 beyond the maintenance of the ditches already built. Two short ditches were built in the vicinity of Nome. One on Osborn Creek takes its water about 3 miles below the mouth of New Eldorado Creek, has a length of 4.2 miles, and a bottom width of 6 feet, and gives a pressure of about 130 feet. The old ditch from Last Chance Creek to Pioneer Gulch was extended to Bangor Creek, near the mouth of Jorosa Creek, where a pressure of nearly 200 feet is obtained. Water is taken from North Fork in a branch ditch and piped across Last Chance Creek to the main ditch; two small ditches from Bangor Creek are also included in the system. A few men were employed on the pipe line from Grand Central River and a small force of men and horses on the Grand Central branch of the Miocene ditch. In the Kougarok region no new work was undertaken. In the Fairhaven district the water was used from the Fairhaven and Candle ditches. (See pp. 392–396.)

The tunnel for sluicing the Iron Creek gravels into Kruzgamepa River, which has been described by Mr. Smith (pp. 322–323), will be watched with much interest. The plan of moving gravels through a flume on a low grade, using a large volume of water, is new to this district and, should it prove successful, may point the way to handling some of the extensive gravel deposits that carry low values.

SOUTHERN SEWARD PENINSULA.

DESCRIPTION OF AREA.

Southern Seward Peninsula is here taken as embracing the area from the coast to and including the Kigluaik Mountains. The region shows three types of topography—a coastal plain, an upland, and a mountain mass.

Bordering the coast line is an area of low relief, absent at Point Rodney, Cape Nome, and Topkok Head, but more than 10 miles wide back of the lagoon at Port Safety. This lowland is made up of wet moss-covered ground, rising with a gentle slope to an elevation of 200 or 300 feet at the southern margin of the upland.

The upland is made up of limestone and schist hills, ranging in elevation from a few hundred to over 2,000 feet. The general trend of the ridges is north and south, especially in the area back of Nome, and the streams flowing into Bering Sea are roughly parallel. This upland extends back about 30 miles from the coast and presents a steep escarpment toward a wide, gravel-filled valley that separates it from the mountain mass.

North of the depression the Kigluaik Mountains, locally known as the Sawtooth Range, rise abruptly, constituting a rugged east-west mass, sharply dissected, with serrated crest line. These mountains have been the center of local glaciation in recent times, and their valleys are characterized by cirques.

Nome River is the only stream which crosses the depression and brings water from the mountains to the vicinity of the rich placer ground near Nome. Hence its waters have been the most sought after for mining purposes, and the three largest ditches in this region have been built to divert them. West of Nome River the Sinuk follows this depression and collects the drainage from the south slope of the mountains, and the valley to the east is occupied by Salmon Lake and Kruzgamepa River, which flows in a broad sweep around the east end of the mountains to Imuruk Basin. The divides between the Nome and the Grand Central and Sinuk valleys are low—785 and 1,012 feet, respectively—a fact which makes it possible to divert water from the headwaters of these rivers to Nome River, where it can be carried in the existing ditches to the mines.

The mountains have a heavy precipitation, reaching as high as 50 to 60 inches a year for small areas, as indicated by run-off records, and are therefore an excellent source of water for mining purposes. The area south of the mountains has a rainfall of 15 to 25 inches, or fully twice that of the country north of the steep mountain wall.

In this region the flow of the streams comes in the early summer from the melting snow, and later from the rains. When the snowfall is heavy, as in 1907, it remains until some time in July, and if the rains come early the streams maintain a good flow all summer. In 1908 the snowfall was light and disappeared early, the ground became dry, and the rains were late, so that the run-off for July was small. In the mountains the snow is protected in the steep gorges and cirques, and remains well into the summer. The ground is generally frozen within a foot or two of the surface, a condition which prevents any water from being taken up as ground storage and causes the rains to run off immediately, producing rapid fluctuations of stage. The greatest regulating effect is produced by the limestone springs that occur on some streams, notably Hobson Creek, Moonlight Creek, Canyon Creek, Solomon and Grand Central rivers.

GAGING STATIONS.

The points in southern Seward Peninsula at which gages were established or measurements made in 1908 are given in the following list:

Gaging stations in southern Seward Peninsula, 1908.

Nome River drainage basin:
- Nome River above Miocene intake.
- Nome River below Pioneer intake.
- Hobson Creek at Miocene intake.
- Hobson Creek below Manila Creek.
- Miocene ditch at Black Point.
- Miocene ditch above Hobson Creek.
- Miocene ditch below Hobson Creek.
- Miocene ditch at flume.
- Campion ditch at Black Point.
- Seward ditch at intake.
- Pioneer ditch at intake.

Grand Central River drainage basin:
- Grand Central River below the forks.
- West Fork of Grand Central River at the forks.
- Crater Lake outlet.
- Thompson Creek.

Kruzgamepa River drainage basin:
- Kruzgamepa River at outlet of Salmon Lake.
- Kruzgamepa River above Iron Creek.
- Fox Creek at mouth of canyon.

Kruzgamepa River drainage basin—Con.
- Crater Creek.
- Big Creek.
- Iron Creek.
- Pass Creek.
- Smith Creek.

Solomon River drainage basin:
- Solomon River below Johns Creek.
- Solomon River below East Fork.
- East Fork ditch.
- Midnight Sun ditch.

Casadepaga River drainage basin:
- Casadepaga River below Moonlight Creek.
- Moonlight Creek at ditch intake.
- Lower Willow Creek above Ridgeway Creek.
- Canyon Creek below Boulder Creek.

American Creek drainage basin:
- American Creek below Auburn Ravine.
- American Creek below Game Creek.

NOME RIVER DRAINAGE BASIN.

Nome River is formed by the junction of Buffalo and Deep Canyon creeks, which have their sources in the Kigluaik Range. The principal tributaries are David, Sulphur, Darling, Buster, and Osborn creeks from the east, and Divide, Dorothy, Clara, and Hobson creeks from the west. Hobson Creek, the most important of these tributaries, is a short stream, but receives a large flow from limestone springs.

Four ditches have been built to divert water for mining purposes, and any additional water supply that may be obtained in other high-level streams can best be brought to the mines by way of the valley of Nome River.

The Miocene ditch has its intake on Nome River just below the mouth of Buffalo Creek and extends along the right bank of Nome River to the Ex. Here it forks, one branch delivering water to Glacier and Anvil creeks, the other to Dexter Creek and its tributaries. The ditch crosses and diverts the flow of Hobson Creek and several other small creeks. The David Creek lateral delivers water to Nome River above the intake, the Grouse Creek branch comes in at the flume, and the Glacier Creek branch enters at the Ex.

The Campion ditch has its intake on Buffalo Creek, about one-half mile above the mouth, and extends 4 miles to Dorothy Creek, into which its water is dropped. The Seward ditch has its intake just below the mouth of Dorothy Creek and receives much of its water supply from the Campion ditch. The Pioneer Nome River ditch takes its water about 3 miles below the Seward. Both of the latter ditches have laterals to Hobson Creek, and measurements of these laterals are given with those of that stream.

The total amount of water that can be made available for these ditches includes not only the discharge of Nome River itself, but also that of Grand Central River and some of its tributaries, which can be directed over the Nugget divide. (See p. 374.) These discharges have been summarized by weekly periods in the accompanying table. The amount available for use at elevation 400 to 450 feet includes all above the level of the Miocene ditch; that for use at elevation 220 to 280 feet includes all additional water down to the level of the Pioneer ditch. Sinuk River and its tributaries, Windy and North Star creeks, could also be made to furnish some water, but only by a rather long ditch line and at considerable expense. Their discharge at elevation 800 feet may be estimated at one-half that of upper Grand Central River, Thompson Creek, and Gold Run.

Mean weekly water supply, in second-feet, available for Nome River ditches, 1908.

Date.	For use at elevation 220 to 280 feet.	For use at elevation 400 to 450 feet.			Total.
	Nome River, low-level flow.	Nome River, high-level flow.	Upper Grand Central River, Thompson Creek, and Gold Run.	Nugget, Copper, and Jett creeks.	
June 17-23	98.7	124	....	24.8	248
June 24-30	64.4	83.2	....	16.6	164
July 1-7	25.0	32.3	132	5.8	195
July 8-14	18.5	24.9	89.2	4.0	137
July 15-21	14.6	18.5	64.4	3.0	100
July 22-28	16.0	14.0	45.1	2.2	77.3
July 29-August 4	49.1	83.9	148	15.1	296
August 5-11	107	62.7	159	11.3	340
August 12-18	91.5	61.8	182	11.1	346
August 19-25	70.2	77.8	218	14.0	380
August 26-September 1	62.4	69.2	154	12.4	298
September 1-8	44.0	58.5	99.3	10.5	212
September 9-15	38.3	40.3	56.0	7.3	142
September 16-22	29.5	33.7	49.4	6.1	119
Mean	52.1	56.1	116	10.3	218
Maximum	107	124	218	24.8	380
Minimum	14.6	14.0	45.1	2.2	77.3

Daily discharge, in second-feet, of Nome River and Hobson Creek, 1908.

Day.	Nome River at Miocene intake.[a] Elevation, 572 feet; drainage area, 15 square miles.				Nome River at Pioneer intake.[b] Elevation, 320 feet; drainage area, 38 square miles.			Hobson Creek at Miocene intake.[c] Elevation, 500 feet; drainage area, 2.6 square miles.			
	June.	July.	Aug.	Sept.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	......	23	35	38	53	94	117	......	14.3	6.7	12.8
2	......	17.3	26	42	44	50	104	......	11.1	6.6	12.5
3	......	18.3	34	39	41	53	90	......	10.6	6.4	12.5
4	......	17.2	142	35	38	202	82	......	8.5	6.7	12.5
5	......	17.3	96	33	37	476	75	......	8.2	8.8	12.7
6	......	18.7	57	33	35	192	73	......	8.1	9.1	12.7
7	......	16.8	32	31	35	102	69	......	7.8	10.2	13.0
8	......	13.3	25	29	33	75	68	......	8.7	8.5	12.1
9	......	11.6	19.4	27	32	63	65	......	7.6	7.9	11.8
10	......	9.8	17.6	24	27	62	62	......	7.9	8.0	11.0
11	......	12.7	33	20	29	85	58	......	7.5	8.7	11.1
12	......	24.3	65	20	36	190	58	......	6.2	9.6	10.6
13	......	16.3	40	20	32	185	61	......	6.9	10.3	10.2
14	......	10.8	46	18.4	26	166	53	......	7.3	11.7	9.8
15	......	8.5	31	23	22	120	61	......	7.2	11.4	9.9
16	......	8.4	28	22	22	84	63	......	7.1	12.3	9.5
17	......	9.9	27	22	20	81	54	......	7.6	11.9	8.1
18	......	9.7	25	22	20	76	48	......	7.6	12.2	7.4
19	......	8.6	48	21	19.4	128	48	13.8	7.7	12.5	7.1
20	......	8.7	66	18.3	21	93	46	12.0	6.6	12.8	7.3
21	82	9.0	43	17.5	21	47	44	10.0	6.9	12.0	6.2
22	76	7.1	36	16.0	20	83	46	10.0	6.6	12.4	6.8
23	85	6.1	42	......	18.8	144	......	10.0	6.4	13.1	6.5
24	67	6.8	47	......	19.1	213	......	10.0	6.6	13.1	......
25	54	6.3	54	......	19.2	164	......	12.0	6.6	14.1	......

[a] These values were found by subtracting the flow of the David Creek, Nugget Creek, and Jett Creek ditches from the actual flow and adding that of Campion ditch.

[b] These values were found by subtracting the flow of the Nugget Creek and Jett Creek ditches from the actual flow of Nome River below Pioneer intake and adding the discharge of the Pioneer and Seward ditches and of the Miocene ditch at Clara Creek as estimated from the records at Black Point and above Hobson.

[c] These values were found by subtracting the discharge of the Miocene ditch above the dam from that below the dam; practically no water was spilled from the wasteway.

Daily discharge, in second-feet, of Nome River and Hobson Creek, 1908—Continued.

Day.	Nome River at Miocene intake. Elevation, 572 feet; drainage area, 15 square miles.				Nome River at Pioneer intake. Elevation, 320 feet; drainage area, 38 square miles.			Hobson Creek at Miocene intake. Elevation, 500 feet; drainage area, 2.6 square miles.			
	June.	July.	Aug.	Sept.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
26	75	6.5	45	......	19.1	142	......	12.3	6.2	14.1	......
27	49	6.5	42	......	19.1	104	......	12.6	6.0	14.1	......
28	47	6.3	36	......	18.9	85	......	13.3	5.7	14.1	......
29	29	6.1	34	......	18.9	84	......	14.1	5.7	13.8	......
30	31	66	32	......	121	79	......	15.7	6.2	14.4	......
31	......	93	61	......	316	140	......	......	6.3	13.1	......
Mean	59.5	16.2	44.0	26.0	39.8	125	65.7	12.2	7.5	11.0	10.2
Mean per square mile	3.97	1.08	2.97	1.73	1.05	3.29	1.73	4.09	2.88	4.23	3.92
Run-off, depth in inches	1.48	1.24	3.42	1.41	1.21	3.79	1.41	2.09	3.32	4.88	3.35

Discharge measurements of Hobson Creek below Manila Creek and diversions, 1908.

[Drainage area, 5.1 square miles.]

Point of measurement.	June 19.	July 10.	Aug. 12.	Sept. 1.
	Sec. ft.	*Sec. ft.*	*Sec. ft.*	*Sec. ft.*
Miocene intake	[a] 13.8	7.9	9.6	12.8
Seward lateral	7.1	3.1	6.1	5.3
Pioneer lateral	6.1	2.6	5.0	4.8
Desephan ditch	1.8	0	3.4	2.0
Hobson ditch below Manila Creek	8.4	5.0	3.3	5.2
	27.1	18.6	27.4	30.1

[a] Only 3.7 second-feet was diverted in the Miocene ditch.

Daily discharge, in second-feet, of Miocene ditch, 1908.

Day.	Miocene ditch at Black Point.				Miocene ditch above Hobson Creek.				Miocene ditch below Hobson Creek.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	......	30.1	38.8	42.2	......	19.3	28.3	32.7	......	33.6	35.0	45.5
2	......	20.8	28.6	42.2	......	15.7	23.8	33.0	......	26.8	28.0	45.5
3	......	16.4	26.4	42.2	......	11.4	22.4	33.0	......	22.0	26.5	45.5
4	......	14.5	31.3	42.2	......	9.3	25.3	33.0	......	17.8	28.0	45.5
5	......	14.2	36.4	38.8	......	8.4	30.4	31.1	......	16.6	39.2	43.8
6	......	13.1	42.2	34.5	......	7.9	31.1	28.6	......	16.0	40.2	41.3
7	......	12.5	41.2	32.6	......	6.6	30.4	28.6	......	14.4	40.6	41.6
8	......	9.7	33.5	33.5	......	4.7	28.3'	29.2	......	13.4	36.8	41.3
9	......	8.8	29.8	30.4	......	5.3	25.0	27.4	......	12.9	32.9	39.2
10	......	7.4	27.0	29.5	......	4.1	25.0	26.8	......	12.0	29.8	37.8
11	......	7.8	40.5	20.4	......	4.1	29.8	23.2	......	11.6	38.5	34.3
12	......	13.6	42.2	23.2	......	8.8	31.7	21.6	......	15.0	41.3	30.8
13	......	9.9	42.2	26.7	......	6.8	31.7	23.8	......	13.7	42.0	34.0
14	......	8.5	42.2	22.9	......	4.1	31.7	19.6	......	11.4	43.4	29.4
15	......	7.4	42.2	29.2	......	3.4	32.4	24.4	......	10.6	43.8	34.3
16	......	6.9	37.4	28.8	......	2.7	30.4	28.3	......	9.8	42.7	37.8
17	......	6.7	35.8	24.9	......	1.4	30.1	26.2	......	9.0	42.0	34.3
18	......	6.6	36.4	22.3	......	1.4	29.8	22.4	......	9.0	42.0	29.8
19	......	5.5	42.2	22.9	......	.5	33.[illegible]	21.6	5.7	8.2	45.5	28.7
20	......	5.8	42.2	20.4	......	.8	32.4	20.4	8.3	7.4	45.2	27.7
21	......	5.0	0	20.4	......	.8	0	18.2	10.0	7.7	12.0	24.4
22	......	4.2	42.2	20.1	......	.2	32.4	18.2	10.0	6.8	44.8	25.0
23	......	4.1	42.2	......	......	.1	32.4	15.4	10.0	6.5	45.5	13.4
24	12.9	4.3	42.2	......	......	.1	32.4	......	10.0	6.7	45.5	......
25	22.3	4.3	42.2	......	15.4	.1	31.4	......	12.0	6.7•	45.5	......

Daily discharge, in second-feet, of Miocene ditch, 1908—Continued.

Day.	Miocene ditch at Black Point.				Miocene ditch above Hobson Creek.				Miocene ditch below Hobson Creek.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
26	24.0	4.3	42.2	......	15.7	0	31.4	......	28.0	6.2	45.5	......
27	24.0	4.3	42.2	......	15.4	0	31.4	......	28.0	6.0	45.5	......
28	28.8	3.8	42.2	......	18.2	0	31.4	......	31.5	5.7	45.5	......
29	27.6	3.8	42.2	......	21.6	0	31.4	......	35.7	5.7	42.0	......
30	31.0	31.3	38.8	......	22.1	10.4	30.4	......	37.8	14.4	44.8	......
31	......	37.1	42.2	......	......	28.0	32.7	......	......	34.3	45.8	......
Mean	24.4	10.7	37.3	29.8	18.1	5.4	29.0	25.5	18.9	12.8	39.5	35.3

Daily discharge, in second-feet, of Campion, Seward, and Pioneer ditches, 1908.

Day.	Campion ditch at Black Point.				Seward ditch at intake.				Pioneer ditch at intake.		
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	July.	Aug.	Sept.
1	......	9.6	7.1	5.0	......	22.6	27.8	34.0	17.0	20.5	33.3
2	......	9.6	6.7	11.2	......	18.9	18.9	34.0	16.0	14.3	34.1
3	......	9.8	11.0	9.6	......	18.9	19.6	34.0	15.0	14.0	30.5
4	......	8.8	0	8.4	......	17.6	22.6	30.6	14.0	23.7	26.9
5	......	8.2	0	10.2	......	16.3	30.6	27.8	13.4	33.3	24.9
6	......	7.3	0	12.3	......	15.0	34.0	29.0	12.5	31.7	24.1
7	......	6.3	13.9	9.6	......	15.0	34.0	26.2	12.5	30.5	22.5
8	......	5.4	11.6	9.2	......	14.7	29.0	25.8	12.5	23.7	20.9
9	......	4.9	9.6	9.0	......	14.7	23.8	24.6	11.6	18.8	20.5
10	......	4.7	11.6	8.2	......	10.7	23.4	21.8	11.3	17.7	19.8
11	......	7.7	13.4	7.3	......	13.7	34.0	21.1	11.0	26.9	18.8
12	......	13.9	0	7.3	......	16.3	34.0	21.8	11.0	38.1	18.8
13	......	9.2	7.0	7.0	......	15.0	34.0	21.8	9.5	34.5	19.1
14	......	6.5	17.8	6.7	......	12.4	34.0	18.2	8.3	32.5	18.8
15	......	5.2	13.2	7.3	......	10.4	34.0	23.8	7.8	32.5	17.7
16	......	4.9	12.1	8.2	......	9.6	31.9	22.6	8.0	28.9	17.7
17	......	4.9	11.2	8.2	......	9.0	29.0	17.9	8.0	28.5	16.7
18	4.0	4.9	10.8	7.3	......	9.0	28.2	15.6	7.6	24.1	15.5
19	6.0	4.2	0	7.0	......	9.0	34.0	16.3	8.0	34.5	15.2
20	7.3	4.1	14.4	6.7	31.1	9.6	34.0	15.6	8.6	32.5	14.0
21	11.2	4.2	13.9	5.7	29.4	9.3	34.0	16.9	8.3	27.7	12.5
22	11.2	3.1	13.4	......	29.8	9.0	34.0	16.6	7.6	25.3	......
23	13.6	2.8	10.8	......	29.8	8.8	34.0	15.0	7.0	33.3	......
24	12.1	3.3	10.8	......	29.8	9.0	34.0	......	7.0	33.3	......
25	11.2	3.3	12.1	......	29.8	9.0	34.0	......	7.0	32.5	......
26	13.0	3.3	13.6	......	29.0	9.0	34.0	......	7.0	32.5	......
27	10.4	3.3	13.0	......	29.8	9.0	34.0	......	7.0	33.3	......
28	10.2	2.9	11.9	......	29.8	9.0	34.0	......	7.0	28.9	......
29	10.8	2.7	11.2	......	27.4	8.8	34.0	......	7.0	26.9	......
30	11.2	0	10.8	......	28.2	31.5	31.9	......	27.7	25.3	......
31	......	7.0	0	......	......	32.3	34.0	......	29.3	34.9	......
Mean	10.2	5.7	9.4	8.2	29.4	13.6	31.1	23.1	11.1	28.2	21.1

GRAND CENTRAL RIVER DRAINAGE BASIN.

Grand Central River rises in the heart of the Kigluaik Mountains, where the peaks reach an elevation of 3,000 to 4,500 feet. The river and its tributaries head in glacial cirques and flow through U-shaped valleys over broad gravel beds. North Fork rises on the east side of Mount Osborn, the highest peak of the range; West Fork rises to the south of the same mountain, and the two forks join at elevation 690 feet. West Fork receives the waters of Crater Lake, a glacial lake having an area of 43 acres, through a short tributary from the south. About 3 miles below the junction of the forks the river is joined by the two principal tributaries, Thompson Creek from the west and Gold Run from the east. From this point the river flows southeastward into Salmon Lake.

In order to make the waters of Grand Central River available for use near Nome, they must be carried over the Nugget divide, which has an elevation of 785 feet. The diversion must be made about a mile above the forks and 8 or 9 miles of ditch will be required. There are two waterways being built to divert this water—a 42-inch wood pipe line, starting at Crater Lake, with laterals taking water from North Fork at about elevation 1,030 feet and from West Fork at elevation 1,010 feet, and a ditch 8 feet wide on the bottom with a 5-foot bank, having its intake on the forks at an elevation of about 850 feet.

Daily discharge, in second-feet, of Grand Central River and tributaries, 1908.

Day.	Grand Central River below the forks. Elevation, 680 feet; drainage area, 14.6 square miles.			West Fork of Grand Central River at the forks. Elevation, 690 feet; drainage area, 7.7 square miles.			Crater Lake outlet. Elevation, 925 feet; drainage area, 1.8 square miles.			Thompson Creek. Elevation, 720 feet; drainage area, 2.5 square miles.		
	July.	Aug.	Sept.	July.	Aug.	Sept.	July.	Aug.	Sept.	July.	Aug.	Sept.
1	115	72	146	70	67	60	20	21	11.5	32	18	17
2	105	80	125	62	48	58	18	9.0	10.5	29	13	11.0
3	95	80	108	55	60	48	16	18	9.0	26	13	11.0
4	85	99	90	48	77	43	14	21	7.8	24	18	9.0
5	80	225	71	40	170	36	12	63	5.0	21	35	7.0
6	70	150	62	35	101	34	11	30	4.5	18	25	6.0
7	60	123	55	32	60	32	10	14	4.0	16	13	5.2
8	57	91	50	28	60	31	8.4	11.5	3.5	14	11.0	5.2
9	43	80	48	25	43	30	7.5	11.5	3.0	9.4	9.0	5.2
10	43	80	46	25	36	29	6.9	9.0	3.0	9.4	9.0	5.0
11	65	80	44	35	36	29	9.0	9.0	3.0	16	9.0	5.0
12	106	210	44	77	170	29	21	40	3.0	25	35	4.8
13	58	180	44	36	112	29	14	26	2.9	13	22	4.6
14	52	123	44	26	87	29	11.5	21	2.9	10.2	18	4.4
15	50	99	44	25	60	29	9.0	14	2.9	9.0	13	4.2
16	46	123	43	25	60	28	7.8	14	2.8	9.8	16	3.9
17	46	99	42	25	48	27	8.4	9.0	2.7	9.8	9.0	3.7
18	46	90	41	26	48	26	9.0	9.0	2.6	11.0	9.0	3.5
19	43	150	40	22	94	26	8.7	21	2.5	11.0	35	3.3
20	41	150	40	22	77	26	7.5	14	2.5	9.0	18	3.1
21	41	123	39	22	60	25	7.5	14	2.4	7.5	13	2.9
22	36	99	38	21	60	24	7.5	9.0	2.3	6.9	9.0	2.8
23	33	180	37	18	94	23	6.0	21	2.2	6.0	42	2.7
24	33	195	36	20	60	22	6.9	21	2.1	6.0	50	2.6
25	33	169	35	18	87	22	5.6	20	2.1	6.0	35	2.5
26	31	132	33	18	77	22	5.2	14	1.9	5.6	18	2.3
27	29	132	33	18	60	22	5.0	14	1.9	6.0	13	2.3
28	29	88	33	20	29	22	5.0	9.0	1.9	6.0	9.0	2.3
29	29	71	33	20	22	22	5.6	7.5	1.9	6.0	9.0	2.3
30	180	71	33	130	22	22	30	6.0	1.9	50	8.7	2.3
31	165	160	......	170	80	......	63	14	......	42	25	......
Mean	62.7	123	52.6	39.2	69.8	30.2	12.2	17.2	3.7	15.2	18.7	4.9
Mean per square mile	4.29	8.42	3.60	5.09	9.06	3.92	6.78	9.56	2.06	6.08	7.48	1.96
Run-off, depth in inches	4.95	9.71	4.02	5.87	10.4	4.37	7.82	11.0	2.30	7.01	8.62	2.19

NOTE.—Discharges from September 6 to 30 are based on gage readings taken about five days apart; from July 1 to 7 they are estimated by comparison with Salmon Lake; at other times the gages were read daily.

KRUZGAMEPA RIVER DRAINAGE BASIN.

Kruzgamepa or Pilgrim River heads in Salmon Lake and, after traversing a valley filled with glacial débris, flows around the east end of the Kigluaik Mountains and through broad flats to Imuruk Basin. Its principal tributaries are Iron and Sherrette creeks from the south; Crater, Big, and Homestake creeks from the southern slope of the Kigluaik Mountains; and Goldengate, Pass, Smith, Grand Union, and several unnamed creeks from the northern slope of the mountains. The Kruzgamepa offers excellent opportunities for power development at Salmon Lake and at other points lower down.

Daily discharge, in second-feet, of Kruzgamepa River, 1908.

Day.	At outlet of Salmon Lake. Elevation 442 feet; drainage area, 81 square miles.							Above Iron Creek. Elevation, 250 feet; drainage area, 150 square miles.			
	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	June.	July.	Aug.	Sept.
1	......	375	295	210	99	70	67	......	536	681	456
2	......	355	275	210	87	70	67	......	476	576	425
3	......	335	242	210	92	68	67	......	445	566	425
4	......	295	242	210	96	68	67	......	395	735	410
5	......	275	418	210	103	68	67	......	370	808	385
6	......	242	465	196	92	67	67	......	338	533	365
7	......	226	395	182	89	67	67	......	324	456	345
8	......	210	355	182	86	67	67	......	320	450	345
9	......	196	295	182	86	67	67	......	304	425	336
10	......	182	258	169	84	67	67	......	284	375	309
11	......	182	258	156	82	67	67	......	288	400	296
12	......	196	315	156	79	67	67	......	278	472	264
13	......	182	335	156	78	68	67	......	262	560	264
14	......	182	335	156	73	68	67	......	242	506	264
15	......	169	335	156	76	68	67	......	230	472	284
16	......	156	315	156	76	70	(a)	......	226	445	300
17	......	156	295	156	74	70	......	......	223	425	304
18	......	156	258	156	73	70	......	......	220	405	260
19	......	144	258	156	73	68	......	......	216	400	260
20	......	132	258	144	73	68	......	......	220	415	236
21	550	144	242	144	73	68	......	......	216	395	252
22	465	132	242	144	73	68	......	602	206	385	244
23	465	132	242	132	73	68	......	586	202	420	228
24	465	132	258	110	72	68	......	597	195	533	228
25	440	121	275	101	73	68	......	663	186	500	214
26	465	121	275	92	73	68	......	636	177	478	224
27	440	110	258	101	73	68	......	674	171	456	207
28	465	92	242	99	74	68	......	652	171	425	190
29	418	92	242	97	76	68	......	614	165	415	178
30	395	110	226	97	74	68	......	570	342	385	169
31	......	226	210	......	73	......	......	......	808	400	......
Mean	457	186	288	154	80.0	68.1	67.0	622	291	481	280
Mean per square mile	5.64	2.30	3.56	1.90	.99	.84	.83	4.15	1.94	3.21	1.93
Run-off, depth in inches	2.10	2.65	4.10	2.12	1.14	.94	.46	1.39	2.24	3.70	2.15

a The river was frozen over after about December 15, but the discharge probably remained nearly constant.

Daily discharge, in second-feet, of Iron and Pass creeks, 1908.

Day.	Iron Creek near mouth. Elevation, 280 feet; drainage area, 50 square miles.				Pass Creek. Elevation, 1,100 feet.		Day.	Iron Creek near mouth. Elevation, 280 feet; drainage area, 50 square miles.				Pass Creek. Elevation, 1,100 feet.	
	June.	July.	Aug.	Sept.	July.	Aug.		June.	July.	Aug.	Sept.	July.	Aug.
1	......	73	59	55	......	52	21	......	21	46	44	22	......
2	......	39	40	51	......	36	22	112	21	45	35	20	......
3	......	42	38	50	......	24	23	97	20	73	32	20	......
4	......	37	38	46	......	32	24	122	19	68	38	14	......
5	......	37	213	44	......	82	25	108	19	59	30	17	......
6	......	37	70	43	......	46	26	87	19	53	35	15	......
7	......	34	52	45	......	36	27	101	20	49	38	15	......
8	......	34	44	45	......	32	28	99	19	47	40	15	......
9	......	32	43	43	......	30	29	67	19	46	31	15	......
10	......	28	38	40	24	30	30	80	146	44	25	82	......
11	......	29	46	40	32	30	31	......	202	59	......	82	......
12	......	29	55	36	53	64							
13	......	26	64	34	29	41	Mean	97.0	37.6	57.4	40.0	28.9	38.3
14	......	26	64	33	28	28							
15	......	24	55	33	28	36							
16	......	23	68	42	26	32	Mean per square mile	1.94	.75	1.15	.80	......	......
17	......	24	49	42	26	28							
18	......	23	46	50	24	30							
19	......	23	58	40	24	......	Run-off, depth in inches	.65	.86	1.33	.89	......	......
20	......	21	49	41	24	......							

Miscellaneous measurements in Kruzgamepa River drainage basin, 1908.

Date.	Stream and locality.	Elevation.	Discharge.
		Feet.	*Sec.-ft.*
June 21	Crater Creek 2 miles above mouth	550	76
July 17	Big Creek at edge of mountains	......	14
July 18	Iron Creek below Canyon Creek	425	23
July 20	Smith Creek	950	47
August 18	do	950	40
September 5	Fox Creek at mouth of canyon	550	26

SOLOMON RIVER DRAINAGE BASIN.

Solomon River empties into Bering Sea at Solomon, 40 miles east of Nome. This stream has been a good producer of gold, and several ditches have been built to utilize its water and that of its tributaries, including the East Fork ditch, the Midnight Sun ditch from Big Hurrah Creek, the Brogan ditch from the mouth of Johns Creek to East Fork, and a ditch about 7 miles long on Coal Creek. A ditch has been started by the Three Friends Mining Company to furnish power for its dredge at Oro Fino. It will take water from the river just below East Fork and extend to a point below the mouth of Shovel Creek, where a head of 75 feet will be available.

Daily discharge of Solomon River below East Fork, 1908.

[Elevation, 140 feet; drainage area, 66 square miles.]

Day.	July.	Aug.	Sept.	Day.	July.	Aug.	Sept.
1	130	164	105	20	44	100	....
2	100	115	100	21	43	90	....
3	75	95	95	22	44	90	....
4	72	223	90	23	43	130	....
5	70	626	85	24	44	120	....
6	69	280	82	25	43	115	....
7	69	150	82	26	41	107	....
8	62	112	80	27	40	93	....
9	76	110	78	28	43	90	....
10	72	110	75	29	43	85	....
11	70	120	75	30	360	85	....
12	76	140	72	31	638	110	....
13	63	170	70				
14	65	140	70	Mean	89.3	140	83.8
15	61	120	70	Mean of East Fork			
16	58	110	85	ditch	6.7	10	12.2
17	58	110	100	Mean total	96.0	150	96.0
18	50	110	93	Mean per square mile	1.45	2.27	1.45
19	47	105	....	Run-off, depth in inches	1.67	2.62	.97

NOTE.—The above values are approximate, on account of lack of sufficient measurements and gage readings, and the shifting character of the stream bed.

Miscellaneous measurements in Solomon River drainage basin, 1908.

Date.	Stream and locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 4	Solomon River below Johns Creek	245	60	40	1.50
July 12	.....do	245	37	40	.92
August 6	.....do	245	190	40	4.75
August 27	.....do	245	61	40	1.52
September 18	.....do	245	57	40	1.42
July 4	East Fork ditch near mouth of East Fork	290	11.9	....	....
July 12	.....do	290	0	....	....
August 6	.....do	290	7.5	....	....
August 27	.....do	290	12.6	....	....
September 18	.....do	290	12.7	....	....
September 18	Midnight Sun ditch near mouth of Big Hurrah Creek	160	18.6	....	....

CASADEPAGA RIVER DRAINAGE BASIN.

Casadepaga River, the largest western tributary of the Niukluk, rises south of Iron Creek and joins the main stream about 15 miles above Council. Its principal tributaries are Willow, Curtis, Ruby, Penelope, and Big Four creeks from the southeast, and Moonlight, Lower Willow, Canyon, and Goose creeks from the northwest. Placer gold has been found widely distributed in its basin and considerable mining has been done from Ruby Creek to the mouth of the river, but the total output has probably not been large. Several ditches have been built to obtain water for hydraulicking. There are two on Canyon Creek and one on Moonlight, Ruby, Penelope, and Goose creeks. There are many limestone springs in this basin, notably on Moonlight and Canyon creeks.

Daily discharge of Casadepaga River below Moonlight Creek, 1908.

[Elevation, 400 feet; drainage area, 47 square miles.]

Day.	July.	Aug.	Sept.	Day.	July.	Aug.	Sept.
1	110	76	60	19	30	56	
2	70	56	55	20	36	56	
3	66	56	52	21	36	42	
4	100	100	50	22	30	42	
5	100	246	50	23	25	75	
6	66	300	50	24	25	70	
7	56	76	50	25	20	70	
8	56	56	50	26	20	66	
9	56	56	49	27	20	60	
10	49	56	48	28	20	55	
11	49	76	45	29	20	52	
12	49	76	42	30	1,080	50	
13	49	127	40	31	420	70	
14	42	76	38				
15	42	76	42	Mean	92.1	78.7	51.9
16	36	56	50	Mean per square mile	1.96	1.67	1.10
17	42	56	88	Run-off, depth in inches	2.26	1.93	.74
18	36	56	76				

NOTE.—At times there was a little water diverted past the station in the Moonlight Creek ditch.

Miscellaneous measurements in Casadepaga River drainage basin, 1908.

Date.	Stream and locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 3	Moonlight Creek at ditch intake	485	8.0	0.8	([a])
July 12	do	485	7.6	.8	([a])
August 5	do	485	17.0	.8	([a])
August 26	do	485	10.2	.8	([a])
September 17	do	485	6.5	.8	([a])
August 4	Lower Willow Creek above Ridgeway Creek	400	[b] 6.0	15.4	0.39
August 26	do	400	10.4	15.4	.68
September 17	do	400	17.0	15.4	1.10
July 11	Canyon Creek below Boulder Creek	355	15.4	22	.70
August 3	do	355	11.0	22	.50
August 25	do	355	21.9	22	1.00
September 17	do	355	27.0	22	1.23

[a] The discharge of Moonlight Creek comes from large limestone springs, having their source outside of the drainage basin of the creek.
[b] Estimated.

AMERICAN CREEK.

American Creek rises in the hills lying to the west of the area mapped as the Casadepaga quadrangle. About 8 miles from its head it flows through a canyon 2 miles long and nearly 400 feet deep in places. Below this canyon it enters the lowland area east of Kruzgamepa River and skirts along the edge of the hills to its junction with the Niukluk. In its upper portion it has a fairly wide, gravelly bed and a considerable amount of fall. Its principal tributaries are Auburn Ravine and Game Creek, both from the south. Some prospecting has been done on American Creek and its tributaries, but very little mining.

Discharge measurements of American Creek, 1908.

Date.	Point of measurement.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 9	Below Auburn Ravine	600	2.0	13	0.15
July 18	do	600	1.2	13	.092
August 3	do	600	2.0	13	.15
September 17	do	600	7.2	13	.55
July 9	Below Game Creek	480	5.7	24	.24
July 18	do	480	2.6	24	.11
August 25	do	480	5.9	24	.25

CENTRAL SEWARD PENINSULA.

DESCRIPTION OF AREA.

The central portion of Seward Peninsula, lying north of the Kigluaik and Bendeleben mountains, shows two types of topography—(1) a lowland area 10 to 15 miles wide, lying at the foot of the mountains, and (2) an upland, with flat-topped ridges rising to an elevation of 1,000 to 1,600 feet, representing a former level of erosion. Several mountain masses rise above the level of the plateau, notably Kougarok, Midnight, and Baldy mountains. The streams have cut their channels deep into this plateau, and one or more levels of benches can usually be traced above the present streams. The principal streams are Kuzitrin River and its tributaries Kougarok and Noxapaga rivers.

This region is an area of low precipitation, especially in the early summer, and as there is no unfrozen ground the discharge is very small at low water.

GAGING STATIONS.

The points in central Seward Peninsula at which gages were established or measurements made in 1908 are given in the following list:

Gaging stations in central Seward Peninsula, 1908.

Kuzitrin River drainage basin:
- Kuzitrin River at Lanes Landing.
- Birch Creek at elevation about 400 feet.

Kougarok River drainage basin:
- Kougarok River at Homestake intake.
- Kougarok River above Coarse Gold Creek.
- Macklin Creek at mouth.
- Henry Creek at mouth.
- Coarse Gold Creek at mouth.

Kougarok River drainage basin—Cont'd.
- North Fork above Eureka Creek.
- Windy Creek above Anderson Gulch.
- Homestake ditch at intake.
- Homestake ditch at penstock.
- Windy Creek ditch above Anderson Gulch.

Noxapaga River drainage basin:
- Noxapaga River above Goose Creek.
- Turner Creek at intake.
- Boulder Creek at claim No. 5.

KUZITRIN RIVER DRAINAGE BASIN.

Kuzitrin River is formed by the junction of North and South forks, which rise in the lava beds in the central portion of Seward Peninsula. Below their junction the river crosses the Kuzitrin Flats, a lowland area 20 miles long and averaging over 10 miles in width, lying north of the Bendeleben Mountains. The valley narrows to less than half a mile just above Lanes Landing, but widens as the river enters the lowland lying around Imuruk Basin. In the lower 10 miles of its course the Kuzitrin mingles its waters with those of the Kruzgamepa in an intricate network of channels and sloughs. The principal tributaries are Minnie, Ella, Bonanza, Birch, and Belt creeks from the Bendeleben Mountains on the south and Noxapaga River, Garfield Creek, and Kougarok River from the plateau region to the north.

A measurement made of Birch Creek at elevation about 400 feet, July 30, gave a discharge of 122 second-feet.

Daily discharge, in second-feet, of Kuzitrin River at Lanes Landing, 1908.

[Elevation, 40 feet; drainage area, 1,720 square miles.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	5,900	870	955	385	19	2,860	345	310	480
2	5,900	790	752	408	20	2,640	328	365	455
3	5,900	680	680	385	21	1,640	310	345	430
4	6,560	645	408	408	22	1,520	328	345	385
5	6,180	715	680	430	23	1,300	310	345	385
6	6,940	530	1,040	385	24	1,460	328	385	328
7	6,360	505	1,140	408	25	1,520	295	408	295
8	4,840	430	1,000	408	26	1,580	295	408	250
9	4,330	430	752	365	27	1,460	280	385	250
10	3,850	430	715	365	28	1,300	280	365	250
11	3,690	408	505	345	29	1,090	265	345	250
12	3,770	408	480	328	30	912	280	345	250
13	3,770	430	480	310	31	....	680	345	......
14	3,690	408	480	328					
15	3,690	385	430	310	Mean	3,490	433	528	357
16	3,770	345	408	310	Mean per square mile.	2.03	0.25	0.30	0.21
17	3,160	345	385	365					
18	3,080	345	385	455	Run-off, depth in inches	2.26	.29	.35	.23

NOTE.—Discharges for June are very uncertain, as no high-water measurements were obtained.

KOUGAROK RIVER DRAINAGE BASIN.

Kougarok River drains a large area lying in the central portion of Seward Peninsula and empties into the Kuzitrin about 8 miles above Lanes Landing. It rises southeast of Kougarok Mountain and flows northward, then eastward, and after making a sharp bend to the right, a little east of south to its mouth. The largest tributaries are Taylor Creek and North Fork from the east and Henry, Coarse Gold, and Windy creeks from the west. Of less importance are Washington, Columbia, Macklin, Homestake, Goose, California, Arctic, Arizona, Louisa, Galvin, and Dan creeks and Left Fork. Quartz Creek, which empties into the river below those named above, and its tributaries, Coffee, Dahl, Checkers, Carrie, and Independence creeks, have been the most important gold producers of the region, but have a very small run-off except at times of heavy rain.

Several ditches have been built to divert water of the river and its tributaries for hydraulicking. The largest are the Homestake ditch, on the upper Kougarok, the North Star and Cascade ditches, on Taylor Creek; and the Henry Creek and Coarse Gold Creek ditches. There are smaller ditches on Arizona Creek, North Fork, and Windy Creek.

The amount of water available for the principal ditches in the Kougarok River drainage basin, built and proposed, is summarized by weekly periods in the following table:

Mean weekly water supply, in second-feet, of Kougarok River drainage basin, 1908.

Date.	For Dahl Creek at elevation 300 feet.			For upper Kougarok, at elevation 550 to 650 feet.				
	Kougarok River.	North Fork.	Total.	Kougarok River.	Taylor Creek.[a]	Henry Creek.	Coarse Gold Creek.[b]	Total.
July 1-7	57.7	33.9	91.6	11.6	9.8	18.1	8.1	47.6
July 8-14	29.0	11.8	40.8	5.2	5.3	8.6	3.6	22.7
July 15-21	24.1	9.1	33.2	4.1	5.1	5.5	2.9	17.6
July 22-28	17.7	8.1	25.8	3.1	4.0	3.3	2.2	12.6
July 29-Aug. 4	27.7	8.1	35.8	5.0	6.3	4.6	3.5	19.4
August 5-11	40.0	10.2	50.2	5.8	8.8	9.2	4.1	27.9
August 12-18	27.0	8.6	35.6	4.5	6.5	4.0	3.2	18.2
August 19-25	30.4	8.2	38.6	5.8	6.6	5.7	4.1	22.2
August 25-September 1	33.7	8.2	41.9	6.3	7.8	5.2	4.4	23.7
September 2-8	47.4	8.5	55.9	11.7	9.8	7.8	8.2	37.5
Mean	33.5	11.5	45.0	6.3	7.0	7.2	4.4	24.9
Maximum	57.7	33.9	91.6	11.7	9.8	18.1	8.2	47.6
Minimum	17.7	8.1	25.8	3.1	4.0	3.3	2.2	12.6

[a] These values are estimated from the discharges at other points; about 75 per cent of the discharge is available for the North Star ditch, the remainder for the Cascade ditch.
[b] Estimated.

Daily discharge, in second-feet, of Kougarok River below Homestake intake and of Homestake ditch at intake, 1908.

[Elevation, 635 feet; drainage area, 44 square miles.]

Day.	June.		July.		August.		September.	
	River.	Ditch.	River.	Ditch.	River.	Ditch.	River.	Ditch.
1			15.6	3.1	5.6	8.3	1.2	11.5
2			11.2	5.6	.3	3.6	1.2	7.2
3			3.7	5.8	.4	3.3	6.8	10.6
4			3.2	5.6	.3	3.9	6.2	13.7
5			2.7	4.3	.3	8.6	1.8	9.3
6			7.2	2.9	.3	8.3	1.5	6.2
7			6.7	3.9	.3	7.8	3.1	7.2
8			1.8	4.3	4.1	.0	3.4	3.9
9			1.2	3.9	3.4	.0	2.8	2.9
10			1.2	3.9	.3	3.7	1.2	.0
11			1.1	4.5	.3	3.3		
12			1.1	3.9	.0	2.3		
13			1.2	3.9	.0	2.0		
14			1.1	3.6	.0	2.0		
15			1.1	3.6	.0	10.6		
16			1.1	3.6	.0	7.6		
17			1.1	3.9	.0	4.3		
18			.8	2.9	.0	2.9		
19			.6	2.9	.0	2.6		
20			.6	2.6	.4	10.9		

Daily discharge, in second-feet, of Kougarok River below Homestake intake and of Homestake ditch at intake, 1908—Continued.

Day.	June.		July.		August.		September.	
	River.	Ditch.	River.	Ditch.	River.	Ditch.	River.	Ditch.
21	......	......	.9	2.9	.1	6.0	......	......
22	......	......	.8	2.6	.1	3.6	......	......
23	......	......	.8	2.6	.1	3.9	......	......
24	......	......	.6	2.3	.1	6.5	......	......
25	......	......	.5	2.3	.1	6.5	......	......
26	......	......	.4	2.3	.4	12.1	......	......
27	0.41	9.1	.5	2.6	.0	6.5	......	......
28	.36	5.3	.4	2.8	.5	3.4	......	......
29	.22	14.0	.4	2.6	.5	2.8	......	......
30	.32	.0	.4	2.6	.4	2.0	......	......
31	......	......	.5	2.6	.5	2.6	......	......
Mean	32.8	7.1	2.3	3.4	.61	4.9	2.9	7.3
Mean total	39.9		5.7		5.5		10.2	
Mean per square mile	.91		.13		.125		.23	
Run-off, depth in inches	.14		.15		.14		.09	

Daily discharge, in second-feet, of Kougarok River and tributaries, 1908.

Day.	Kougarok River above Coarse Gold Creek. Elevation, 356 feet; drainage area, 250 square miles.				Henry Creek at mouth. Elevation, 410 feet; drainage area, 50 square miles.				North Fork above Eureka Creek. Elevation, 370 feet; drainage area, 66 square miles.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.[a]	Aug.	Sept.
1	......	96	36	51	......	42	13.4	9.3	......	8.4	8.1	8.8
2	......	76	32	51	......	35	6.6	13.4	......	50.0	7.8	8.8
3	......	49	28	57	......	26	5.5	12.9	......	43.0	7.8	8.6
4	......	49	32	65	......	26	7.8	12.4	......	37.0	8.4	8.4
5	......	49	36	57	......	19.7	14.4	11.4	......	37.0	8.8	8.4
6	......	44	54	44	......	17.0	19.0	10.3	......	37.0	11.6	8.4
7	......	41	57	32	......	15.7	18.4	9.2	......	25.1	11.4	8.4
8	......	36	39	26	......	13.4	18.4	8.2	......	15.0	10.3	8.4
9	......	32	36	28	......	12.9	9.8	6.8	......	12.5	9.7	8.1
10	......	26	30	21	......	11.8	6.6	5.4	......	12.5	9.9	......
11	......	30	28	15	......	13.4	5.5	4.1	......	11.6	9.7	......
12	......	32	26	13	......	12.6	5.5	......	......	10.3	9.9	......
13	......	26	30	......	......	11.8	5.5	......	......	10.3	9.2	......
14	......	21	23	......	......	10.5	6.0	......	......	10.3	8.4	......
15	......	23	26	......	......	9.3	6.6	......	......	10.3	8.1	......
16	......	17	30	......	......	8.5	5.9	......	......	9.4	8.1	......
17	......	32	28	......	......	8.5	5.4	......	......	9.2	8.1	......
18	......	28	26	......	......	7.6	4.9	......	......	9.5	8.1	......
19	......	23	26	......	......	6.6	4.4	......	......	8.4	8.1	......
20	......	23	23	......	......	6.6	9.3	......	......	8.4	8.1	......
21	......	23	28	......	......	7.4	8.8	......	......	8.4	7.9	......
22	......	19	44	......	......	5.9	8.3	......	......	8.4	8.1	......
23	......	26	39	......	......	5.5	7.8	......	......	8.4	8.4	......
24	......	21	30	......	......	4.7	9.3	......	......	8.4	8.4	......
25	......	15	23	......	......	4.5	9.0	......	......	7.9	8.1	......
26	285	17	30	......	......	4.3	8.8	......	......	7.8	8.2	......
27	150	13	36	......	154	4.1	8.5	......	......	7.8	8.1	......
28	166	13	32	......	64	3.9	7.4	......	......	7.8	7.9	......
29	112	17	23	......	57	3.7	5.9	......	37.0	7.6	7.9	......
30	96	21	28	......	50	3.5	4.9	......	9.9	8.1	7.8	......
31	......	28	36	......	......	5.9	7.6	......	......	8.6	9.0	......
Mean	162	31.2	32.1	38.3	81.2	11.9	8.6	9.4	23.4	15.0	8.7	8.5
Mean per square mile	.65	.12	.13	.15	1.62	.24	.17	.19	.35	.23	.13	.13
Run-off, depth in inches	.12	.14	.15	.07	.24	.28	.20	.08	.03	.27	.15	.04

[a] Most of the discharge from July 2 to 7 came from the melting of the ice bed just above the station.

Miscellaneous measurements in Kougarok River drainage basin, 1908.

Date.	Stream and locality.	Discharge.
		Sec.-ft.
June 27	Macklin Creek at mouth	3.8
June 26	Coarse Gold Creek at mouth	30
June 28	do	35
July 26	do	1.4
June 25	Windy Creek above Anderson Gulch, including ditch	15.2
June 29	do	8.5
July 24	do	2.1
September 11	do	2.0
June 27	Homestake ditch above penstock	5.8
June 28	do	8.3
September 10	do	.8
June 25	Windy Creek ditch above Anderson Gulch	2.1
July 24	do	1.3

NOXAPAGA RIVER DRAINAGE BASIN.

Noxapaga River is the largest tributary of the Kuzitrin and enters that stream from the north about 15 miles above the mouth of the Kougarok. The northwestern portion of its basin resembles that of Kougarok River, which it adjoins. An extensive lava flow covers the eastern portion, and the southern or lower end lies in the lowland area known as the Kuzitrin Flats.

Above the mouth of Goose Creek the river has been crossed by a recent lava flow that forms rapids in which there is a descent of 96 feet in 2.3 miles. Above the rapids the river has hardly any fall for several miles.

During 1907 a ditch was built by the McKay Hydraulic Mining Company from Turner Creek, a tributary to the Noxapaga from the northwest, to benches on the river above Goose Creek. It has a total length of 16 miles and diverts water from Turner, Boulder, Miller, Winona, and several smaller creeks.

Miscellaneous measurements in Noxapaga River drainage basin, 1908.

Date.	Stream and locality.	Discharge.	Drainage area.	Discharge per square mile.
		Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
June 30	Noxapaga River above Goose Creek	126	340	0.37
July 21	do	67	340	.20
September 8	do	71	340	.21
June 29	Turner Creek at intake	4.1	13	.32
July 20	do	.6	13	.046
September 8	do	1.6	13	.12
July 1	Boulder Creek at claim No. 5	3.4	6.5	.52
July 21	do	.9	6.5	.14

FAIRHAVEN PRECINCT.

DESCRIPTION OF AREA.

The Fairhaven precinct (see fig. 21) comprises all of Seward Peninsula that drains northward into Kotzebue Sound, except the flat area near Devil Mountain, west of Goodhope Bay. It is an area of relatively low relief, none of the mountains having an elevation of more than half a mile. There is no dominant mountain range like the Kigluaik and Bendeleben mountains to the south. The principal rivers, in order from west to east, are the Goodhope, Inmachuk, Kugruk, Kiwalik, and Buckland. The southwestern portion of the precinct, together with parts of the adjacent Kougarok and Koyuk precincts, is covered with a recent lava flow, which has caused a considerable readjustment of drainage. The most notable effect of this flow is the formation of Imuruk Lake, the largest body of fresh water in Seward Peninsula. An area of older eruptive rocks east of Kiwalik River forms a rugged, dissected mass which reaches an altitude of 2,000 to 2,500 feet. In general, the country is underlain by frozen muck and ground ice, in some places to a depth of 30 or 40 feet or more.

The climatic and other conditions affecting the run-off from the Fairhaven precinct are very similar to those prevailing in the Kougarok region. The run-off during the summer comes mostly from the rain, aided somewhat by melting snow and ice, ground water, and springs. The rainfall is relatively small, even in a rainy season, and runs off quickly. Most of the streams have a large drainage area, however, and in an ordinary season should yield a good volume of water.

There are springs in limestone on Glacier Creek, in the Kiwalik River basin, and on the upper Inmachuk, and in the lava on Kugruk, Pinnell, and Goodhope rivers. These springs give the streams a steady flow during the summer, and the melting of the ice banks formed by their overflows during the winter yields a large amount of water during the early part of the open season.

GAGING STATIONS.

The points in the Fairhaven precinct at which gages were established or measurements made in 1908 are given in the following list. The numbers refer to figure 21, page 356.

Gaging stations in Fairhaven precinct, 1908.

1. Inmachuk River above Hannum Creek.
2. Inmachuk River below Pinnell River.
3. Inmachuk River above Cue Creek.
4. Hannum Creek at mouth.
5. Pinnell River at mouth.
6. Fairhaven ditch at intake of upper section.
7. Fairhaven ditch at Camp 2, upper section.
8. Fairhaven ditch at Camp 4, upper section.
9. Fairhaven ditch at intake of lower section.
10. Fairhaven ditch at Camp 2, lower section.
11. Fairhaven ditch above Snow Gulch.
12. Fairhaven ditch above penstock.
13. Kugruk River at mouth of canyon.
14. Kugruk River above Chicago Creek.
15. Chicago Creek at coal mine.
16. Wade Creek (Burnt River) near mouth.
17. Kiwalik River below Candle Creek.
18. North Fork of Quartz Creek near proposed intake.
19. South Fork of Quartz Creek near proposed intake.
20. Gold Run near proposed intake.
21. Glacier Creek at Candle ditch intake.
22. Dome Creek at siphon crossing.
23. Hunter Creek near proposed intake.
24. Candle Creek at mouth.
25. Bear Creek at intake.
26. Bear Creek above Cub Creek.
27. Eagle Creek at intake.
28. Polar Creek at intake.
29. Split Creek near mouth.
30. Bob Creek near mouth.
31. Cub Creek near mouth.

INMACHUK RIVER DRAINAGE BASIN.

Inmachuk River rises against the head of Trail Creek, a tributary of the Goodhope, flows northeastward and empties into Kotzebue Sound at Deering. Its principal tributaries are Hannum Creek, from the northwest, and Pinnell River, from the south, each of which has a larger drainage area than the main stream above the junction. Arizona, Fink, Washington, West, Cue, and Mystic creeks are small tributaries below the mouth of Pinnell River. About 3 miles from its source and the same distance above Hannum Creek the Inmachuk receives the flow of a large limestone spring.

Hannum Creek occupies a deep and rather narrow valley. Its principal tributaries are Cunningham, Milroy, and Collins creeks. Pinnell River rises in a broad, flat swamp, or "goose pasture," formed by the lava flow. About 6 or 8 miles from its source the river has cut down through the lava, forming a deep, narrow canyon in which it drops 250 to 300 feet in about half a mile. Its principal tributaries are Magnet, June, Perry, and Old Glory creeks and Snow Gulch.

A striking feature of the Inmachuk Valley is the lava rim which extends down the Pinnell from the canyon, following the left side of the valley for several miles, then crossing to the right side and extending down the Inmachuk to the coastal plain and up Hannum Creek nearly to its head. Its elevation is generally 300 to 400 feet above the stream.

Only a few measurements were made in the Inmachuk River basin, but the river was low and the discharge steady after July 15, so that the following results give a good idea of the conditions during the latter part of the summer of 1908.

Discharge measurements in Inmachuk River drainage basin, 1908.

Date.	Stream and locality.	Elevation.[a]	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 26	Inmachuk River above Hannum Creek	230	8.5	10	0.85
August 15	do	230	7.5	10	.75
July 27	Inmachuk River below Pinnell River	160	19.0	142	.13
August 15	do	160	16.4	142	.12
August 22	do	160	14.3	142	.10
August 21	Inmachuk River above Cue Creek	60	38.0	177	([b])
July 26	Hannum Creek at mouth	230	2.3	34	.068
August 15	do	230	2.9	34	.085
July 26	Pinnell River at mouth	160	5.2	90	.058
August 15	do	160	4.1	90	.046

[a] Approximate. [b] This includes about 25 second-feet from the Fairhaven ditch.

FAIRHAVEN DITCH.

The Fairhaven ditch takes water from Imuruk Lake and delivers it to claims on Inmachuk River. It is described in the paper on the mining operations. (See pp. 358–359.)

The object of the measurements made along the ditch was principally to determine the amount of water lost by seepage. The Fairhaven is a good example of a waterway built mostly in "glacier." The bottom has settled in some places 2 feet or more. The fine material is taken up in suspension by the water and redeposited along the sides and bottom, forming a tight lining. The measurements show that nearly all the water turned into the intake is delivered to the mine, over 40 miles below. As there was almost no inflow from the upper side of the ditch during either series of gagings the seepage from the ditch must be very small.

Seepage measurements of Fairhaven ditch, 1908.

Date.	Point of measurement.	Distance between stations.	Discharge.
		Miles.	*Sec.-feet.*
July 23	Intake of upper section		12.2
July 24	Camp 2, upper section	4.5	12.5
July 24	Camp 4, upper section	7.5	12.2
July 24	Intake of lower section	11.5	12.4
July 25	Camp 2, lower section	5.8	12.2
July 25	Above Snow Gulch	5.7	12.0
July 25	Above penstock	7.1	[a]10.6
August 18	Intake of upper section		27.2
August 18	Camp 4, upper section	12.0	[b]25.6
August 19	Intake of lower section	11.5	[b]25.5
August 19	Camp 2, lower section	5.8	[b]24.4
August 20	Above Snow Gulch	5.7	[b]22.7
August 20	Above penstock	7.1	[b]22.6
August 22	Above penstock		26.7

[a] About 0.6 second-foot was spilled from waste gate below Snow Gulch.
[b] Discharge less than normal; water was turned out for repairs to the ditch about 5 miles below intake for a few hours August 18. Water had again reached normal stage above penstock on August 22.

IMURUK LAKE DRAINAGE BASIN.

Imuruk Lake has an area of 30 square miles and a drainage basin of 99 square miles and therefore affords an abundant supply of water for the Fairhaven ditch. The amount of inflow can be determined for two periods of twelve months each—August 16, 1906, to August, 1907, and October 1, 1907, to September 25, 1908. During the first period there was no outflow and the water surface rose 2.17 feet; during the second period the rise was 1.53 feet and the outflow was estimated as follows: June, ten days, 75 second-feet; July 1 to 20, 12.5 second-feet; July 21 to September 25, 30 second-feet. From these data the total run-off has been computed.

Water supply and run-off from Imuruk Lake drainage basin, 1906–1908.

[Elevation, 950 feet; area, 99 square miles.]

	August, 1906, to August, 1907.	Oct. 1, 1907, to Sept. 25, 1908.
Rise of lake surface ... feet	2.17	1.53
Equivalent water supply ... acre-feet	41,600	29,400
Outflow ... do	0	6,400
Total water supply ... do	41,600	35,800
Mean annual discharge ... second-feet	58	49
Discharge for 100-day season ... do	210	180
Run-off from drainage area ... inches	7.9	6.8

KUGRUK RIVER DRAINAGE BASIN.

Kugruk River rises in Imuruk Lake and empties into Kotzebue Sound near Deering. It has a total length of over 60 miles. About 4 miles below its source, at the edge of the plateau on which Imuruk Lake lies, the river has cut into the lava, forming a canyon about 300 feet deep and 1,000 feet wide at its deepest point. At the mouth of the canyon the river is nearly 550 feet below the level of the lake and is probably at about the elevation it had before the invasion of the lava flow. This canyon affords a favorable location for a plant to develop electric power. Water from the lake can be diverted through a ditch for about 4½ miles and then through a pipe line to the bottom of the canyon, developing a pressure of about 500 feet. Below the canyon the grade of the river is relatively flat. Its principal tributaries are Holtz, Mina, Montana, Reindeer, and Chicago creeks from the east and Ruby and Gold Bug creeks and Wade Creek, locally known as Burnt River, from the west. During the summer of 1908, when the dam was closed at the lake, most of the discharge of the river came from springs in the lava above the canyon. The yield of the area draining into the river below the canyon was very small.

Chicago Creek is of interest on account of the coal mine which lies near its mouth. A weir station was installed on the creek at the mine to determine the supply of water available for condensers at the proposed power plant. The miscellaneous measurements give a fair idea of conditions of flow in this basin during the low water of 1908.

Daily discharge, in second-feet, of Chicago Creek at coal mine, 1908.

[Drainage area, 37 square miles.]

August 24	0.14	September 6	1.97
August 25	.14	September 7	2.19
August 26	.12	September 8	1.56
August 27	.16	September 9	.92
August 28	.12	September 10	.79
August 29	.11	September 11	.70
August 30	.11	September 12	.61
August 31	.09	September 13	.55
September 1	.35	September 14	.55
September 2	.30		
September 3	.64	Mean	.69
September 4	1.56	Mean, August	.12
September 5	1.56	Mean, September	1.02

Miscellaneous measurements in Kugruk River drainage basin, 1908.

Date.	Stream and locality.	Elevation.[a]	Discharge.	Drainage area.[b]	Discharge per sq. mile.
		Feet.	Sec.-ft.	Sq. miles.	Sec.-ft.
August 17	Kugruk River at mouth of canyon	440	31	53	0.58
July 28	Kugruk River above Chicago Creek	120	33	470	.070
August 14	do	120	31	470	.066
July 28	Wade Creek (Burnt River) near mouth	120	1.6	170	.009
August 14	do	120	.9	170	.005

[a] Approximate. [b] Exclusive of Imuruk Lake drainage.

KIWALIK RIVER DRAINAGE BASIN.

Kiwalik River, the longest river on the north side of Seward Peninsula, rises in a low ridge which separates the drainage from that of the Koyuk and flows northward for nearly 70 miles to Kotzebue Sound, at Kiwalik. The river traverses a flat lowland area, several miles wide in places, which narrows a few miles above Candle to less than half a mile. Near its mouth the river widens into a lagoon.

The tributaries from the west drain rather narrow basins, roughly parallel and separated by long, low ridges. The principal streams from this side are Canoe Creek, Gold Run, and Glacier, Dome, Bonanza, Eldorado, Candle, and Minnehaha creeks. The largest tributaries from the east are Quartz and Hunter creeks, which rise in the mountainous mass separating the Kiwalik basin from that of Buckland River.

The Candle ditch was built in 1907 to divert water from Glacier and Dome creeks to Candle Creek. It is proposed to extend it eventually to Gold Run. It is described in the paper on mining developments (pp. 366–367). A line has been surveyed for a second ditch to Candle Creek which will take its water from Quartz and Hunter creeks. It will have its intakes on the forks of Quartz Creek, about 2 miles above the junction, and extend along the left bank of the river for about 7 miles, then cross the creek as a siphon 4,230 feet long and follow the east side of Kiwalik River valley to a point about 3 miles above Candle. The water will be carried across Hunter Creek in a siphon 4,850 feet long and across Kiwalik River in 5,880 feet of pipe. The flow of Hunter Creek will be diverted by a ditch about 9 miles long on its left bank. The proposed system will require a total of about 65 miles of ditch and 14,000 feet of pipe. The ditch will give a pressure of 303 feet above the mouth of Candle Creek.

The 1908 measurements on Quartz Creek were made after a rain, when the discharge was larger than it had been earlier in the season. At low water the flow of Glacier Creek comes mostly from springs; early in the summer it comes from the melting of the ice bed formed by the freezing of the spring water in the winter. The measurements of Dome Creek were made about 3 miles below the ditch intake. Candle Creek was dry part of the summer and supplied sufficient water for sluicing for only a few days early in the season and late in September.

Daily discharge, in second-feet, of Glacier and Hunter creeks, 1908.

Day.	Glacier Creek at Candle ditch intake. Elevation, 409 feet; drainage area, 10 square miles.			Hunter Creek, near proposed intake.[b] Elevation, 510 feet; drainage area, 37 square miles.		Day.	Glacier Creek at Candle ditch intake. Elevation, 409 feet; drainage area, 10 square miles.			Hunter Creek, near proposed intake.[b] Elevation, 510 feet; drainage area, 37 square miles.	
	July.[a]	Aug.	Sept.	Aug.	Sept.		July.[a]	Aug.	Sept.	Aug.	Sept.
1	14.0	2.9	2.1	8.0	9.0	20	2.9	2.1	5.8	6.1	13.0
2	12.0	2.2	2.1	8.0	9.4	21	2.5	1.9	......	6.1	......
3	10.0	2.2	2.2	7.0	13.0	22	2.5	1.9	......	6.1	......
4	8.5	2.5	2.1	7.0	15.8	23	2.5	2.5	......	6.5	......
5	6.9	3.5	2.1	13.0	14.1	24	2.5	2.2	......	7.0	......
6	5.5	4.0	2.4	17.4	13.6	25	2.5	2.1	......	7.0	......
7	6.2	2.5	2.1	15.8	9.8	26	2.0	1.9	......	8.5	......
8	6.4	2.2	2.1	9.8	9.0	27	2.0	1.9	......	7.0	......
9	4.5	1.9	1.9	11.0	7.8	28	2.0	1.9	......	6.5	......
10	4.4	1.9	2.5	9.0	6.8	29	2.0	1.9	......	6.5	......
11	5.8	1.8	2.5	8.0	6.8	30	2.0	1.9	......	6.5	......
12	5.1	2.1	2.2	8.0	6.8	31	5.8	2.1	......	6.8	......
13	4.8	1.9	2.2	7.0	6.5						
14	4.4	1.9	2.2	7.0	6.8	Mean	4.7	2.1	3.4	8.1	11.9
15	3.6	1.8	3.0	8.5	6.8						
16	2.9	1.7	5.6	7.0	15.8	Mean per square mile	.47	.21	.34	.22	.32
17	2.9	1.8	7.3	6.1	21.8						
18	2.9	1.7	8.2	6.5	26.6	Run-off, depth in inches	.54	.24	.25	.25	.24
19	2.9	1.7	6.4	6.1	19.1						

[a] Discharges for July are based on estimates and float measurements by D. H. Davidson and H. M. Long.
[b] The discharge for the latter part of July was probably less than that for the period covered by the records.

Miscellaneous measurements in Kiwalik River drainage basin, 1908.

Date.	Stream and locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 29	Kiwalik River below Candle Creek	0	33	800	0.041
August 1	do	0	43	800	.054
August 13	do	0	137	800	.171
August 25	do	0	70	800	.088
September 9	do	0	126	800	.158
August 27	North Fork of Quartz Creek at proposed intake.	590	13.4	21	.64
August 30	do	590	8.7	21	.41
August 27	South Fork of Quartz Creek at proposed intake.	580	13.1	26	.50
August 30	do	580	8.6	26	.30
August 10	Gold Run at proposed intake	....	1.4	9	.16
September 4	do	....	1.9	9	.21
August 10	Boulder Creek at proposed intake	....	.2	4	.05
September 4	do	....	.3	4	.08
July 31	Dome Creek at siphon crossing	230	.7	16	.044
August 9	do	230	.5	16	.031
August 11	do	230	.4	16	.025
September 5	do	230	1.7	16	.11
September 6	do	230	1.9	16	.12
July 29	Candle Creek at mouth	0	0	60	.00
August 13	do	0	.5	60	.008
August 25	do	0	2.6	60	.043
September 9	do	0	1.7	60	.028

BEAR CREEK DRAINAGE BASIN.

Bear Creek rises opposite the headwaters of Quartz and Hunter creeks and flows southeastward for about 20 miles into West Fork of Buckland River. Its principal tributaries are Eagle, Polar, Split, Bob, and Cub creeks from the west, and May, Camp, and Sheridan creeks from the east. The Bear Creek ditch has its intake just below the mouth of May Creek and extends along the right bank nearly to Split Creek, diverting water from Eagle and Polar creeks. Measurements were made in 1908 of Bear, Eagle, and Polar creeks at the ditch intake and of the other principal streams near their mouths.

Miscellaneous measurements in Bear Creek drainage basin, 1908.

Date.	Stream and locality.	Discharge.
		Sec.-ft.
August 6	Bear Creek at intake	1.6
August 28	do	.4
August 31	do	.5
August 29	Bear Creek above Cub Creek	19.2
August 5	Eagle Creek at intake	1.2
August 28	do	1.4
August 31	do	1.2
August 5	Polar Creek at intake	2.9
August 28	do	2.1
August 31	do	2.3
August 5	Split Creek at mouth	16.0
August 28	do	4.0
August 31	do	3.3
August 29	Bob Creek at mouth	5.9
Do	Cub Creek at mouth	12.3

RAINFALL RECORDS.

Records of precipitation were obtained at eight stations in Seward Peninsula for a part or the whole of the season of 1908. It has been the object, as far as possible, to obtain the records near the drainage basin on which records of discharge were kept. The stations have, therefore, been placed in the interior, at mining and ditch camps, where it is hard to obtain records for an entire season. The location, elevation, etc., of these stations is given in the following table:

Rainfall stations in Seward Peninsula, 1908.

Station.	Latitude.	Longitude.	Elevation. Above sea level.	Elevation. Above ground.	Observer.	Date established.
	° ′	° ′	*Feet.*	*Feet.*		
Nome	64 30	165 24	40	20	Arthur Gibson	June 14, 1906
Black Point	64 51	165 16	575	2	F. F. Miller	June 23, 1907
Grand Central	64 58	165 14	690	2	Fred Walford	July 10, 1907
Sowik	64 58	164 38	350	2	Clyde Hager	June 22, 1908
Shelton	65 13	164 48	60	2	Lars Gunderson	July 12, 1907
Taylor	65 42	164 48	500	2	A. Schrader	July 18, 1907
Budd Creek	65 37	165 33	200	2	J. P. Samuelson	July 1, 1908
Candle	65 55	161 56	25	15	Ward Estey	Aug. 11, 1908

The records obtained show, as in previous years, that the precipitation is high in the Kigluaik Mountains, moderate in the area south of them, and very low in the northern half of the peninsula. The daily rainfall for 1908 and the monthly total for the seasons of 1906 to 1908 are given below.

Monthly rainfall, in inches, in Seward Peninsula, 1906–1908.

Station.	June.	July.	August.	September.	Total, June to August.	Total, June to September.	Total, July to September.
1906.							
Nome	Trace.	2.38	2.50	1.02	4.88	5.90	5.90
Salmon Lake	Trace.	4.92	3.33	3.26	8.25	11.51	11.51
Ophir	Trace.	3.57	1.91	(a)	5.48		
1907.							
Nome	1.31	2.08	2.68	1.41	6.07	7.48	6.17
Black Point	2.62	1.94	2.85	3.26	7.41	10.67	8.05
Salmon Lake	2.31	1.79	3.65	2.26	7.75	10.01	7.70
Grand Central	(a)	3.61	7.19	5.06			15.86
Shelton	(a)	.71	1.33	.47			2.51
Taylor	(a)	.66	.96	1.17			2.79
1908.							
Nome	.90	2.10	2.92	.52	5.92	6.44	5.54
Black Point	.57	2.30	3.42	.63	6.29	6.92	6.35
Grand Central	(a)	4.02	6.21	.72			10.95
Sowik	(a)	1.67	1.27	.30			3.24
Shelton	.44	1.32					
Taylor	(a)	.68	1.11	.23			2.02
Budd Creek	(a)	.69	1.87				
Candle	(a)	(a)	[b] .50				

[a] No record. [b] August 11–31.

Daily rainfall [a] and snowfall, in inches, at Nome, 1907–8.

Day.	December.		January.		February.		March.		April.	
	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.
1							0.16	2.0		
2							.23	(b)		
3							.23	(b)		
4	0.06	2.0			0.09	1.5				
5					.15	2.5	.09	1.0		
6							.08	1.0		
7										
8					.04	.8				
9					.03	.5				
10									0.02	0.3
11										
12					.02	Trace.	.06	1.0		
13										
14										
15	.02	.5	0.03	0.5						
16	.11	2.0	.03	.8						
17					.08	1.0				
18	.05	1.0								
19	.01	Trace.								
20	.03	.75			.11	1.75				
21	.02	.5			.14	2.4				
22							.06	1.0		
23			.13	2.8			.19	(b)		
24			.03	.8						
25			.16	3.0	.10	1.5	.06	(b)		
26			.05	1.0						
27										
28							.03	.4		
29										
30										
31										
	.30	6.75	.43	8.9	.76	11.95	1.19	(c)	.02	.3

[a] Water equivalent of snow. [b] Snow and rain. [c] Total, estimated, 13.1 inches.

Daily rainfall and snowfall,[a] in inches, at stations in Seward Peninsula, 1908.

Day.	May.		June.			July.						
	Nome.	Black Point.	Nome.	Black Point.	Shelton.	Nome.	Black Point.	Grand Central.	Sowik.	Shelton.	Taylor.	Budd Creek.
1												
2	0.06					0.08		[b]0.10			Trace.	
3					0.18	.13	0.15	[b].30	0.06	0.18	0.01	
4			0.30		.02						Trace.	
5			.09	0.12	.12							
6			.14	.14	.02							
7			.30	.25	.10							
8			.07	.06								
9												
10	.04											
11						.37	.19	.25	.09	.44	.11	0.10
12							.04	.52		.03		.08
13												
14												
15	.09	0.11										
16							Trace.			.02		
17												
18						Trace.						
19						.04	.05					
20						.21	.12		.11			
21								.15		.01		
22										.14	Trace.	
23						.01			.06		.11	
24						Trace.	.05					
25						.02						
26							.04					
27		.29									Trace.	
28												.30
29						.07	.06					
30						.80	.82	1.20	.79	.10		.21
31						.37	.78	1.50	.56	.40	.45	
	.19	.40	.90	.57	.44	2.10	2.30	4.02	1.67	1.32	.68	.69

[a] Figures give rainfall, except where snow also is given; there the figures for rain give the water equivalent of the snowfall.

Estimated, gage installed July 8.

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RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

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An asterisk (*) indicates that the Geological Survey's stock of the paper is exhausted. If a price is given, the document can be had for that amount from the Superintendent of Documents, Washington, D. C. Certain papers have been issued separately, as well as collected with others in volume form. The separates can be had only from the Geological Survey, but the volumes can be bought from the Superintendent of Documents, as follows: Bull. 259 at 15 cents, Bull. 314 at 30 cents, and Bull. 345 at 45 cents. Bull. 284 is still in stock and can be had free from the Geological Survey.

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*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 No. 45, 1906, 327 pp. $1.00.

*Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin No. 259, 1905, pp. 18–31.

The mining industry in 1905, by A. H. Brooks. In Bulletin No. 284, 1906, pp. 4–9.

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*The mining industry in 1907, by A. H. Brooks. In Bulletin No. 345, pp. 30–53.

Railway routes, by A. H. Brooks. In Bulletin No. 284, 1906, pp. 10–17.

Administrative report, by A. H. Brooks. In Bulletin No. 259, 1905, pp. 13–17.

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*Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin No. 263, 1905, 362 pp. 35 cents. (*Abstract in Bulletin No. 259, 1905, pp. 32–46.)

Geographic dictionary of Alaska, by Marcus Barker, second edition, by James McCormick. Bulletin No. 299, 1906, 690 pp.

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*Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin No. 345, 1908, pp. 54–77.

*Water-supply investigations in Alaska in 1906–7, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, 156 pp. 25 cents.

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Topographic maps.

*Topographic map of Alaska; scale, 1:2500000. Preliminary edition by R. U. Goode. Contained in Professional Paper No. 45. Not published separately.

Map of Alaska, showing distribution of mineral resources; scale, 1:5000000; by A. H. Brooks. Contained in Bulletin 345 (in pocket). Not published separately.

Map of Alaska, showing areas covered by exploratory, reconnaissance, and detailed surveys; scale, 1:5000000. (Map A.) 10 cents.

SOUTHEASTERN ALASKA.

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Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by Alfred H. Brooks. Professional Paper No. 1, 1902, 120 pp.

*The Porcupine placer district, Alaska, by C. W. Wright. Bulletin No. 236, 1904, 35 pp. 15 cents.

*The Treadwell ore deposits, by A. C. Spencer. In Bulletin No. 259, 1905, pp. 69–87.

*Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin No. 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 No. 287, 1906, 161 pp.

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The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright. Bulletin No. 347, 1908, 210 pp.

Yakutat Bay region, Alaska: Physiography and glacial geology, by R. S. Tarr; Areal geology, by R. S. Tarr and B. S. Butler. Professional Paper No. 64, 1909, 185 pp.

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Topographic map of the Juneau gold belt, Alaska. Contained in Bulletin 287, Plate XXXVI, 1906. Not issued separately.

Juneau special map; scale, 1:62500. (Map 581A.) 5 cents.

Berners Bay special map; scale, 1:62500. (Map 581B.) 5 cents.

In preparation.

Geology and ore deposits of Kasaan Peninsula and the Copper Mountain region, Prince of Wales Island, by C. W. Wright.

The Yakutat Bay earthquake of September, 1899, by R. S. Tarr and Lawrence Martin.

Geology of Glacier Bay and Lituya Bay region, by F. E. Wright and C. W. Wright.

Kasaan Peninsula special map; scale, 1:62500, by D. C. Witherspoon, R. H. Sargent, and J. W. Bagley.

Copper Mountain special map; scale, 1:62500; by R. S. Sargent.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

Reports.

*The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall and F. C. Schrader. Professional Paper No. 15, 1903, 71 pp. 30 cents.
*Bering River coal field, by G. C. Martin. In Bulletin No. 259, 1905, pp. 140–150.
*Cape Yaktag placers, by G. C. Martin. In Bulletin No. 259, 1905, pp. 88–89.
*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139. Abstract from Bulletin No. 250.
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Geology and mineral resources of Controller Bay region, by G. C. Martin. Bulletin No. 335, 1908, 141 pp.
Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin No. 345, 1908, pp. 176–178.
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*Map of Mount Wrangell district; scale, 12 miles=1 inch. Contained in Professional Paper No. 15. Not issued separately.
Copper and upper Chistochina rivers; scale, 1:250000; by T. G. Gerdine. Contained in Professional Paper No. 41. Not issued separately.
Copper, Nabesna, and Chisana rivers, headwaters of; scale, 1:250000; by D. C. Witherspoon. Contained in Professional Paper No. 41. Not issued separately.
General map of Alaska coast region from Yakutat Bay to Prince William Sound; scale, 1:120000; compiled by G. C. Martin. Contained in Bulletin No. 335. Not issued separately.
Map of Controller Bay region; scale, 1:62500. (Map 601A.) 35 cents.

In preparation.

The Nabesna-White copper belt, by F. H. Moffit and Adolph Knopf.
The geology and mineral resources of Prince William Sound region, by U. S. Grant.
Chitina quadrangle map; scale, 1:250000; by T. G. Gerdine and D. C. Witherspoon.
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*Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin No. 259, 1905, pp. 151–171.
*Gold placers of Turnagain Arm, Cook Inlet, by F. H. Moffit. In Bulletin No. 259, 1905, pp. 90–99.
Mineral resources of the Kenai Peninsula: Gold fields of the Turnagain Arm region, by F. H. Moffit, pp. 1–52; Coal fields of the Kachemak Bay region, by R. W. Stone, pp. 53–73. Bulletin No. 277, 1906, 80 pp.
Preliminary statement on the Matanuska coal field, by G. C. Martin. In Bulletin No. 284, 1906, pp. 88–100.
*A reconnaissance of the Matanuska coal field, Alaska, in 1905, by G. C. Martin. Bulletin No. 289, 1906, 36 pp. 25 cents.

Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin No. 314, 1907, pp. 157-163.
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 No. 328, 1908, 343 pp.
Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin No. 345, 1908, pp. 206-250.
The Seward Peninsula tin deposits, by Adolpf Knopf. In Bulletin No. 345, 1908, pp. 251-267.
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Water supply of the Nome and Kougarok regions, Seward Peninsula, in 1906-7, by F. F. Henshaw. In Bulletin No. 345, 1908, pp. 272-285.
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*Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, pp. 156. 25 cents.

Topographic maps.

Seward Peninsula, northeastern portion of, topographic reconnaissance map of; scale, 1:250000; by D. C. Witherspoon and E. C. Hill. Contained in Bulletin No. 247. Also published separately (map 650); 25 cents.
Seward Peninsula, northwestern portion of, topographic reconnaissance map of; scale, 1:250000; by T. G. Gerdine and D. C. Witherspoon. Contained in Bulletin No. 328. Also published separately (map 651); 25 cents.
Seward Peninsula, southern portion of, topographic reconnaissance map of; scale, 1:250000; by E. C. Barnard, T. G. Gerdine, and others. Contained in Bulletin No. 328. Also published separately (map 646); 25 cents.
Grand Central special map; scale, 1:62500. (Map 646A.) 5 cents.
Nome special map; scale, 1:62500. (Map 464B.) 5 cents.
Map of Casadepaga quadrangle; scale, 1:62500. (Map 646C.) 5 cents.
Map of Solomon quadrangle; scale 1:62500. (Map 646D.) 5 cents.

In preparation.

Geology of the area represented on the Nome and Grand Central special maps, by F. H. Moffit, F. L. Hess, and P. S. Smith.
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Reports.

A reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak [Kobuk] rivers, by W. C. Mendenhall. Professional Paper No. 10, 1902, 68 pp.
*A reconnaissance in northern Alaska across the Rocky Mountains, along the Koyukuk, John, Anaktuvuk, and Colville rivers, and the Arctic coast to Cape Lisburne, in 1901, by F. C. Schrader and W. J. Peters. Professional Paper No. 20, 1904, 139 pp. 40 cents.
*Coal fields of the Cape Lisburne region, by A. J. Collier. In Bulletin No. 259, 1905, pp. 172-185.
*Geology and coal resources of Cape Lisburne region, Alaska, by A. J. Collier. Bulletin No. 278, 1906, 54 pp.

Topographic maps.

Reconnaissance map of Fort Yukon to Kotzebue Sound; scale, 1:1200000; by D. L. Reaburn. Contained in Professional Paper No. 10. Not published separately.
*Koyukuk River to mouth of Colville River, including John River; scale, 1:1200000; by W. J. Peters. Contained in Professional Paper No. 20. Not published separately.

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