DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

BULLETIN 345

MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN 1907

BY ALFRED H. BROOKS AND OTHERS

WASHINGTON
GOVERNMENT PRINTING OFFICE
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By Alfred H. Brooks and others.

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By Alfred H. Brooks.

PREFACE.

This volume, as indicated by the title, is a progress report, but this term has a double significance. It is the purpose here to chronicle not only the progress of the investigations of Alaskan mineral resources and to make public the more important economic results, but above all to note the advance of the mining industry throughout the Territory during the year 1907. It is the aim to make these volumes[a] handy works of reference for those who are interested in the mining industry of this northern field. As the preparation and publication of the more elaborate reports and maps, which is the ultimate purpose of the Alaskan work, always requires considerable time, it seems desirable to present the more important economic conclusions in advance. This is especially important in a field like Alaska, where mining advances are taking place so very rapidly. If the information gained by the geologist and engineer is to be of use to the prospector and pioneer miner, it must be given to the public before the explorative stage of mining has passed, even at the risk that some of the conclusions presented in this preliminary way may be set aside when the laboratory investigations are completed.

As in former volumes, the papers here presented fall into three groups—(1) summaries of progress of the various phases of the

[a] Three similar reports have already been issued: Report on progress of investigations of 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.

mining industry in various parts of the Territory during the year, (2) preliminary accounts of investigations in progress or completed, and (3) statements of the results of minor investigations not to be published elsewhere.

The increasing facilities for transportation and the improvement of the mail service make it possible each year to make these reports more complete as an accurate record of the advancement of the mining industry. As, however, only 20 technical men are engaged in the work, and as they devote a large share of their time to the more elaborate investigations and survey, it is not possible to send a representative of the Geological Survey to each Alaska mining district every year. Therefore the data collected at first hand are supplemented, so far as possible, by information gleaned from various sources, chiefly by correspondence with representative mining men. It is very gratifying to note that there is an increased interest in this phase of the investigation on the part of the mining public, and that much valuable information has been furnished by representative residents of Alaska. Among the many that have assisted in this way are the following, to whom the writer would make special acknowledgment: C. D. Garfield, Wild Goose Mining Company, and Arthur Gibson, of Nome; C. W. Thornton, of Solomon; John A. Dexter, of Golofnin; Falcon Joslyn; Maj. J. P. Clum; R. Wood; P. G. Charles; W. H. Parson, of Fairbanks; S. J. Marsh, of Caro; A. J. Childs, of Deadwood; H. F. Thumm and W. B. Ballon, of Rampart; Frank E. Howard, of Coldfoot; F. J. Wanderwall, of Eagle; F. C. Kelsie, of Kodiak; George M. Esterly, of Nizina; Melvin Dempsey, of Chisna; and the Pioneer Mining Company.

As much the larger part of the value of the annual mineral production comes from the gold placers, the description of placer districts rather dominates other phases of the work in this report. With the increased knowledge of the bed-rock geology gained both through the investigations here to be outlined and through the mining developments, there is a constant accretion of facts bearing on the occurrence of the metalliferous deposits in the bed rock, and in this report, therefore, a more complete statement of this phase of the subject can be presented for southeastern Alaska, the Yukon district, Seward Peninsula, and the Copper River region than has been previously given.

The composite authorship of this volume is evident from the fact that it contains fourteen different papers by eleven different authors. The arrangement of the contributions is, in general, geographic—from south to north—beginning with some papers of a general character. It is unfortunate that the exigencies of prompt publication make it imperative to omit all elaborate illustrations, the reproduction of which necessarily consumes considerable time, and to include only such outline maps and diagrams as can be quickly prepared for printing. The complete reports will contain more detailed illustrative matter.

PROGRESS OF SURVEYS.

INTRODUCTION.

During the season of 1907 twelve parties were engaged in Alaskan surveys and investigations. Of these six were carrying on geologic work, four were making topographic surveys, and two were engaged in stream gaging. The personnel of these parties included 19 technical men and 20 to 25 camp hands. Of the technical men twelve were geologists, four topographers, and three engineers. In addition to these the geologist in charge spent some two months in the field carrying on geologic investigations and visiting field parties. In addition to the field force, four clerks were employed in the office for the whole or a part of the year.

During 1907 topographic reconnaissance surveys were carried over an area of 6,125 square miles. The geologic investigations included reconnaissance surveys of about 4,000 square miles and detailed surveys of about 400 square miles. Much of the time of the geologists was devoted to a study of the mining districts or special problems yielding results which can not be expressed in square miles, and for this reason the area covered by the geologic work is much smaller than that embraced in topographic surveys.

The geographic distribution of the work can be summarized as follows: In southeastern Alaska two parties were at work for a part or the whole of the summer. One was engaged in making detailed surveys of one of the copper and gold mining districts, as well as in general study of the mineral deposits of that section; the other was engaged in making detailed topographic surveys of one of the important mining districts. In the Copper River region one geologic party was devoted to a study of the copper deposits of the Chitina region. In the Yukon placer district one party was engaged in a study of general geologic economic problems. Two parties were employed in the detailed topographic mapping of the mining district adjacent to Fairbanks, and a third was engaged in making a general reconnaissance of the water resources of the same area. In Seward Peninsula one party was engaged in mapping the areal geology of the Solomon and Casadepaga quadrangles; another was engaged in a study of the tin deposits of the western part of the peninsula; a third was engaged in stream-gaging work, supplementing that of the previous season. The following table shows the allotment of the total appropriation of $80,000 to the various districts investigated:

Allotment to Alaskan surveys and investigations, 1907.

Continuation of general investigations of coal resources	$4,700
Surveys and investigations in southeastern Alaska	5,300
Surveys and investigations in Copper River region	12,000
Surveys and investigations in Yukon region	41,000
Surveys and investigations in Seward Peninsula	17,000
	80,000

The appended table summarizes briefly the results of the Alaska work during the ten years which have elapsed since systematic surveys were begun. This table, however, does not show the many detailed investigations which have been carried on in certain mining districts, much of the appropriation having been spent on a class of work that can not be shown in tabular form. It should be noted that practically every district in Alaska that has produced any mineral wealth has been studied, and that many of them have been investigated in considerable detail.

When the reports now in print or in preparation are completed, a statement of the mineral resources of all of southeastern Alaska will have been published, accompanied by geologic maps. Reports on the two most important coal fields—Matanuska and Controller Bay—are in print, containing geologic and topographic maps. The maps of the Matanuska field are on a scale of 4 miles to the inch; those of Controller Bay on a scale of 1 mile to the inch. In the Copper River region the southern copper belt has been investigated and mapped on a scale of 4 miles to the inch, and preliminary statements concerning the northern belt, together with topographic maps, have been issued.

Reconnaissance surveys of the Yukon-Tanana field have been completed and detailed investigations have already been inaugurated. A preliminary report on the entire Seward Peninsula has now been issued, including geologic maps showing the distribution of the gold placers, so far as they have been determined. In addition to this, two of the largest gold-producing districts of this region have been mapped in detail, both geologically and topographically.

The water resources of both Seward Peninsula and the Fairbanks district have been studied, and preliminary reports have been published. In the former district this work will be completed during the coming summer, but the final report on the water available for placer-mining operations in the Yukon-Tanana region must await more extensive surveys.

The investigations above mentioned do not cover all the Survey activities, but a more complete account of the publications will be found at the end of this volume.

Progress of surveys in Alaska, 1898–1907.

Year.	Appropriation.	Areas covered (square miles).					
		Geologic.		Topographic.		Hydrographic.	
		Reconnaissance.	Detailed.	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	1,000	200
1907	80,000.00	4,000	400	6,125	501	1,000	400
	551,189.60	94,500	1,700	117,277	2,305	2,000	600

The above table indicates that, including about 50,000 square miles surveyed by other Government organizations, topographic reconnaissance surveys have been extended over about one-quarter of the Territory of Alaska. Geologic reconnaissance surveys cover about the same amount of territory. The detailed surveys up to the present time are confined to small areas. The rapid mining developments going on in some districts call for detailed surveys, and these will be pushed as fast as means will permit. Besides this, reconnaissance surveys are urgently needed over at least 100,000 square miles additional. Though the hydrographic surveys cover only comparatively few square miles, yet the areas which have been chosen are the most important ones, and it is not likely that the investigations will ever be carried over any considerable percentage of the total area of Alaska.

In planning the work it is aimed to take up the most important investigations first, and therefore much money is spent on the placer districts, which, up to the present time, have yielded by far the larger part of the mineral wealth of the Territory. With the close of the coming field season the investigations of many of the placer districts will be brought to a completion, and this will make it possible to extend the work into other little-known fields and also to give more attention to areas which give promise of becoming centers of lode mining.

GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

GENERAL.

Most of the time of the writer has been given to general administrative duties, in which he has been aided by T. G. Gerdine, who has continued the general supervision of the topographic work. He has also received assistance from E. M. Aten, who was transferred to the division in July, and who has looked after the office routine during the writer's absence in Alaska. The writer was engaged in office work until August, 1907, when he proceeded to southeastern Alaska and spent about ten days with Mr. Wright and Mr. Paige in a study of some of the geologic problems of Kasaan Peninsula. Later he went to Fairbanks, where his time was devoted to familiarizing himself with the more recent mining developments and in visiting the Gerdine, Sargent and Covert parties. The extension of his work into Seward Peninsula, as planned, was prevented owing to delays in travel caused by the low water in the Yukon. After returning to the office, the writer was in part occupied in preparing his statistical report on the gold and silver production in Alaska for 1906, which was published in the Mineral Resources of the United States, 1906. In this work he was assisted by C. W. Wright and A. G. Maddren.

In pursuance of plans outlined about two years ago, W. W. Atwood, assisted by H. M. Eakin, has continued the study of the stratigraphy of the Cretaceous and Tertiary coal-bearing rocks of the Territory for the purpose of establishing correlations and obtaining information in regard to the relative values of the different coal fields. Messrs. Atwood and Eakin began their work in the coal-bearing rocks of southeastern Alaska in May, visiting Admiralty and Kuiu islands. In June they proceeded to the Yukon and spent the balance of the summer in studying the stratigraphy of the coal-bearing rocks. A number of important areas were mapped both topographically and geologically.

Some years ago a systematic study of the methods and costs of placer mining in Alaska was undertaken by C. W. Purington under the auspices of the Geological Survey. The published report [a] found such favor among the mining public that the edition was soon exhausted, and a second edition is in preparation. Mr. J. P. Hutchins, who contributed a valuable section on dredging to this report, has kindly consented to prepare the paper on placer mining and prospecting which forms a part of the present volume. In this paper he discusses some of the important features in the recent evolution in mining methods which has taken place in Alaska. It is fortunate that this phase of the subject of mining, which falls outside of the field of geology, is here treated by one who has had not only the theoretical training, but also long experience in actual mining operations under the peculiar conditions which prevail in this northern region.

[a] Purington, C. W., The methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905.

SOUTHEASTERN ALASKA.

As reconnaissance work in the important mining districts of southeastern Alaska was completed in 1906, it seemed desirable to devote the funds available for this field in 1907 to the detailed mapping. With this object in view D. C. Witherspoon, assisted by J. W. Bagley, was directed to begin the topographic mapping of Kasaan Peninsula, the most important copper-producing district of southeastern Alaska. Work was begun about the first of May and continued until the first of June, when it was necessary for the party to take up the work in the Yukon district. About 64½ square miles were mapped on a scale of 1 mile to the inch, with 50-foot contours. It is unfortunate that in the short time available for this work it was not possible to complete the mapping of the entire area which should be covered, but plans are under way to accomplish this during the coming field season.

The geologic work in this district was carried on by C. W. Wright, assisted by Sidney Paige, who spent about three months in a detailed examination of the geology and mineral resources of the area. Much attention was given to a close study of the ore deposits as exposed in the rather extensive mining developments of the district. The lack of base maps over the entire area made it impossible to complete the field work, but it is of considerable advantage in the work to be able to revisit some of the localities after the laboratory investigation has been made. A preliminary statement of the results of these investigations is contained elsewhere in this report. (See pp. 98–115.)

At the close of the season Mr. Wright made a hasty trip to the Juneau and other districts, with a view to keeping in touch with the development of the mining industry throughout this part of Alaska. During the last three years he has given special attention to the geology of the ore deposits in southeastern Alaska and the results attained have justified the presentation of a more complete statement of the ore deposits and their relation to the bed-rock geology than has previously been issued. (See pp. 78–97.)

COPPER RIVER REGION.

The first surveys in the Copper River region were made in 1898. This work was continued in 1900, when a geologic reconnaissance of the Chitina Valley was made by F. C. Schrader and A. C. Spencer, and a topographic map of the same area by T. G. Gerdine and D. C. Witherspoon. In 1902 F. C. Schrader and W. C. Mendenhall studied the geology of the northern part of the copper district, while T. G. Gerdine and D. C. Witherspoon executed topographic surveys over the same area. These surveys have been of great value to the mining interests, but in view of the rapid industrial advances in this field it has seemed imperative to supplement them by further investigations of the copper deposits. By so doing the prospector as well as the operator can be furnished with more exact data in regard to the resources and occurrences of mineral deposits, and it also gives opportunity to select the most important areas to be taken up first for detailed investigation.

F. H. Moffit, assisted by A. G. Maddren, was charged with this investigation. The party left Valdez in June and spent the months of July and August and the early part of September in visiting nearly all the prospects of the Kotsina-Chitina copper belt. The latter part of the season was devoted to a study of the geology of the lower part of Copper River. A preliminary account of this investigation is presented in this report (pp. 127–175). The more complete statement is in preparation, and it is hoped that it will be ready for publication about the first of June, and may be issued not later than the first of January, 1909. This later report will contain a topographic map of the lower Copper River region which will be corrected on the basis of the various surveys made in this district for railways and mining developments.

YUKON BASIN.

The systematic surveys begun in the Yukon basin in 1898 have been continued with some interruptions ever since. During 1907 important results were obtained and some large areas were covered by topographic reconnaissance surveys. To L. M. Prindle has fallen the geologic investigations in the general Yukon-Tanana region since 1903. In 1907 Mr. Prindle spent the early part of the season in the study of the geology and mineral resources of the Fortymile region, and reached some important conclusions regarding the distribution and origin of the gold. (See pp. 187–197.) He later visited some of the other mining districts and also studied the section of the Yukon exposed along the Ramparts between Fort Hamlin and the mouth of the Tanana.

Special attention should be here directed to the report which Mr. Prindle has prepared on the distribution and source of the gold in the Yukon-Tanana region. (See pp. 179–186.) His conclusions, though occupying a very few pages, represent the results of extensive field and office studies, and should prove of value to the miner and prospector.

D. C. Witherspoon and J. W. Bagley were charged with the extension of the topographic reconnaissance mapping west of the international boundary and south of the area previously surveyed. They began work the latter part of June near the international boundary south of the Fortymile quadrangle and continued it until about the middle of September, when they went down the

Tanana to Fairbanks by boat. An area of about 6,000 square miles was covered, including practically the entire unmapped belt lying between the Yukon and the Tanana, and extending westward from the boundary as far as the mouth of Delta River. Tanana River from the mouth of the Delta to Fairbanks was also surveyed.

The importance of investigating the water resources in the placer districts having been proved by the work done at Nome in 1907, it was decided to extend similar hydrographic surveys to the Fairbanks district. The funds available for this work were adequate only to prosecute it on a small scale. C. C. Covert reached Fairbanks the latter part of June and spent the balance of the open season in stream measurements in the Fairbanks placer district and in the areas tributary to it. Although the results of one season's investigations can not be considered final in regard to the stream volumes, yet they have value in showing at least the minimum flow for that particular season. Hydrographic data were procured regarding the run-off of about 800 to 1,000 square miles and an area of at least 300 to 400 square miles was surveyed in some detail. Mr. Covert's report is now in print and a brief abstract is presented in another section of this volume. (See pp. 198–205.)

SEWARD PENINSULA.

In view of the complexity of the geology of Seward Peninsula, it is possible to gain an adequate knowledge of the stratigraphic succession only by a large amount of detailed mapping. Such studies alone will furnish information on which to base conclusions regarding the occurrence and distribution of the gold in the bed-rock terranes. During the last two years work of this kind has been carried on in the Nome and Grand Central quadrangles, and in 1907 similar lines of investigation were taken up in the Solomon and Casadepaga areas, where the detailed base maps were also available, by P. S. Smith, assisted by George I. Finlay and F. J. Katz. The entire area of the Solomon quadrangle was completed and the larger part of the Casadepaga also. In addition to this, considerable attention was paid to the economic and mining problems of other mining districts of the peninsula. (See pp. 206–271.)

In accordance with the original plans laid out for investigating the water resources of Seward Peninsula, F. F. Henshaw, assisted by Raymond Richards, was detailed to continue the stream measurements. This work made it possible not only to gain additional information about the streams previously measured, but also to extend this into adjacent areas. Special attention was given to the Kougarok district, and some measurements were also made in other mining districts. A brief statement of the results of this work is given elsewhere in this report (pp. 272–285).

COLLECTION OF STATISTICS.

The Geological Survey is charged by law with the duty of collecting statistics of the mineral production for the entire country. The value of such data has long been fully recognized in the States, where they are depended on by producers, consumers, publishers, and all others who are desirous of obtaining accurate information. Their importance to the various interests of Alaska is incalculable, for it is only on the basis of past production, considered with estimates of the mineral reserves, that the future progress of the mining industry can be forecast.

It is evident that such statistics can have value only provided they are accurate. Though general estimates may have some interest, they can not be relied on as can the accurate statistics which can be made up only from data collected from the individual producers.

The general recognition of these facts by the precious-metal mine operators in the States is attested by the fact that, of the 15,000 to whom schedules are sent, less than 3 per cent fail to reply, and these are, for the most part, the small producers. In Alaska, on the other hand, of the 1,600 placer mine operators to whom the schedules were sent, nearly 60 per cent failed to reply, and among the delinquents were some of the largest companies, who, in all other matters, have shown a great desire to cooperate with the Geological Survey. It is gratifying to record the fact that practically all the Alaska lode-mine operators have shown their interest in the statistical work, for in 1906 all but one furnished the desired information. The same is true of the coal-mine operators and those producing building stone and structural material.

If it were possible to send a representative of the Geological Survey to each one of the gold placer producers, no doubt the information could readily be procured, as then a full explanation of the purposes and the uses to which the figures are put could be made. Unfortunately, however, the conditions of transportation and the funds available for this work do not permit of such procedure. The Survey is, therefore, forced to rely on the courtesy of the individual producer in replying to the schedule sent to him by mail. If the producer does not return the schedule in time to have it included when the statistics are made up, he may, by the amount that he produces (provided there are no other sources of information), reduce the total credited to his district, and thereby nullify the whole purpose of the investigation, which is to obtain accurate figures. That such a procedure has done a grave injustice to Alaska in the past is shown by the fact that in one of the recent years it was discovered that a general estimate published had credited to one of the States $500,000 worth of gold which had been produced in Alaska. Fortunately the mistake was rectified in the publications of the Geological Survey. When accurate returns are obtained from the producers themselves, such a mistake is impossible. It seems probable that this may have happened before, and, unless certain large mining companies modify their practice of refusing information, it will probably happen again and thereby hurt the mining industry of the Territory.

The above criticism applies particularly to the large mining companies and, more especially, to those of Seward Peninsula. This neglect on the part of some of the Nome operators, in the opinion of the writer, is probably due to an oversight rather than to a lack of public spirit, as they have showed a willingness to cooperate with the Geological Survey in other matters. In the Yukon district nearly all the operators to whom blanks were sent have given the desired information, and the writer feels under special obligations to many who have not only returned the schedules promptly, but also furnished lists of other placer-mine operators.

It may be well in this connection to call attention to the fact that the returned schedules are kept under lock and key, and only the few officers of the Geological Survey who make up the totals are allowed access to them. Every precaution is taken to prevent any published figures from giving information, even by inference, of the output of any individual operator. For example, if there are only one or two large producers in a district, the total of that district is not published separately, but is combined with that of another district in the printed report.

The statistics contained in the report for 1907 are based, in part, on estimates, for at this writing not all the schedules have been received from the operators. It is therefore impossible to include the accurate figures in this report. They will, however, be included in next year's volume, just as the accurate statistics of 1906 are included in this report.

It will be the purpose in the future to include, as far as possible, a summary of the mineral production of the Territory in all branches of mining, and it is hoped that before many years the operators will return the schedules so promptly that the correct figures can be given in the annual progress report. If this is not possible, however, they will always find room in the annual report published by the Survey, entitled "Mineral Resources of the United States," and will also appear in the progress report of the following year.

It should be noted that the Survey began collecting statistics from the operators only in 1905, and that previous to that time the statements in regard to production are based entirely on estimates. This holds true of the copper as well as the gold.

PUBLICATIONS ISSUED OR IN PRESS IN 1907.

There have been some unavoidable delays in the publication of some of the reports. This is in part because the stress of other work has prevented authors from completing manuscripts. Another cause of deferred publications is that most of the reports include illustrations whose reproduction, which is done by contract, may require from four to eight months and sometimes even longer. The delay of publications is also due in part to the fact that the funds available for printing have not been adequate for the purpose. For these various reasons the issuing of the reports (now in press) on Seward Peninsula and the Matanuska and Controller Bay regions, has been unavoidably delayed. The publication of the report on the Wrangell and Ketchikan districts has been postponed owing to the fact that the more detailed information gathered in the work of mapping Kasaan Peninsula afforded additional data which it seemed desirable to incorporate, in part at least, in the preliminary report. The following reports were issued during 1907:

REPORTS INCLUDING MAPS.

Administrative report, 1906, by Alfred H. Brooks. Bull. No. 314, pp. 11–19.

The mining industry in 1906, by Alfred H. Brooks. Bull. No. 314, pp. 19–39.

The Alaska coal fields, by G. C. Martin. Bull. No. 314, pp. 40-45.

Lode mining in southeastern Alaska, C. W. Wright. Bull. No. 314, pp. 47-72.

Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. Bull. No. 314, pp. 73-80.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. Bull. No. 314, pp. 82-87.

Petroleum at Controller Bay, by G. C. Martin. Bull. No. 314, pp. 89-102.

Reconnaissance in Matanuska and Talkeetna basins, with notes on placers of adjacent region, by Sidney Paige and Adolph Knopf. Bull. No. 314, pp. 104-124.

The Nome region, by Fred H. Moffit. Bull. No. 314, pp. 126-144.

Gold fields of Solomon and Niukluk River basins, by Philip S. Smith. Bull. No. 314, pp. 146-156.

Geology and mineral resources of Iron Creek, by Philip S. Smith. Bull. No. 314, pp. 157-163.

The Kougarok region, by Alfred H. Brooks. Bull. No. 314, pp. 164-179.

Water supply of Nome region, Seward Peninsula, by J. C. Hoyt and F. F. Henshaw. Water Supply Paper No. 196.

The Circle precinct, by Alfred H. Brooks. Bull. No. 314, pp. 205–226.

MAPS PUBLISHED SEPARATELY.

Reconnaissance map of the southern portion of Seward Peninsula.

Reconnaissance map of the northwestern part of Seward Peninsula.

Reconnaissance map of the northeastern part of Seward Peninsula.

These maps are for sale at 25 cents each, or $15 a hundred.

REPORTS AND MAPS IN PRESS.

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 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; including topographic reconnaissance maps. Bull. No. 337.

Berners Bay special map. Scale, 1 : 62,500. Contour interval 50 feet. Topography by R. B. Oliver.

REPORTS 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 1908, provided the funds for printing are sufficient:

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. 2d edition.

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

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

Physiography and glacial geology of the Yakutat Bay region, Alaska, by R. S. Tarr, with a chapter on the bed-rock geology by R. S. Tarr and B. S. Butler.

The Kotsina-Chitina copper region, by F. H. Moffit and A. G. Maddren.

Chitina quadrangle map, scale 1 : 250,000, by T. G. Gerdine and D. C. Witherspoon.

Controller Bay region special map, scale 1 : 62,500, by E. G. Hamilton.

Description of the Fortymile quadrangle, Yukon-Tanana region, by L. M. Prindle.

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

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

Water-supply investigations in Alaska in 1906–7, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218.

Fairbanks special map, scale 1 : 62,500, by T. G. Gerdine and R. H. Sargent.

Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit, F. L. Hess, and P. S. Smith.

Geology of the Solomon and Casadepaga quadrangles, by P. S. Smith and F. J. Katz.

The Seward Peninsula tin deposits, by Adolph Knopf.

THE DISTRIBUTION OF MINERAL RESOURCES IN ALASKA.

By Alfred H. Brooks.

INTRODUCTION.

All the published reports on Alaska deal, either directly or indirectly, with the distribution of the mineral resources. Most of these reports, however, treat of special areas or special forms of deposits, and an adequate discussion of the entire subject must await a more complete investigation which shall cover not only all of the Territory, but also all the different types of mineral deposits. In the three previously issued summary reports something of the distribution of the mineral wealth has been indicated on small-scale maps. Last year's report contained a map [a] which showed in a general way the areas of metamorphic rocks known to be the loci of gold deposits. The same maps showed the areas of copper-bearing rocks, together with symbols indicating the localities of gold and copper mines and prospects, thus exhibiting in a general way the distribution of these deposits. On another map [b] of the same report was represented the general distribution of the coal-bearing rocks, as well as the areas underlain by workable coal beds, a special symbol being used to indicate the character of the coal. These two maps were elucidated in the text by brief accounts of the distribution of the economically important deposits. Thus the occurrence of the gold deposits in the metamorphic rocks and their probable genetic relation to the igneous intrusions were pointed out. The description of the coal-bearing rocks included a brief account of their stratigraphy, distribution, and area.

This, then, with some briefer statements published in previous reports,[c] represents the first attempt to deal with the general problem

[a] Bull. U. S. Geol. Survey No. 314, 1907, Pl. I.

[b] Op. cit., Pl. II.

[c] See Bull. U. S. Geol. Survey Nos. 259 and 284.

of the distribution and genesis of the mineral deposits of Alaska, the solving of which is the ultimate aim of the investigations here chronicled. Inasmuch as even the preliminary survey of the mineral wealth of Alaska, begun but ten years ago, has been extended over less than a quarter of the Territory, it is needless to state that the data at hand are inadequate to discuss these problems in detail. As, however, it may be of value to the mining interests to present even incomplete matter bearing on the occurrence and distribution of deposits of economic value, it seems best to recur to this subject in the present volume. Fortunately, the occurrence of mineral deposits in the more important mining districts of the Territory—such as southeastern Alaska, the Chitina region, the Yukon-Tanana region, and Seward Peninsula—forms the subject of special papers in this report, and the matter, therefore, need here be only outlined.

MAP SHOWING MINERAL RESOURCES.

The map of Alaska which accompanies this volume (Pl. I, in pocket) shows graphically the known facts of the distribution of the mineral resources. It is based, for the most part, on observations of members of the Geological Survey, but data from other reliable sources have been used regarding some localities which have not been examined by Survey men.

The distribution of the different kinds of mineral deposits is indicated by symbols, so far as the scale of the map would permit. It has not been possible, however, to make the symbols altogether consistent. The symbol for gold placers is intended to mark the localities where placer gold has been found in commercial quantities, and for the most part it indicates only those places where actual mining has been done. The symbol for auriferous lodes indicates chiefly the operating mines, but includes some prospects which have not yet been productive. The symbol for copper marks the mine localities, as well as some prospects. The symbol for tin deposits indicates chiefly prospects, though some of these have been small producers.

The fact that the geology of coal is much simpler than that of the metalliferous deposits makes it possible to present more facts in regard to its distribution and to present these with a far greater degree of confidence. On the map the occurrence of sediments belonging to the horizons of the coal-bearing rocks is indicated by stippling. These areas can be regarded as the most promising fields for coal prospecting, but should not be taken to indicate the actual distribution of workable coal seams. The areas known to carry coal, probably in workable beds, are marked in black with a letter indicating the quality of the coal.

The location of petroleum seepages is also indicated on the map. All the known seepages occur on the Pacific coast. At Controller Bay there have been two wells which have made a small production of oil.

To make this map complete as regards mineral deposits which have been productive, the localities in southeastern Alaska where there has been an output of gypsum and marble have been marked. These, however, only include the localities of actual production, and the map must not be interpreted as indicating that there are no other occurrences of such deposits in Alaska.

COMMERCIALLY IMPORTANT MINERALS.

The variety of known minerals found in Alaska is too large to permit their being catalogued in this paper, nor would it be possible even to list all those which give promise of becoming of commercial value. It will be the purpose here to briefly set forth a statement of the minerals which thus far either have been produced in commercial quantities or give some promise of soon being added to the commercial products of the Territory.

The output of Alaska includes the metals gold, silver, copper, lead, and tin, and the nonmetallic minerals coal, petroleum, gypsum, and marble. In addition to these, iron, tungsten, antimony, quicksilver, and graphite deposits have been found, which may prove to have commercial importance.

Gold is both the most widely distributed and by far the most important of the minerals yet developed. It occurs in combination with silver and other impurities in the alluvium. The auriferous lodes include both free-milling and concentrating ores. Tellurides have been found, but not in commercial quantities. A few grains of platinum have been found in some of the gold placers, but nowhere in commercial quantities. Silver occurs in association with the gold, both in the lodes and placers. Silver-bearing galena deposits are widely distributed, but have been but little developed.

The developed copper deposits are for the most part sulphides and are chiefly chalcopyrite and bornite. Other copper sulphides, carbonates, and oxides have been found, but these have so far been of less importance. Native copper has been found both in placers and lodes in the Copper and White River basins, but this form of deposit has not been productive up to the present time.

Tin occurs in the form of cassiterite in the York district of the western part of Seward Peninsula and in smaller quantities in other parts of Alaska. In the York region (see p. 251) some stannite has also been found, but the chief tin-bearing mineral is cassiterite. The occurrences are in placers and lodes, both forms of deposits having yielded a small production.

There has been a small output of lead from the galena-bearing ores which have already been mentioned. Antimony occurs as stibnite, and some prospecting is going on for this mineral. Tungsten occurs in scheelite and wolframite, the former having been found in association with the placer gold and the latter in lodes in association with cassiterite. (See p. 263.) Among other metalliferous minerals which have been found in small quantities are bismuth and molybdenum. Mercury occurring as cinnabar has been found both in placers and in veins. None of these minerals is known to occur in commercial quantities.

Magnetite occurs in large bodies on Prince of Wales Island and elsewhere in association with some chalcopyrite deposits. Some of it is reported to be a good Bessemer ore, but no attempts have been made to mine it except for its copper content.

Of the nonmetallic minerals the fuels are of most importance. Peat is the most widely distributed of mineral fuels, but no investigations have been made to determine the commercial value of the deposits.

Lignitic coal is extensively developed in many parts of Alaska and has been mined at a dozen localities. Bituminous and subbituminous coals occur at widely separated localities and have been developed in a small way. Anthracites and semianthracites have thus far been discovered only in the Pacific slope region. The following table, taken from Mr. Martin's report,[a] gives a concise summary of the composition of these coals:

[a] Martin, G. C., Bull. U. S. Geol. Survey No. 314, 1907, p. 45.

Analyses of Alaska coal.

[Compiled from United States Geological Survey reports.]

	District and kind of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.
	ANTHRACITE.						
1	Bering River, average of 7 analyses	7.88	6.15	78.23	7.74	1.30	12.86
2	Matanuska River, 1 sample	2.55	7.08	84.32	6.05	.57	11.90
	SEMIBITUMINOUS.						
3	Bering River, coking, average of 11 analyses	4.76	13.27	74.84	7.12	1.51	5.68
4	Cape Lisburne, average of 3 analyses	3.66	17.47	75.95	2.92	.93	4.46
5	Matanuska River, coking, average of 16 analyses	2.71	20.23	65.39	11.60	.57	3.23
	BITUMINOUS.						
6	Lower Yukon, average of 11 analyses	4.68	31.14	56.62	7.56	.48	1.90
	SUBBITUMINOUS.						
7	Matanuska River, average of 4 analyses	6.56	35.43	49.44	8.57	.37	1.40
8	Koyukuk River, 1 sample	4.47	34.32	48.26	12.95		1.40
9	Nation River, 1 sample	1.39	40.02	55.55	3.04	2.98	1.39
10	Alaska Peninsula, average of 5 analyses	2.34	38.68	49.75	9.22	1.07	1.30
11	Cape Lisburne, average of 11 analyses	9.35	38.01	47.19	5.45	.35	1.24
12	Anaktuvuk River, 1 sample	6.85	36.39	43.38	13.38	.54	1.20
	LIGNITE.						
13	Port Graham, 1 sample	16.87	37.48	39.12	6.53	.39	1.04
14	Southeastern Alaska, average of 5 samples	1.97	37.84	35.18	24.23	.57	1.02
15	Wainwright Inlet, 1 sample	10.65	42.99	42.94	3.42	.62	1.00
16	Colville River, 1 sample	11.50	30.33	30.27	27.90	.50	1.00
17	Upper Yukon, Canadian, average of 13 analyses	13.08	39.88	39.28	7.72	1.26	.99
18	Upper Yukon, Circle province, average of 3 analyses	10.45	41.81	40.49	7.27	1.30	.97
19	Upper Yukon, Rampart province, average of 6 analyses	11.42	41.15	36.95	10.48	.33	.91
20	Seward Peninsula, 1 sample	24.92	38.15	33.58	3.35	.68	.88
21	Chitistone River, 1 sample	1.65	51.50	40.75	6.10		.79
22	Kachemak Bay, average of 6 analyses	19.85	40.48	30.99	8.68	.35	.77
23	Cantwell River, 1 sample	13.02	48.81	32.40	5.77	.16	.66
24	Kodiak Island, 1 sample	12.31	51.48	33.80	2.41	.17	.66
25	Unga Island, average of 2 analyses	10.92	53.36	28.25	7.47	1.36	.62
26	Tyonek, average of 4 analyses	8.35	54.20	30.92	6.53	.38	.58
27	Chistochina River, 1 sample	15.91	60.35	19.46	4.28		.32

1. Bull. No. 284, p. 74, analyses 1 to 7.
2. Bull. No. 284, p. 98, analysis 1.
3. Bull. No. 284, p. 74, analyses 10 to 20.
4. Bull. No. 278, p. 47, analyses 13 to 15.
5. Bull. No. 284, p. 98, analyses 2 to 17.
6. Bull. No. 218, pp. 62, 63, analyses 26, 28 to 38.
7. Bull. No. 284, p. 98, analyses 18 to 21.
8. Bull. No. 218, p. 62, analysis 28.
9. Bull. No. 218, p. 62, analysis 17.
10. Bull. No. 284, p. 27.
11. Bull. No. 278, p. 47, analyses 1 to 7, 9 to 12.
12. Prof. Paper No. 20, p. 114, analysis 607.
13. Bull. No. 259, p. 170.
14. Bull. No. 284, p. 27.
15. Prof. Paper No. 20, p. 114, analysis 653.
16. Prof. Paper No. 20, p. 114, analysis 620.
17. Bull. No. 218, pp. 61, 62, analyses 3 to 15.
18. Bull. No. 218, p. 62, analyses 16, 18, 19.
19. Bull. No. 218, p. 62, analyses 20 to 25.
20. Bull. No. 247, p. 67.
21. Prof. Paper No. 41, p. 125.
22. Bull. No. 259, p. 170, analyses 3, 4, 7 to 10.
23. Bull. No. 218, p. 62.
24. Bull. No. 259, p. 170.
25. Bull. No. 259, p. 170.
26. Twentieth Ann. Rept., pt. 7, p. 23, analyses 1 to 4.
27. Prof. Paper No. 41, p. 124.

There has been a small production[a] of petroleum from one of the Alaska fields which has been used locally, but the industry is not on a commercial basis. The following extract from a report by Mr. Martin[b] shows the character of the petroleum:

Controller Bay petroleum.—A sample of the petroleum from the well near Katalla has been tested by Penniman & Browne, of Baltimore, with the following results.

[a] Amount unknown.

[b] Martin, G. C., The petroleum fields of the Pacific coast of Alaska: Bull. U. S. Geol. Survey No. 250, 1905, pp. 57–59.

Test of petroleum from Katalla.

Specific gravity	(0.828 at 15.5° C.) 39.1° B.
Distillation by Engler's method:	
Benzine (80°–150° C.)	21%, 54.9° B. (0.7573)
Burning oil (150°–300° C.)	51%, 40.6° B. (0.8204)
Residuum (paraffin base)	28%, 23.9° B. (0.9096)
Sulphur	Trace.

The burning oil was purified by concentrated sulphuric acid and soda, the volume of acid used up being too small to measure. The purified burning oil was put into a small lamp, where it burned dry without incrusting the wick or corroding the burner, and without any marked diminution of flame. The burning oil compares very favorably in these respects with Pennsylvania oil prepared in the same way.

The following analysis of this petroleum was published by Mr. Oliphant:[a]

Analysis of petroleum from Katalla Bay well.

Specific gravity at 60° F., 0.7958, equal to 45.9° Baumé.

Cold test did not chill at 3° F. below zero.

	Per cent.
Distillation below 150° C., naphtha	38.5
150° to 285° C., illuminating petroleum	31
Above 285° C., lubricating petroleum	21.5
Residue, coke and loss	9
Total	100

The results of the tests may be compared with those of other petroleums in the following table:

Tests of petroleum from Alaska and other fields.

	Alaska.[a]	Alaska.[b]	Pennsylvania.[c]	Ohio.[d]	Colorado.[e]	Mexico.[f]	Beaumont, Tex.[g]
Benzine (80°–150° C.)	21	38.5	16.5	10	16	10	2.5
Burning oil (150°–300° C.)	51	[h] 31	54	50	40	60	40
Residuum	28	[h] 30.5	29	40	44	30	57.5
Sulphur	Trace.						1.7
Gravity	39.1° B.	45.9° B.			43° B.		22° B.

[a] Penniman & Browne for this report.
[b] Oliphant, F. H., The production of petroleum in 1902: Mineral Resources U. S. for 1902, U. S. Geol. Survey, 1903, p. 583.
[c] Peckham, S. F., Report on Petroleum, p. 365.
[d] Woodman, Durand, Jour. Am. Chem. Soc., vol. 13, p. 168.
[e] Oliphant, F. H., Petroleum: Mineral Resources U. S. for 1901, U. S. Geol. Survey, 1902, p. 560.
[f] Stillman, T. B., Engineering Chemistry, p. 364.
[g] Hayes and Kennedy, Oil fields of Texas-Louisiana coastal plain: Bull. U. S. Geol. Survey No. 212, 1903, pp. 146–151.
[h] See above.

The petroleum is clearly a refining oil of the same general nature as the Pennsylvania petroleum. It resembles the latter in having a high proportion of the more volatile compounds and a paraffin base and in containing almost no sulphur. The proportions of the several constituents given in the table above do not necessarily represent the full amounts that could be obtained in practice by different treatment.

[a] The production of petroleum in 1902: Mineral Resources U. S. for 1902, U. S. Geol. Survey, 1903, p. 583.

Oil Bay and Cold Bay seepages.—Samples of the seepage petroleum from Oil Bay and Cold Bay have been collected by the writer. They were obtained by skimming the petroleum from the surface of the pools of water, where it was continually rising from the bottom of the pool. An effort was made to obtain as much of the fresher oil as possible. Vegetable and earthy impurities were removed by straining through coarse cloth. Water could not be entirely removed. Oil for lubricating purposes at the neighboring wells is obtained from these pools in this manner.

The fresher oil is dark green. That which has remained on the surface of the pool for some time is dark brown.

The oil has doubtless lost a large part of its volatile constituents. The analyses therefore do not represent the composition which could be expected of the live oil from wells in this region. Such oil would have a lower specific gravity, higher percentage of the more volatile constituents, and lower percentage of the less volatile constituents, residue, and sulphur. It would certainly be better than these samples in all respects, and would resemble them in having a paraffin base. It might not be of so high quality as the Controller Bay petroleum, but nevertheless it would be a refining oil.

The samples were submitted to Penniman & Browne, of Baltimore, who return the following report on their tests:

Tests of samples of seepage petroleum from Oil Bay and Cold Bay.

	Oil Bay.	Cold Bay.
Specific gravity at 60° F	0.9557 (16.5° B.)	0.9547 (16.6° B.)
Distillation by Engler's method:		
Initial boiling point	230° C	225° C.
Burning oil (distillation up to 300° C., under atmospheric pressure)	13.2% (29.5° B.)	13.3% (29.6° B.)
Lubricating oils (spindle oils) (120 mm. pressure, up to 300° C.)	39.2% (22.6° B.)	28.3% (23.8° B.)
Lubricating oils (120 mm. pressure, 300° C.-350° C.)	19.6% (17.9° B.)	18.3% (18° B.)
Paraffin oils (by destructive distillation under atmospheric pressure)	22.4% (20.4° B.)	32.0% (20.4° B.)
Coke and loss	5.6%	8.1%
Total sulphur	0.098%	0.116%

The distillation of the lubricating oils under diminished pressure, corresponding to refinery practice, was carried on until signs of decomposition set in. The resulting residue was unsuitable for making cylinder stock, and was therefore distilled for paraffin oils. These paraffin oils contain a considerable quantity of solid paraffin. It was not practicable to determine the amount of the material with the small amount of oil at our disposal.

The iodine absorption of the oils and distillates has been determined by Hanus's method (solution standing four hours), and is here tabulated:

	Oil Bay.	Cold Bay.
Burning oil	17.8% iodine	17.2% iodine.
Lubricating oil	26.2% iodine	27.2% iodine.
Heavy lubricating oil	35.8% iodine	35.2% iodine.

These iodine numbers upon the lubricating oils were obtained upon the samples. For comparison, samples of similar oils were obtained from the Standard Oil Company, and the iodine numbers determined as follows:

Light distilled lubricating oil (spindle oil) .... 32% iodine
Dark lubricating oil (engine oil) .... 45.4% iodine

The burning oils were tested in a small lamp and found to give a good flame. All the oil was consumed without incrusting the wick or corroding the burner.

The sample of crude oil from Cold Bay was distilled in such a way as to give the maximum yield of burning oil; under these conditions 52.2 per cent of fair quality burning oil was obtained.

The oils are entirely similar; both have paraffin bases, and the products of distillation are "sweet." We are informed that these samples are "seepage oils." If a sufficient yield can be obtained by drilling, a very suitable oil for refinery purposes may be expected, containing a very much larger quantity of the more desirable lighter products.

Of the other nonmetallic deposits, marble and gypsum have been developed and graphite and mica[a] are said to occur in commercial quantities.

Asbestos has been found by Mr. Prindle in the Yukon-Tanana region about 100 miles southeast of Fairbanks and about 20 miles north of Tanana River. A basic dike composed mostly of serpentine cuts the granitic gneisses at this locality and contains small stringers of asbestos up to about 6 inches in width, so far as observed. The dike is several hundred feet wide and apparently of considerable extent. Weathered fibrous masses of the asbestos were found at several places in crossing the dike. There are other dikes of similar character in the same general area, but at no other locality was asbestos observed. The region was only hastily traversed. It is remote and unprospected, and whether asbestos is present in quantities of economic importance has not been determined. It is apparently a favorable area for prospecting for this mineral.

Mention should be made of potable mineral waters which have been exploited in a small way in southeastern Alaska. Hot springs are not uncommon in most of the mining districts, but no investigation has been made of the composition of the waters.

GEOLOGIC OCCURRENCE AND GEOGRAPHIC DISTRIBUTION OF MINERAL DEPOSITS.

In general, it may be said that the Alaska gold deposits are associated with metamorphic rocks, chiefly of lower Paleozoic or pre-Paleozoic age. In several localities auriferous Mesozoic rocks have been found, and there may be some gold deposits which are as late as Tertiary. The copper deposits are in association with Paleozoic (probably chiefly Devonian and Carboniferous) and Mesozoic terranes, with some that may be of Tertiary age. Other metalliferous lode deposits besides those of gold and copper occur in a similar association. In many places there has been found an intimate relation between intrusives (chiefly granitic and especially those of Mesozoic age) and the metal-bearing veins.

[a] See p. 116 of this bulletin.

The lignitic coals of Alaska occur chiefly in strata which have been correlated under the general name Kenai formation and are probably, for the most part, Eocene in age. Lignitic and subbituminous coals are found in rocks of upper Cretaceous age, and Jurassic terranes (upper) have also been found to carry some low-grade bituminous coals. The high-grade bituminous and anthracite coals occur chiefly in Tertiary rocks, provisionally assigned to the Miocene; but Carboniferous formations (chiefly Mississippian) are known to carry bituminous coals locally. The petroleum seepages of Controller Bay are found in Tertiary rocks, but the source of the oil is probably in strata of older horizons. In the Cook Inlet field the petroleum seepages are from Mesozoic (Jurassic) sediments. Both the marble and the gypsum deposits are of Paleozoic age.

In view of the close association of the gold deposits with the metamorphic rocks and their probable genetic connection with the intrusives, it becomes important to consider the distribution of these two kinds of rocks. This matter was discussed at some length in the Progress Report of last year.[a] It was there shown that there are three fairly well defined belts of metamorphic rocks in Alaska, and to these should now be added some smaller outlying zones of the main belts. One, skirting the Pacific seaboard, stretches through southeastern Alaska, probably occurs in the St. Elias Range, and has been recognized on lower Copper River, in Kenai Peninsula, and on Kodiak Island. The St. Elias Range has not been traversed, but the presence of metamorphic rocks is inferred from what is known of the geology along both margins, and that they are mineralized is indicated by the fact that the alluvium derived from them is locally auriferous. This zone of metamorphic rocks is known to include rocks belonging to the Paleozoic, from the Silurian to the Carboniferous; it may include older sediments, and, as defined, probably embraces some Mesozoic beds.

In southeastern Alaska the metamorphic rocks, chiefly of Paleozoic age, are bounded on the east by the great granitic batholiths of the Coast Range, and stocks of similar rocks are abundant in the coastal fringe of islands. Granitic and granodioritic intrusives are also known to occur in the St. Elias Range. In the Prince William Sound and Kenai Peninsula region intrusives are also present, but apparently are not so common as in the eastern and southern parts of the belt. An extension of the Coast Range intrusives has also been traced along the eastern margin of the St. Elias Range, through Canadian territory, and into the Nutzotin Mountains, which form the easterly extension of the Alaska Range. This zone is represented by isolated stocks, marking one general axis. It is probably safe to conclude that the intrusive masses of the Alaska Range are of the same age. If this

[a] Bull. U. S. Geol. Survey No. 314, 1907, pp. 22–26.

is true, the granites reported in the Iliamna and Lake Clark region probably belong to the same period of igneous activity.

In another section of this report (pp. 81–85) Mr. Wright points out the close association and genetic relation of the ore bodies and the granitic intrusives in southeastern Alaska. This holds both for the copper and gold deposits. The good exposures and accessibility of this region and the relatively large amount of prospecting and mining done have made it possible to trace out certain zones of mineralization which are the loci of the commercial ore bodies. Less work has been done by both the prospector and the geologist in the Prince William Sound region, so that the geographic distribution and the genetic relations of the ore bodies are still obscure; and in Kenai Peninsula the problems connected with the bed-rock source of the placer gold are practically entirely unsolved.

On tracing the eastern line of intrusion it is found that the Rainy Hollow copper district and the Kluane copper and gold deposits, both in Canada, probably bear a relation to the granitic rocks similar to that shown by those of southeastern Alaska. To pass still farther westward, what is known of the geology of the Chistochina placer district[a] and inferred of the Valdez Creek placers suggests a causal relation between the intrusives and the bed-rock source of the gold. Similar conditions may hold in the Alaska Range, where the same types of rocks are found in association, and gold has been found on both margins of the mountains, namely, in the Bonnifield and Kantishna districts on the north and in the Yentna district on the south.

This belt of altered sediments along the Pacific coast, with its northern arm skirting the upper part of the Copper River basin and extending into the Alaska Range, is, then, a locus of mineral deposits which, in part at least, bear a genetic relation to the intrusives. The facts presented show that the mineralization is widespread, but it is not intended to imply that the entire belt carries workable ore bodies. In fact, the studies of Mr. Wright in southeastern Alaska clearly show that the mineralization there follows certain zones lying within the metamorphic belt and that the position of these zones is determined by the intrusive mass.

The two zones of copper-bearing rocks which lie north and south of the Wrangell Mountains belong to this same general province, but the type of mineralization appears to be different from those above described. As Mr. Moffit (see p. 135) points out, the southern or Kotsina-Chitina belt lies at the contact of a greenstone and an overlying Mesozoic limestone, and the same probably holds true of the northern or White-Nabesna belt. It is probable that in the north-

[a] Mendenhall, W. C., The geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41, 1906.

ern area some of the Tertiary lavas are also copper bearing. It will require much more field investigation to determine the geologic relation of these inland copper districts than to reach similar results for the coastal zone.

A second belt of metamorphic rock, locally auriferous, lies inland, stretching through the Yukon-Tanana region from the international boundary, and may be extended to the southwest toward the Bering Sea. The recently discovered auriferous gravels on the lower Yukon and in the Innoko region (see pp. 47–49) may lie in a southwesterly extension of this belt of metamorphic rocks. The sediments of this zone are of various ages, but schists of pre-Ordovician age and Devonian limestones, greenstones, and slates predominate, though Silurian, Carboniferous, and Mesozoic rocks are also present. (See p. 180.) Granite and other intrusives are not uncommon.

Within this belt there are a number of important placer fields; in fact, from a scientific standpoint, all of the alluvium included in it is more or less auriferous. Mr. Prindle describes this field in another part of the report (see p. 184) and suggests a possible genetic relation between the intrusives and the source of the metals. It is of interest to note that some of the Mesozoic slates included in this zone are mineralized and that the intrusives are in part of Mesozoic age, all of which suggests an analogy to the deposits of the coastal belt, though much more work will have to be done before the geologic relation of the two can be established.

A third belt of metamorphic rocks lies north of the Yukon and south of the Endicott Mountains, which separate the basin of that river from the Arctic slope. These rocks stretch westward and, traversing the Kobuk Valley, are probably continued in the altered Silurian and older sediments which make up the larger part of Seward Peninsula. Within this belt placer gold has been found in the Koyukuk, Chandalar, and Kobuk valleys and over much of Seward Peninsula. The occurrences of metalliferous lodes in Seward Peninsula are discussed elsewhere in this volume by Mr. Smith and Mr. Knopf (pp. 206–271). The age of the mineralization in this region is unknown, but it seems possible, at least, that it belongs to the same period as that of the Yukon.

Although the gold and copper deposits thus far developed lie for the most part in the zones of metamorphic rocks (chiefly of Paleozoic age) above described, yet there are some other types of ore bodies which seem to fall into a different category. The occurrence of copper in the Tertiary lavas of the White-Nabesna belt has been already referred to. In Alaska Peninsula and the adjacent islands some auriferous lodes have been found in lavas which may be Tertiary and are certainly no older than the Mesozoic. One deposit of this kind, the Apollo mine on Unga Island, has been a large producer, and some recent lode discoveries in Alaska Peninsula appear to give promise of being of commercial importance. An auriferous quartz vein has also been found on Unalaska Island, but has not proved to be extensive enough for profitable exploitation. It is worthy of note that stocks of granitic rocks are reported in this province, and it is not impossible that here, too, the ore bodies may have a genetic relation to the intrusives.

As the coal resources of Alaska were discussed at some length by Mr. Martin in last year's report,[a] it will not be necessary to do more than briefly outline the subject here. The map (Pl. I, in pocket) shows that coal-bearing rocks are widely distributed, but that there is no one field which is comparable in size to many of those in the States. Mr. Martin has computed the entire area of the known Alaskan coal fields to be 12,644 square miles, which is about the same as that of the bituminous field of Pennsylvania. Two facts should be borne in mind in connection with these figures: (1) In more than half of this area the coal is lignitic and (2) there is a strong probability that large coal fields exist in the unexplored portions of northern Alaska. Of the 12,644 square miles of coal-bearing rocks only about 10 per cent are known to carry workable coal seams, the balance being practically unprospected. The Controller Bay and Matanuska fields, aggregating about 100 square miles of land underlain by workable coals, are the only areas containing fuels of the highest grade which have thus far been found in the Territory. The Cape Lisburne fields, however, carry a fairly good grade of bituminous coal, and it may be found to extend much farther eastward than is indicated on the accompanying map.

The known petroleum-bearing areas are confined to the Pacific coast regions of Alaska. One is at Controller Bay, with an eastern extension at Yaktag; the other lies along the margin of Alaska Peninsula. At both these localities there are strong seepages, and at Controller Bay two wells have been drilled which have made a small production.

The marble thus far developed occurs in the Paleozoic rocks of southeastern Alaska. Quarries have been opened at three localities, and there is a probability of marble being found at other places in this part of the Territory. Gypsum deposits have been found in the Carboniferous rocks of Chichagof Island, but are not known elsewhere in the Territory. Granite is widely distributed, and in the coastal belt of the Territory may have a future value as a building stone.

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[a] Bull. U. S. Geol. Survey No. 314, 1907, pp. 40-46.

THE MINING INDUSTRY IN 1907.

By Alfred H. Brooks.

INTRODUCTION.

The year 1907 witnessed a marked advancement in the mining industry as a whole throughout Alaska, though the statistics show a falling off in both the gold and the copper production. The former is due to certain labor difficulties at Nome and Fairbanks, and the latter to the general depression in the copper-mining industry prevalent throughout the country. Had it not been for these setbacks, the mineral output of Alaska for 1907 would have exceeded that of 1906. Considering the conditions, the production, as shown in the following table, is large.

Mineral production in Alaska, 1906–7.

	1906.		1907.		Increase (+) or decrease (−).	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold.........ounces..	1,066,033	$22,036,794	[a] 966,146	$19,600,000	− 99,884	−$2,436,794
Silver.........do....	203,500	136,345	[a] 186,271	111,963	− 16,229	− 24,382
Copper.......pounds..	5,871,811	1,133,260	[a] 5,200,000	1,040,000	−671,811	− 93,260
Tin..........	....	38,640	....	[a] 20,000	....	− 18,640
Coal......short tons..	5,541	17,974	5,150	27,850	− 391	+ 9,876
Marble and gypsum...	....	11,995	....	71,958	....	+ 59,963
		23,375,008	....	20,871,771	....	− 2,503,237

[a] Preliminary estimates.

Though the year 1907 shows a falling off of two and a half million dollars in the value of the mineral production as compared with 1906, yet it must be remembered that much of the advancement in the mining industry can not be expressed in terms of statistics of production. This is especially the case in a new land like Alaska, where a very great amount of unproductive preliminary work must be done before large mining plants can be installed. The following table shows the total value of the mineral production since the first placers were opened up in 1880. The value of the mineral output in 1880 is estimated at $20,000; that of 1907 at over $20,000,000, or nearly three times the purchase price of the Territory.

Value of total mineral production of Alaska, 1880–1907.

By years.				By substances.	
1880–1890	$1,686,714	1900	$8,238,294	Gold	$123,185,494
1891	916,920	1901	7,007,398	Silver (commercial value)	1,059,468
1892	1,096,000	1902	8,400,693	Copper	3,436,779
1893	1,053,570	1903	8,941,614	Tin	92,640
1894	1,305,257	1904	9,567,535	Coal	270,329
1895	2,386,722	1905	16,477,742	Marble and gypsum	87,507
1896	2,980,087	1906	23,375,008		
1897	2,538,241	1907	20,837,861		128,132,217
1898	2,585,575				
1899	5,703,076		128,098,307		

In 1907 notable advances were made in the development of the copper mines of the Ketchikan district and in certain features of gold mining in the Juneau district. To the west there has been great activity in the construction of railways to reach the Controller Bay coal fields and the Kotsina-Chitina copper district. On Prince William Sound there has been much prospecting, and several of the mines have made shipments. There has also been considerable prospecting on gold and copper lodes in Kenai and Alaska peninsulas. Mining has continued in the Yentna district, which still appears to be a field of small operators. Systematic prospecting has been continued in the Matanuska coal field, and considerable work has been done on the Alaska Central Railway from Seward, the completion of which will render both the Matanuska and the Yentna districts more accessible.

In the Yukon basin great activity has been shown in the Fairbanks district, where the railroad has been extended and a number of new creeks have been opened up. In the Fortymile region several dredges have been installed, and several ditches have been built in the Circle and Rampart districts. The only verified discoveries of the year were the Innoko and Chandalar placer fields. In the latter part of 1907, however, an important discovery of placer gold was reported from the Koyuk district, but at this writing the news remains unverified. In Seward Peninsula the advancements have been along the lines of developing placer deposits already prospected, but there has also been considerable prospecting for lode deposits.

TRANSPORTATION.

The high cost of transportation is still the most serious problem which confronts the Alaskan miner. Although the conditions in southeastern Alaska and other portions of the Pacific seaboard leave little to be desired, and the water rates to Nome are comparatively low, yet, when the coastal region is left behind, all mining operations have to pay a heavy tax to transportation. This affects not only the material and supplies used in mining, but also the labor. As in most Alaska placer camps there is a much larger demand for labor in summer than in winter, the annual influx of a large number of miners in summer should be encouraged. Unfortunately, the cost of transportation to many of the interior camps has, up to the present time, been so high as to discourage laboring men from going into the interior for the short summer season, in spite of the high wages which are paid. A movement is now on foot in Fairbanks to rectify these conditions somewhat, but the problem can never be adequately solved until the Yukon districts are connected with the Gulf of Alaska by a railway.

In Seward Peninsula there has been no railway construction additional to what was reported last year. At Fairbanks, however, about 20 miles of railway were added to the Tanana Valley system and practically all the creeks are now connected by railway with water transportation on the Tanana.

The Alaska Central Railway continued construction during the year 1907, but owing, it is said, to financial conditions, not many miles of track were laid down. The railway still lacks nearly 100 miles of reaching the Matanuska coal fields. The railway situation at Copper River is treated by Mr. Moffit in another part of this report. It appears that in this part of Alaska there has been a lack of a systematic plan in the choice of a coast terminal or of a route inland, and this fact, together with rivalry between conflicting interests, has seriously retarded construction.

Some of the most important work that the Federal Government is doing in Alaska to further commercial advancement is the construction of wagon roads, carried on under the direction of Maj. W. P. Richardson. In his report for 1907[a] Major Richardson states that about 90 miles of wagon road, 251 miles of sled road, and 118 miles of trail were constructed during the year. This makes the total to date 165 miles of wagon road, 242 miles of trail, and 384 miles of sled road.

METAL MINING.

INTRODUCTION.

Though the statistics of production show a decided decrease in the output of metals in 1907 as compared with 1906, yet the industry as a whole showed a healthy growth. As in previous years, by far the greater part of the value of the output was in the gold, most of which came from placers. It is estimated that the value of placer-gold production in 1907 was $16,400,000, as compared with a production of $3,200,000 from the lode mines. The following table[b] presents a summary of the metal production since mining began in 1880:

[a] Ann. Rept. War Dept., fiscal year ended June 30, 1907.

[b] A statement of the method of collecting statistics will be found on p. 14.

Production of gold, silver, and copper in Alaska, 1880–1907.

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				
1884	9,728	201,000	10,320	$11,146		
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	2,831,000	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	250,000	40,000
1901	335,369	6,932,700	47,900	28,598		
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	966,146	19,600,000	186,271	111,963	5,200,000	1,040,000
	5,739,026	123,185,494	1,713,646	1,059,468	19,734,566	3,436,779

NOTE.—Gold and silver production for 1880–1904 based on estimates of the Director of the Mint; for 1907, 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 1907, preliminary estimate. Copper values are based on averages for year.

In the absence of detailed information regarding the source of the metal production for 1907, it may be of interest to consider that of 1906, as shown in the following table:

Source of gold, silver, and copper in Alaska in 1906, by kinds of ore.

Ores.	Gold.		Silver.		Copper.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.	Quantity (pounds).	Value.
Siliceous ores	162,005.12	$3,348,943	23,529	$15,765		
Copper ores	3,911.17	80,851	27,861	18,666	5,871,811	$1,133,260
Placers	900,113.62	18,607,000	114,678	76,835		
	1,066,029.91	22,036,794	[a] 166,068	111,266	5,871,811	1,133,260

[a] This amount of silver is from mine returns. In other tables the silver production shown is from figures arrived at by agreement with the Director of the Mint.

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. 14.) The production from the Pacific coast belt is, for the most part, from the lode mines of southeastern Alaska, for the placers from this region now yield less than $100,000 annually. The gold credited to the Cook Inlet and Copper River region is all from placers and includes the production of the Nizina, Chistochina, Sunrise, and Yentna districts. The gold output from Seward Peninsula and the Yukon basin[a] is nearly all from placers, there being only one lode mine on a productive basis.

Value of gold production of Alaska, with approximate distribution, 1880–1907.

Year.	Pacific coastal 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		1,038,000
1994	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	9,160,000
1905	3,430,000	500,000	6,900,000	4,800,000	15,630,000
1906	3,454,794	332,000	10,750,000	7,500,000	22,036,794
1907	3,100,000	200,000	9,300,000	7,000,000	[a]19,600,000
	40,520,194	3,267,000	35,081,000	44,262,700	123,185,494

[a]Preliminary estimate.

COPPER AND GOLD LODES.

The productive lode deposits include those of gold, silver, copper, and tin. During 1907 some small shipments of antimony ore were made. In 1907 there were twelve gold and silver mines on a productive basis, as compared with thirteen gold and silver mines in 1906. Fifteen copper mines made some shipments of ore in 1907, as compared with fourteen in 1906. It should be added, however, that the depression in the copper-mining industry led to the closing down of most of the copper mines in August and September, 1907. There was, however, a marked activity in prospecting for copper lodes in various districts. The statistics of tonnage and values for 1907 not having been made up, it seems best to make the following quotation in relation to the production of 1906:[b]

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

[b] Mineral Resources U. S. for 1906, U. S. Geol. Survey, 1907, p. 137.

The tonnage of all the lode mines of Alaska in 1906 was 1,510,185 short tons, an increase of 87,670 tons over 1905. Of siliceous ores 1,404,456 tons were mined, of which 1,353,286 tons must be credited to the Treadwell group of mines on Douglas Island, near Juneau, leaving only 51,170 tons as the product of the other gold-quartz mines. The average gold and silver extraction from all siliceous ores was $2.40 per ton. For the 51,170 tons of the siliceous ores other than those from the Treadwell group, it was $4.58 per ton. A total of 105,729 tons of copper ores yielded an average of $0.94 per ton of gold and silver, and copper to the amount of 2.77 per cent. The copper percentage in Prince William Sound was estimated at 3.69. It may be noted from the tables that the content of silver in siliceous ores is less than 1 per cent of the value of the ore.

The production of tin in Alaska since it was first mined in 1902 is shown in the following table. Most of this production is from placer mines, of which two were in operation in 1907.

Value of production of tin in Alaska, 1902–1907.

1902	[a] $8,000
1903	[a] 14,000
1904	[a] 8,000
1905	[a] 4,000
1906	38,640
1907	[b] 20,000
	92,640

The advances made in the productive lode-mining districts are fully set forth in the local reports included in this volume. As in the previous year, the most notable advances in lode mining were the developments in the copper deposits of the Ketchikan district and in the auriferous deposits of the Juneau district. Prince William Sound also was the scene of much mining activity. As yet these are the only fields of extensive lode mining. The total value in 1907 of the metal production from the mines of southeastern Alaska is estimated at $4,100,000; that from Prince William Sound less than $200,000.

Mr. Moffit shows (see pp. 127–178) that much attention was paid to the copper deposits of the Kotsina-Chitina belt. Current reports indicate that about 300 men were engaged during the summer months in prospecting the northern copper field, extending from White River westward to the Nabesna, a westerly fork of the Tanana. The inaccessibility of the region has made it difficult to procure supplies and material necessary for systematic prospecting. In this field both sulphide and native copper deposits have been found. During the last year, however, considerable stripping and some open-cut work was done.

[a] Estimated.

[b] The value for 1907 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.

In the region lying adjacent to Cook Inlet and extending to the south and north, including the Susitna basin, Iliamna Lake, and Alaska Peninsula, considerable lode prospecting has been going on during the last two years. This region has, however, not recently been visited by any representative of the Geological Survey, and the information regarding the lode deposits is very inadequate. Current reports indicate that copper-bearing and auriferous lodes have been discovered in Kenai Peninsula and that they are being carefully prospected. The copper-bearing lode in the Iliamna Lake region, according to current report, is still being investigated.

There is also a reported occurrence of auriferous lodes in the Alaska Peninsula region. Up to the present time the only lode deposit which has been developed in this province is the Apollo mine, on Unga Island, which for a number of years was a very large producer. Current reports indicate that there may be similar deposits in other parts of this region, and specimens sent to the office of the Geological Survey show that auriferous quartz does occur in this field.

Among the other districts in which lode prospecting is said to be yielding favorable results are the Susitna basin and the Kuskokwim basin. Definite information regarding these occurrences, however, is not at hand.

In the Yukon-Tanana region, as shown by Mr. Prindle (see p. 184), practically no lode mining has been attempted, though for the last two years considerable attention has been given to prospecting certain auriferous veins. Noteworthy is the reported discovery of a cassiterite-bearing lode in the Circle district.

In Seward Peninsula Mr. Smith (pp. 206–208) indicates that there was great activity in prospecting during 1907, though up to the present time only one lode mine has reached a producing state. As Mr. Knopf shows (pp. 251–267), there was considerable prospecting in the York tin region. Of considerable interest in this area is the discovery of wolframite-bearing lodes, which may have a value for their tungsten content. The prospecting for antimony in Seward Peninsula has continued, as shown by Mr. Smith (pp. 244–245), and there was a small production of stibnite.

PLACER DISTRICTS.

INTRODUCTION.

The placer mines of Alaska still lead all other forms of mining in the value of the output. In 1907 the placer mines produced about $16,400,000 worth of gold, compared with a production valued at $18,607,000 in 1906. This decrease in value of $2,357,000 can be charged to the labor difficulties at Fairbanks and Nome. Nearly half the placer-gold production in 1907 came from the Fairbanks district, and Seward Peninsula stands second in output, with a production valued at about $7,000,000. It is estimated that the silver recovered from placer gold in 1907 had a value of about $60,000.

The discovery of two new placer districts, the Chandalar and the Innoko, where small productions were made, was reported during the year.

The important feature of the placer-mining industry in 1907 was the general unsettled condition of labor in two of the most important fields, namely, Seward Peninsula and Fairbanks, which led to a notable falling off in production. Of significance is the installation of three dredges in the Fortymile district. Important developments were also made in the Glenn Creek region of the Rampart district.

PACIFIC COAST REGION.

The region tributary to the Pacific coast is of relatively small importance as a producer of placer gold, but includes a number of separate districts. These, named from south to north, are the Juneau and Porcupine districts in southeastern Alaska; the beach placers of Lituya Bay and Yaktag; the Nizina and Chistochina districts of Copper River; the Cook Inlet placer field; and the beach placers of Kodiak and adjacent islands. In 1907 the total production of all these placer districts amounted probably to less than $300,000.

There was but little placer mining in southeastern Alaska. A noteworthy attempt was made by a company to develop the placers on Porcupine Creek in a systematic way. Considerable money was spent in building a flume and preparations were made to mine the alluvial deposits on a large scale. Beach mining continued at several places along the Pacific coast, but the total output probably did not exceed $25,000. The most important locality is Yaktag, but some mining was done also on Kodiak and the adjacent islands.

In the Copper River region a large hydraulic plant was installed in the Nizina district, several other properties were operated, and preparations were made for further installation of mining plants on Dan Creek. Considerable work was also done in the Chistochina district during the summer of 1907, though the gold output was smaller than it has been in past years. The long distance to supplies and the consequent high cost of mining have made it impossible to develop any but the richest ground in this camp.

An important event was the discovery of rich placer ground on the benches of Valdez Creek, a tributary of the upper Susitna, about 200 miles inland from Valdez. Valdez Creek has been a small producer for a number of years, and last summer the discovery of some rich ground was reported. Some very coarse gold was found, a $1,000 nugget being reported. Of the extent of these deposits, however, nothing very definite has been learned by the writer.

In the Cook Inlet field the old Sunrise district (Kenai Peninsula) has been a small producer, as have also some of the streams north of Turnagain Arm. Of more importance in this general field is the development of the Yentna diggings, which lie about a hundred miles from tide water. The ground is said to be shallow and sufficiently rich to pay for operation on a small scale. The largest producers are reported to be Poormans, Nugget, Falls, and Peters creeks, but a number of other streams carry gold. The exact production is not known, but it appears to have exceeded that of the Sunrise district.

SEWARD PENINSULA.

The value of the output of gold in Seward Peninsula for 1907 is estimated to have been about $500,000 less than it was in 1906. This decrease is to be charged chiefly to the labor conditions. The Nome precinct continued to be the first in order of production, with an output of more than 50 per cent of the total $7,000,000 credited to the peninsula. The Council and Fairhaven precincts probably stand second, having an output about equal in value. Mining on Seward Peninsula is fully described by Mr. Smith (pp. 206–250) elsewhere in this report.

YUKON BASIN.

INTRODUCTION.

The preliminary estimates for 1907 credit the Yukon region with a gold production valued at $9,300,000, or considerable more than half of the total for the Territory. The greater part of this comes from the Fairbanks district and bears evidence of the continuous prosperity of this camp in spite of the setback due to the disputes between miners and operators. There was considerable activity in several of the old districts, notably at Fortymile, Birch Creek, and Rampart. Two new districts, the Chandalar and Innoko, have become small producers since 1906.

FAIRBANKS DISTRICT.

The falling off in the gold output of the Fairbanks district from about $9,000,000 in 1906 to about $8,000,000 in 1907 will no doubt be interpreted by those unfamiliar with the conditions as evidence that the district has passed its zenith of production. This is, however, eminently not the case. Had it not been for the labor difficulties, which practically put a stop to the larger mining operations during the months of May, June, and July and seriously hampered them during the balance of the summer, the output of the Fairbanks district in 1907 would undoubtedly have exceeded that of the previous year.

It can not be denied that the richest pay streaks at the scenes of some of the earliest discoveries—such as the upper part of Cleary Creek and parts of Fairbanks Creek—have been worked out, but other discoveries have more than made up for the decreased production from these areas. It is also true that there are large gold reserves in the lower grade gravels which have not yet been touched. It must be admitted, however, that the cost of mining has not been materially reduced since the early days of the camp, and that, until cheaper methods are devised, much of the lower grade gravel can not be profitably exploited. As a matter of fact, the average operator in the Fairbanks district has been so accustomed to exploiting bonanzas that he is very loath to attempt to mine any pay streaks containing lower values. As the bonanzas are of moderate extent, it would appear to be very desirable to improve the methods of mining during the prosperous days of the camp, rather than to wait, as has been done in the Klondike, until these rich pay streaks are exhausted, and thus suffer the years of business depression which must undoubtedly come while the camp is adjusting itself to the new conditions. There appears to be an unfortunate tendency in the camp as a whole to gut the richest deposits, leaving the partly worked out claims for future operators to mine systematically. This is especially true where mining has been done by laymen, who can not be expected to look after anything except the immediate necessity of taking out as much gold as possible, and who care nothing about the condition in which the balance of the unworked material is left. That this is a suicidal policy for the claim holders no one familiar with mining conditions can deny. That it is a necessary evil in the early days of any placer camp is equally certain to all those who have followed the development of mining in the North. It seems, however, that the time has come when some reforms might well be introduced in the Fairbanks district, and that the larger property owners should look to the future as well as to the present.

The greatest need in the Yukon camps, and especially at Fairbanks, is more miners and prospectors. The population of the Fairbanks district and immediately tributary areas can probably be roughly estimated at about 6,000 persons, which is not sufficient to work the ground already opened up, let alone to prospect the areas known to be more or less auriferous. It appears as if there ought to be good opportunities for at least as many more experienced miners and prospectors as are now in the district.

To this 6,000 (estimated as a more or less permanent population) there are to be added several thousand people who annually visit Fairbanks, spending the open season. Probably the chief thing which has deterred laboring men from going to Fairbanks is the high cost of transportation from Puget Sound ports.

As nearly as could be learned by the writer, the difficulties between the miners and operators last season were as follows: The miners demanded a reduction of hours from ten to eight for a day's labor, and an increase of wages from $5 to $6.[a] The operators offered to continue the ten-hour day with wages of $6 or reduce it to eight hours with a wage scale of $5. The miners demanded a recognition of the union, which the operators declined to grant. The strike was called on April 26, just at the time when the sluicing season began. Most of the operators stood firm, and nearly all work was suspended. As a consequence, the water available for sluicing at the time of the spring run-off was lost, and many of the winter dumps were not sluiced until late in the fall. During the summer, however, some operations were begun again, and late in the fall many claims were running at full blast. It appears that an increase of wages was granted by many of the operators, but there was no formal recognition of the union.

In justice to both sides of this dispute, it should be noted that most of the mining at Fairbanks is by drifting, and that the labor is exceedingly arduous and requires more skill than the ordinary open-cut methods, where anyone who can use a pick and shovel can be employed. On the other hand, an eight-hour day would require three shifts, if continuous operations are carried on. Moreover, there can be no doubt that if the operators are forced to pay higher wages the margin of profit will be absorbed, and much ground can not be exploited. If the eight-hour day and $6 wage prevail, it means a very material reduction in the area of gold-bearing gravels which can be profitably exploited. Apparently the only hope of reduction in costs at present is in the item of transportation from the outside, both for passengers and freight.

After the strike was called a large number of the miners left for the newly discovered Innoko placer district, this number amounting, according to some estimates, to as many as 1,200. Many of these men did not return to Fairbanks, and as a consequence there was a shortage of labor all through the summer months. So, even had the strike been settled, it is not probable that the mines could have been run at full force. In spite of these adverse conditions, the gold production was large, showing that, could the labor difficulties have been avoided, the output would have exceeded that of 1906. The open season for mining, which usually extends from the last week in April to the latter part of September, in 1907 was continued into October. This fact very materially increased the gold production for 1907 and nullified the value of all estimates of the output made in September, for probably upward of a million dollars worth of gold was taken out after the usual time of closing the mining season.

[a] This means per day with board.

The general prosperity of Fairbanks is made abundantly evident by the large amount of business which is carried on. About 20,000 to 25,000 tons of freight are annually brought in from outside points. The lumber cut by the local sawmills exceeds 5,000,000 feet. About 200 boilers are annually sold to mine operators, aggregating about 3,500 horsepower. The total horsepower of the boilers used on the creeks in the vicinity of Fairbanks in 1907 is estimated at over 7,000.

The occurrence of gold in the Fairbanks district is fully described in a report now in print,[a] so it will not be necessary to do more than outline the subject here, especially in view of the fact that the geology of this area is to be studied in detail in 1908.

Among the discoveries of the last year perhaps the most significant was the finding of values on Our Creek and in the Smallwood basin and of auriferous gravels on Alder Creek, a tributary of Cripple Creek, and on the lower part of Goldstream Creek. These discoveries considerably extend the known auriferous belt, though the commercial value of this increased area may still have to be proved. Another important discovery is the finding of gold in the upper basin of the Big Chena, which would fall within the easterly projection of the Fairbanks belt. The intervening area would appear to be a favorable field for careful prospecting.

As defined by these new discoveries, the known auriferous zone of the Fairbanks district proper is embraced in an area of 350 to 400 square miles, extending from Esther Creek on the southwest to Fairbanks Creek on the northeast, with a width ranging from 10 to 15 miles. So far as known, the same general geologic conditions prevail both to the northeast and to the southwest of this belt, and there is reasonable hope that the productive area may be found to include a larger zone. There is at least sufficient evidence to warrant the prospecting of the extension of this belt, which, on the one hand, will include the lower valley of Goldstream Creek and its tributaries, where some gold has been found, and, on the other, the basin of the Little Chena. The absence of bed-rock exposures makes it almost impossible to forecast the geology until the mining operations have pierced the heavy alluvial flooring of the valleys. These suggested extensions of the auriferous fields are, however, borne out by what is known of the bed-rock geology, also by the alluvial gold which has been found in the Fish Creek basin and by the prospects reported from Goldstream Creek near the canyon.

In 1907 Cleary, Fairbanks, Dome, Vault, Esther, and Goldstream creeks and their tributaries were the chief producing creeks of the district. Cleary still holds the first place in value of production, with Esther second and Goldstream and Dome ranking next. The

[a] The Fairbanks and Rampart quadrangles, Yukon-Tanana region, with a section on the Rampart placers by F. L. Hess: Bull. U. S. Geol. Survey No. 337, 1908.

finding of placers on Our and Smallwood creeks indicated a broader belt than has been previously supposed. Worthy of special note are the placers developed last year on Vault Creek, which had previously been unproductive. On nearly all the producing streams tributary to the Chatanika the pay streak has been traced well down to the main river.

On Fairbanks Creek there was no notable development during 1907, but operations were continued down as far as claim 10 below Discovery. On Cleary Creek the interest was centered in the operations which were carried on in the Chatanika Flats, near the mouth of the creek. Much mining was, however, done on the upper part of the creek also. On Dome Creek the pay streak was traced down into the Chatanika Flats, and the largest production was from this part of the valley. In September about eight groups of claims on Vault Creek were being operated in a large way. Goldstream Creek, which has been found to carry placers for the upper 7 miles of its course, made one of the large outputs of the district. Many of its tributaries also contain workable placers. Esther Creek, which, previously, had been a comparatively small producer, took second rank in 1907. In fact, the latter part of the summer it was the scene of greater activity than in any other part of the district. Cripple Creek, to which Esther Creek is tributary, carries gold, but so far only a series of bench claims about a mile below the mouth of Esther Creek have been productive. It seems as if the rest of the creek would be worth careful prospecting, but the width of the valley floor has deterred many operators from searching for the pay streak. Alder Creek, a westerly tributary of Cripple Creek, was carefully prospected last year, but it was not learned by the writer whether values were found. An event of special import was the discovery of gold on the bench on the east side of Esther Creek. Though this bench is not definitely proved to carry commercial values, yet it is suggestive of a further extension of the mining operations in this stream valley. The upper part of Smallwood Creek, a tributary of the Little Chena, has been prospected for several years, and a little gold taken out. In 1907 more prospecting was done and some values were found on the creek. Of more interest, however, is the fact that gold was discovered about 5 miles below at a depth of 320 feet. It was not known at the time of the writer's visit whether these deposits are of commercial value, but they indicate a wide distribution of the alluvial gold and suggest at least an extension of the district in this direction.

Among the smaller creeks which have become producers in 1907 is Little Eldorado, where there was a small output. Our and Big Eldorado creeks also made small productions, as did a number of other tributaries of Goldstream Creek.

The lines of development during the next few years would seem to be in the direction of further prospecting on the lower part of Goldstream Creek and on Smallwood Creek beyond the point where commercial values have been found, and the prospecting of the Chatanika Flats to look for old channels of streams tributary from the southeast—that is, buried and abandoned channels of the present drainage system. It is also suggested that it might be profitable to prospect both the streams lying southwest of Esther Creek and those tributary to the Little Chena, which would fall into the general extension of the auriferous belt, so far as it has been outlined. Above all, the systematic effort should be made to reduce the cost of extraction, thus making available large bodies of auriferous gravel which now must remain untouched.

Mr. Covert elsewhere in this report (pp. 198–205) discusses the water conditions at Fairbanks. It is not necessary to repeat this matter here, except to emphasize again the point that, even under the best conditions, there is not sufficient water to carry on all the mining projects. It seems probable that there are possibilities in the development of electric power in some of the adjacent stream basins which might be utilized in reducing the cost of mining. The outlook for bringing in water by ditches, as pointed out by Mr. Covert, is not favorable.

CHENA-SALCHA REGION.

Chena and Salcha rivers are large northerly tributaries of the Tanana which are confluent within 30 miles of Fairbanks. Their sources lie in a region of high relief 30 or 40 miles north of the Tanana, where their headwaters interdigit with streams tributary to Charley River and Birch Creek. According to Prindle,[a] the bed rock of their lower courses is chiefly mica and quartz schist, but in their headwaters there are known to be some large areas of granite.

The northerly tributaries of the central part of the Salcha and the adjacent portions of the Chena basin to the north are auriferous, and some workable placers have been opened up. This gold-bearing district lies about 50 miles east of Fairbanks and is reached either direct by trail or by steamer to the mouth of the Salcha and then by poling boat and overland. The first discoveries in this district were made on Butte and Caribou creeks in 1905.

Of the streams tributary to the Salcha, Butte and Caribou creeks are the most important. On these streams the alluvial floor averages about 25 feet in thickness, of which 18 to 20 feet is gravel. The gold is of a higher value than that of the Tenderfoot district described below, and the deposits are not so deep, but up to the present time the output has been small.

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[a] Prindle, L. M., Description of Circle quadrangle: Bull. U. S. Geol. Survey No. 295, 1906, Pl. I.

Interest in the Chena basin to the north was started by the reported discovery of gold in 1906, but there was relatively little work done until 1907. The gravel deposits are said to be not as deep as those of Fairbanks. It is too soon to forecast the future of this district, but the outlook appears to be encouraging.

TENDERFOOT DISTRICT.

The name Tenderfoot is generally given to an auriferous area lying about 60 miles east of Fairbanks, tributary to Tanana River and including Banner, Shaw, and Tenderfoot creeks. It may be reached by steamer up the Tanana to Richardson and thence by pack trail. This field has been one of active prospecting for a number of years, and a considerable amount of gold has been produced. During 1907 the gold output had an estimated value of $325,000.

The bed rock of the region, according to Prindle,[a] is chiefly mica schist, with some granite and crystalline limestone. Tenderfoot Creek, which, up to the present time, has been the largest producer, is about 6 miles in length. The alluvium is 40 to 100 feet or more in depth, of which about 36 to 80 feet is muck. The deposits on Banner Creek, which joins the Tanana a few miles below Tenderfoot Creek, are of similar character. The most striking feature of these deposits is the low value of the gold, as it carries a very high percentage of silver. It runs on an average about $13 to the ounce.

BONNIFIELD AND KANTISHNA REGIONS.

The Bonnifield and Kantishna placer districts lie south of the Yukon and close to the foothills of the Alaska Range. They were described in last year's Progress Report by Prindle[b] and therefore it will not be necessary to consider them in any detail here. The Bonnifield district is characterized as a whole by very heavy terraces of gravel which are somewhat auriferous. It appears that this gold has in places been concentrated in the present creek bed by natural sluicing, and these deposits have so far formed the workable placers of the district. The gold production of the Bonnifield district has been small, and no very rich or extensive placers have been discovered. The future of the district seems to rest on the possibility of working large bodies of gravel. The nearness of the placer deposits to the high mountains, which should afford a water supply, has led to some investigations looking to the introduction of hydraulic plants. Preliminary examinations of this district were made during the summer of 1907 by engineers representing capitalists.

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[a] The Yukon placer fields: Bull. U. S. Geol. Survey No. 284, 1906, p. 123.

[b] The Bonnifield and Kantishna regions: Bull. U. S. Geol. Survey No. 314, 1907, pp. 205–226.

The Kantishna district embraces an area lying within 20 or 30 miles of the base of Mount McKinley, but in streams tributary to the Tanana. This area was the scene of great excitement two years ago, and some gold was taken out, but chiefly from one creek. Since 1906 there has been very little activity in this district, though probably a dozen or so men have continued prospecting and a little sluicing has been done. The inaccessibility of the region has rendered the cost of mining very high. Over much of the district the gravel deposits are very deep, and it seems to be rather exceptional to find shallow deposits which can be worked by hand methods. For the present the outlook for mining does not seem hopeful.

The entire production of the Kantishna and Bonnifield districts for 1907 was probably less than $20,000 in value.

CHANDALAR AND KOYUKUK DISTRICTS.

A belt of metamorphic rock lying north of the Yukon stretches westward from the Chandalar into the Koyukuk Valley, and has in places been found to be auriferous. The Koyukuk has been a gold producer since 1899, but mining has always been handicapped by the heavy cost of operating. The geology and mineral resources of this district have been described by F. C. Schrader on the basis of his investigations made in 1899 [a] and in 1901,[b] since which time there has been no opportunity to send a party into it.

The producing creeks in the Koyukuk district in 1907 were Myrtle, Blake, Emma, Smith, Nolan, Fay Gulch (a tributary of Nolan), Vermont, Swift, Julian, Gold, and Mascot creeks. Myrtle and Emma creeks in this district are worked by open-cut methods, but most of the other streams are worked by drifting. Smith, Emma, Nolan, and Myrtle creeks are said to be the largest producers. It is reported that some very rich gravels were found on Nolan Creek at a depth of 125 feet in November, 1907. This discovery has stimulated mining and prospecting in all parts of the district.

Transportation to this district is uncertain and very expensive. Steamers make three or four trips a year up as far as Bettles—a distance of about 500 miles from the mouth. From that point supplies are taken up in winter by sleds and in summer by poling boats about 100 miles farther to Coldfoot, which is near the producing creeks. It is estimated that about 200 men work in this district, and the output ranges from $100,000 to $125,000 in value annually. The excitement in regard to the Chandalar district took many of the operators out of the Koyukuk region, and hence the production in 1907 was

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[a] Schrader, F. C., A reconnaissance along the Chandlar and Koyukuk rivers in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 471–485.

[b] A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904.

probably somewhat less than that of 1906. It is estimated to have a value of about $100,000.

In 1906 gold discoveries on the Chandalar were reported, and in 1907 there was a large stampede into this district. The scene of discovery is said to be on Big Creek, a tributary of the north fork of Chandalar River. It is of interest in this connection to note that Schrader pointed out the fact eight years ago that the gravels of this district were auriferous, though, of course, as there had been no prospecting, he could not determine whether commercial values were present.

According to the statement of S. J. Marsh, United States commissioner of the Chandalar precinct, dated November 14, 1907, at Caro, values have been found on three creeks in the district. About 100 men were engaged in prospecting and mining, but only 21 were working claims. Five claims were worked, and the estimated production is valued at $28,000. During the winter of 1907–8 twelve boilers were placed in position for operation on deep ground, and it is probable that 75 men will be engaged in prospecting and developing work during the winter on eight different creeks. The district is reached by steamer, which runs up the Chandalar for about 100 miles.

GOLD ON THE LOWER YUKON.

Much of the bed rock of the lower Yukon (which will here be made to include that part of the river below the mouth of the Tanana) belongs to the coal-bearing series, and hence is not auriferous. There is, however, a belt of metamorphic rocks which stretches from the Tanana parallel to the Yukon on the north, and this touches the river at a number of places. Some metamorphic rocks also lie to the south of this part of the river, but less is known of them. Spurr [a] described a quartz vein which he observed at Gold Mountain, 25 miles below the mouth of the Tanana, and which carried some gold and silver. This part of the belt, therefore, has long been known to be auriferous, but up to last year no values have been found in the gravels.

During the summer of 1907 there was a reported discovery of placer gold in the so-called Goldhill region, about 35 miles below the mouth of the Tanana, on the north side of the Yukon. The discovery is reported to have been made about 15 miles from the river, and the gold is said to have been found on a creek called Columbe, which is said to have yielded wages, under shovel methods. Lower down on the creek, it is reported, a hole 119 feet deep was sunk without reaching bed rock.

There was a reported discovery of placer gold on Ruby Creek, which enters the Yukon from the south about 30 miles below Kok-

[a] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 293.

rines. Ruby Creek is about 2 miles long and surface prospects of 2 cents per pan are reported. Some open-cut work was done in the summer of 1907 and is said to have showed good values on bed rock. It is said that about 30 men were prospecting the placers in this district.

INNOKO REGION.

Several years ago there was a reported discovery of placer gold on some of the streams which are tributary to the Innoko in the region lying south and west of the lower Yukon. These discoveries appear to have been made by trappers and attracted but little notice. During the winter of 1906–7, however, news came from the Innoko of the finding of rich auriferous alluvium in this area. This report became current at Fairbanks just at the time when the labor troubles found a large number of dissatisfied men, and for this reason many were attracted by the new find. It is estimated that 1,200 men started for the Innoko, and of these probably 400 or 500 reached the scene of discovery.

The Innoko Valley has never been examined by the Geological Survey; in fact, it is unsurveyed, except for the work done by Lieutenant Zagoskin,[a] who traversed a part of it in 1843. The writer has compiled the following data from various reliable sources. He is under special obligations to Charles F. Ramsden, of St. Michael, and to E. N. Welter, of Fairbanks, who furnished notes and sketch maps, also to W. A. Vinal, United States commissioner for the Innoko district, resident at Moore City, who furnished a statement regarding the mining developments.

The Innoko, the largest easterly tributary of the lower Yukon, discharges into the main river through two channels, one about 30 miles above and the other about 30 miles below Anvik, near the Holy Cross Mission. The lower river is said to traverse a broad flat, fairly well covered with timber and, to judge from descriptions, 50 or 60 miles wide. Above this flat the Innoko occupies a broad timbered valley. The lower part of the Innoko has an exceedingly tortuous course, with very sluggish current. The distance from the Yukon by the river to Deekakat, an Indian village and the upper limit of steamboat navigation, is estimated to be more than 200 miles. However, as this point is probably not over 60 miles in an air line from the mouth, the distance by water is probably less than that estimate. A small river enters from the east at Deekakat, and 20 miles above the Innoko receives another eastern tributary called the Deetna.

About 25 or 30 miles up the Deetna are a number of creeks on which some gold is said to have been found. The most important dis-

[a] Ueber die Reise und Entdeckungen des Lieutenant Zagoskin im Russischen Amerika: Archiv für wissenschaftl. Kunde von Russland von A. Erman, Berlin, 1848, vols. 6 and 7.

covery of gold, however, is on Gains Creek, which is tributary to the Innoko, at a distance of over 200 miles from Deekakat, as estimated by prospectors. A comparison of the maps would indicate that this distance was probably between 75 and 100 miles, though, as the river is here also very tortuous, it is quite likely that the actual distance by river is very much greater. During the spring freshet steamboats are said to be able to go up the main Innoko for at least 100 miles above Deekakat.

Gains Creek and the headwaters of the Deetna are separated from the Kuskokwim waters by a high mountain ridge on which there is reported to be some permanent snow. This would indicate the high altitude of the range and suggest that a water supply for sluicing purposes could be had all through the summer months. The summer of 1907 was exceedingly wet in the Innoko district, and it is probable that the rainfall here is much greater than in the upper country.

The bed rock of the country is said to be chiefly slate, with some quartzite, and in the mountains some granite. Between the upper Innoko and the Yukon there is said to be a belt of mica schist. A little impure lignitic coal is reported on the lower river.

There is said to be a portage from the head of the Innoko north of James Creek to the Kuskokwim. The actual carriage is supposed to be a distance of only 7 miles. Deekakat is said to be about 75 miles, or three days' travel in winter, from Kaltag, on the Yukon.

The discovery of gold was made on Gains Creek and on a bench which is 8 or 10 feet above the water level. During the summer of 1907 four claims are said to have been opened up. The gold which was taken out (estimated at between $10,000 and $20,000) all came from benches on this creek. The gold is said to be coarse. The floor of the creek to bed rock is said to be 15 or 20 feet deep, all of which is gravel. The ground for the most part is unfrozen, and the presence of live water makes prospecting difficult. Newspaper accounts report the discovery of values in the bed of Gains Creek during the winter of 1907–8. On Madison Creek a depth of 31 feet to bed rock is reported, of which the upper 9 feet is clay or muck, overlying well-assorted gravel, and some gold has been found, though not in commercial quantities. A little gold has been found on the bars on the Innoko some distance below the mouth of Gains Creek. The trees on the creeks are scattering and scrubby, but fairly good timber is found on the main river.

Of special interest is the reported discovery of an auriferous quartz ledge on Gains Creek. In this the gold is said to be free and to carry good values. A shaft sunk about 30 feet did not reach solid bed rock, and up to this depth the ledge was very ill defined.

Probably 500 men were in the Innoko region during the summer of 1907, but most of them spent their time in staking claims and in moving supplies, and little prospecting was done. It is reported that about 200 men will winter in the Innoko region. During the summer of 1907 the cost of freight to Gains Creek from Nome was about $400 a ton. Winter rates for freighting from the Yukon were 50 cents a pound.

It is worthy of note that there have been reported discoveries of gold in the region lying east of the Innoko, in the Kuskokwim basin. There can be no doubt that during the coming two years this country will be thoroughly prospected and the finds that have been made would seem to warrant further search.

RAMPART-BAKER CREEK REGION.

The area generally known as the Rampart district embraces the streams tributary to Minook Creek, and also the area south of the divide, including Glenn and other creeks lying in the Baker Creek basin. Now that the southern part of the field has become the larger producer, the name Rampart no longer appears to apply. The year 1907 saw great activity in this district, but the larger part of the production came from the southern half of the area.

In the northern part of the field one hydraulic plant was at work on Hunter Creek, and considerable sluicing and some drift mining were done on the other creeks of this part of the district. The most important developments, however, were made in the southern part of the area, particularly on Thanksgiving Creek. A ditch was built from California and Alder creeks to Thanksgiving Creek, giving an 80-foot head at Discovery claim. Another ditch was built to Glenn Creek from the head of Pioneer. Considerable prospecting was also done in this area, with the aid of a diamond drill, which was found to be a very economical method of operation. Plans are under way for building a ditch to Pioneer and Eureka creeks from the head of Hutlina Creek, near Montana Creek. This ditch is to furnish water for all the benches from Glenn Creek to New York Creek.

Some auriferous gravels were found during the summer of 1907 on Patterson Creek, tributary to the Tanana. The scene of the discovery is at the mouth of Easy Money and Sullivan creeks and near the trail leading from the Hot Springs to Fort Gibbon. The bed rock is chiefly slate and is covered by gravels 35 to 70 feet deep. The gold is said to be similar in character to that found on Glenn Creek, and its location suggests that this deposit may be a southwesterly extension of the Glenn Creek belt. If this is so, it would be worth while to prospect the general extension of the same belt to the southwest. Though there was no actual mining in the summer of 1907, sufficient gold appears to have been found to warrant further careful prospecting in this field. Several boilers were put on the creek during the summer of 1907, and it will probably be pretty well prospected during the winter of 1907–8.

It is estimated that between 500 and 600 men were engaged in prospecting and mining in the Rampart-Baker Creek district during the summer of 1907, and considerable mining was also done during the winter months. The total output of the district is estimated to be somewhat over $300,000. Its accessibility to the Tanana and Yukon, especially since roads have been constructed from both Hot Springs and Rampart, gives it the advantage over a number of the Yukon camps.

BIRCH CREEK REGION.

The season was rather dry in the Birch Creek district in 1907, and the gold output was somewhat less than in the previous year. Deadwood Creek and Mastodon Creek and its tributaries continue to be the chief producers of the district. No new enterprises were inaugurated on the north side of the divide in 1907. Prospecting on the lower part of Deadwood Creek developed some interesting facts. Twenty holes were sunk at depths of 14 to 20 feet on the flats, but no bed rock was reached and the ground was found to be unfrozen. Gold is said to have been found throughout the whole body of gravel, except in the upper 3 feet, and estimates of values are reported at 40 cents to $1.50 a cubic yard. It would appear that this creek would be worthy of further investigation with a view to handling the ground by dredges.

On the south side of the divide considerable developments were made on Eagle Creek, where two ditches were constructed, bringing water from both forks of the main creek for hydraulic purposes. Mining continued in a small way on Woodchopper, Fourth of July, and other streams tributary to the Yukon. The estimated value of the production of the Circle precinct for 1907 is $200,000.[a]

COAL MINING.

The accompanying table shows the production of coal in Alaska since coal mining first began in 1888. The figures for years previous to 1898 are only approximations, as no accurate statistics were collected up to that time. The later years, however, are represented by statistical data collected in large measure by actual correspondence with the producers. Up to 1906 most of the coal produced was of a lignitic nature, though some subbituminous coal was mined on the lower Yukon and at Cape Lisburne several years ago. The delay in

[a] The Fortymile district is discussed in another section of this report by Mr. Prindle. (See pp. 187–197.)

procuring patents on Alaska coal lands has seriously hampered the coal-mining industry, and until the legal questions are settled no considerable advances can be expected.

Production of coal in Alaska, 1888–1907.

Year.	Amount (short tons).	Value.
1888–1896	6,000	$84,000
1897	2,000	28,000
1898	1,000	14,000
1899	1,200	16,800
1900	1,200	16,800
1901	1,300	15,600
1902	2,212	19,048
1903	1,447	9,782
1904	1,694	7,225
1905	3,774	13,250
1906	5,541	17,974
1907	5,150	27,850
	32,518	270,329

NOTE.—The production for 1888–1898 is estimated on the best data obtainable. The figures for the years subsequent to 1898 are based for the most part on data supplied by operators.

In 1907 there were only three coal producers in Alaska, as compared with five in 1906. One important advance was made, however—the first attempt at developing the high-grade coals of the Controller Bay region. Considerable coal was mined on Bering Lake for local use, and its production was of very material benefit to the railway construction which was going on in the vicinity. The reported easterly extension of the Controller Bay coal fields is worthy of note. Coal is reported to have been found in the high ranges back of Bering Glacier and also near Yaktag. In the Controller Bay field as a whole prospecting has also been actively pushed, and the promise of a railway which is soon to reach the coal fields will accelerate the work in this region. In the Matanuska field much prospecting has been done, including some driving of tunnels. A mine in Seward Peninsula continued to produce coal for local use, and one small mine was running on Alaska Peninsula, also to supply a local demand.

The lignite from the Yukon has been entirely neglected for the last two years—that is, since the introduction of oil-burning engines on the river steamers. This is to be regretted, because some of the lignites would undoubtedly furnish a valuable source of fuel, if they were systematically developed. On the Canadian side of the boundary a considerable amount of the same grade of coal is mined and used at Dawson and other points. On the Alaska side no coal was mined in 1907, and as a consequence there was a proportionate devastation of the rather meager supply of timber. The Fairbanks district alone is estimated to use 35,000 cords of wood every year. The lignite coal field, lying on the upper waters of the Nenana and stretching farther eastward toward the Delta, should furnish a valuable coal supply, even though the coal is of low grade, were it opened up by a railway. It seems only too likely that the time will come when the Alaskan placer miner will feel the pinch for fuel, and then he will have to depend on the lignite coals. It is even already noticeable that in many older camps the timber is getting very scarce. Much has been used for mining purposes and a far larger amount has been destroyed by forest fires.

The Alaska coal fields, particularly those carrying a high-grade fuel, like the Controller Bay and Matanuska fields, are destined to play an important part in the advancement of industry on the entire Pacific seaboard of the North American continent. Their early opening up is therefore a vital question to all residents of the Pacific coast.

PETROLEUM.

There have been no developments in the petroleum industry in Alaska in 1907. Two of the wells which were drilled several years ago at Controller Bay, however, were pumped and furnished a local supply of petroleum for use in railway construction. Some further prospecting with drills was also done but does not seem to have yielded any very definite results. So far as learned, no work whatever has been done in the last two years on the Cook Inlet fields.

BUILDING MATERIAL, ETC.

The appended table shows the value of the production of gypsum and marble since mining of these products was begun in Alaska.

Value of marble and gypsum produced in Alaska, 1901–1907.

1901	[a] $500
1902	[a] 255
1903	[a] 389
1904	1,700
1905	710
1906	11,995
1907	71,958
	87,507

The quarrying of marble has become an industry of some importance in the Ketchikan and Wrangell districts, and in the Sitka district the production of gypsum is increasing. Owing to the fact that there are only a few producers of these two minerals, it is necessary to group them together in the production tables, so as to avoid

[a] Estimated.

giving any clew to individual outputs. It will be noted that the value of the production for 1907 is almost three times that of 1906. These mineral deposits are described at some length by Mr. Wright (pp. 116–175), and it will not be necessary to consider them further here.

Among the nonmetallic minerals of value should be mentioned mineral water, which has been produced in a small way in southeastern Alaska. Hot springs are not uncommon throughout Alaska, and many of them have been utilized both as local health resorts and as centers of gardening, notably the Baker Hot Springs in the Tanana Valley and the Hot Springs in the Kuzitrin Valley, Seward Peninsula. During past years the actual bottling of mineral waters has been attempted only in southeastern Alaska, and so far as known, there was no production in 1907.

Mr. Smith elsewhere describes some occurrences of graphite in Seward Peninsula. (See p. 250.) These deposits have not been developed, but appear to give promise of having a possible commercial importance. Mica has also been found in the Council region of Seward Peninsula, but it is not known to be of commercial importance, though some large slabs have been brought out. Asbestos has been found by Mr. Prindle at a locality in the Yukon-Tanana region (see p. 25), but is entirely undeveloped.

PROSPECTING AND MINING GOLD PLACERS IN ALASKA.

By John Power Hutchins.

INTRODUCTION.

During the last decade placer-mining operations in Alaska have developed from the crude methods of the pioneer, whose implements often consisted of little more than the shovel, the pick, and the whip-saw, to modern well-equipped plants, representing investments of many thousands of dollars. Like all other industrial evolutions, this development has not been without its failures. Inasmuch as the financial loss entailed by such unsuccessful enterprises has often been great, and as many of them might have been prevented by a more thorough knowledge of conditions prevailing in the north, it will be in the interest of those engaged in or contemplating placer mining to present briefly some of the essential facts bearing on the systematic exploration of Alaskan placers.

It is to be regretted that data respecting the tenor of gold per cubic yard and the working cost per cubic yard under varied conditions are not more generally kept and published by the operators. Such records could not fail to be of value in the exploitation of gravels under similar conditions elsewhere. Comparison of records would carry much weight where a number of miners were operating under similar conditions, but by different methods.

Among the many factors which influence the commercial success of placer-mining operations, those of general application will be considered in detail. It is evident that location, with which is involved the whole problem of transportation and therefore costs, is a dominating factor. Climate, involving length of working season, rainfall, condition of alluvium, timber, etc., is another. Topography, as affecting stream gradients, and hence dumping ground, and the installation and maintenance of reservoirs and ditches to conserve and conduct water for placer work, has the closest relation to mining cost.

The factors above outlined may be said to be the geographic conditions affecting all placer enterprises. The extent, character, and distribution of the auriferous alluvium, the character of the bed rock, the distribution of metallic content, and peculiarities of pay streak and of overburden are matters that must be determined in detail for each deposit. In the final analysis of a property it may be found that the gold content per cubic yard alone will determine the possibility of successful exploitation, for, if this is high enough, practically all the other factors may be disregarded. The present paper, however, is not intended to treat of bonanzas, but of large bodies of auriferous gravel the gold content of which is such that they can be worked profitably only by the exercise of the miner's skill and business acumen. Any peculiarity that bears on the working cost is important and should have as great weight in determining the value of a property as the gold content.

In the discussion which follows, intended primarily for those unfamiliar with the conditions in Alaska, the subject will be treated from the technologic as distinguished from the geologic point of view. This paper can not pretend to be a complete statement, and therefore while certain methods such as prospecting with churn drills, dredging, etc., of which the writer has made a special study, will be treated at some length, other modes of testing and exploiting placer ground will be discussed very briefly.

FROZEN GROUND.

The extent and distribution of the ground frost in Alaska and other northern countries may become a governing factor in counting the working cost of an enterprise, especially of one in which the operation of mechanical excavators is contemplated. There are two kinds of frozen ground in Alaska—(1) that which is permanently frozen and (2) that which is subject to superficial freezing in winter but thaws during the summer. Both are a great hindrance to mining operations. For example, in general permanently frozen ground can not be dredged profitably. It is likewise an obstacle to the erection of dams, ditches, bridges, buildings, etc. Seasonal frost is less prejudicial, but may seriously hamper dredging by curtailing work for many days each season.

The only kind of mining that is even in part benefited by frost is drift mining. It is possible to drift frozen ground that could not be mined except at a prohibitive cost for pumping and timbering were it unfrozen. Deep deposits of drained gravel can be drifted more cheaply if unfrozen, except where timber is so scarce that its cost would be greater than that of thawing.

Permanent frost is the normal condition in Alaska except in the Pacific coast region. Observations made by the writer indicate that permanent frozen ground is generally found in the beds of small streams and it may be present at irregular intervals even in the beds of large streams. Frozen ground is often found in the flats of a stream valley adjacent to the unfrozen stream bed even though the stream carries several hundred second-feet. Wherever there is an overburden of muck or tundra, it is almost certain that frozen ground will be found beneath it. A growth of willows on Seward Peninsula is said to be an infallible index of unfrozen ground beneath, and this is generally though not invariably true.

Seasonal ground frost penetrates each winter to a depth of 6 to 10 feet or more in the stream beds, and dredging operations in the early part of the working season are handicapped by this blanket of frozen material. It thaws but slowly, and therefore interferes with the work during a considerable part of the season. When it partly thaws it often leaves a frozen stratum 1 to 3 feet in thickness which sometimes breaks down in large slabs that are troublesome to handle.

No accurate or detailed data in regard to ground temperatures in Alaska are available. All that is known is that some ground is frozen and other ground is not. Investigations and records of the ground temperatures of both frozen and unfrozen ground would possibly suggest a means of thawing the enormous volumes of material which can not now be profitably worked, but which if thawed would be lucrative. Should such observations result in evolving a cheap means of thawing the consequences would justify a considerable expenditure. The problem of thawing presents discouraging features, but it is not hopeless. The only way to solve it, if indeed it can be solved, is by scientific investigation, coupled with large patience and a knowledge of the mining requirements of the far north.

PROSPECTING.

GENERAL CONDITIONS.

The subject of prospecting will be especially emphasized here, because probably three-fourths of the failures in placer mining are due to the fact that the equipment has been installed before the ground has been properly tested. Millions of dollars have been wasted through this cause and there is still a lamentable tendency to install expensive mining plants with insufficient data as to the real value of the property under consideration. Operations of considerable magnitude are at the present time being undertaken where the gold content or the working cost per cubic yard is not known within 25 per cent of the real figures.

The popular conception of placer mining is extremely hazy. The mind of one who is uninitiated does not readily grasp its complexity. The general idea of a placer pictures a volume of material of no particular size, containing a high gold content, so rich that mining an inconsiderable amount of it will result in large dividends. As a matter of fact, such bonanzas are exceptional, and when they are found the public has no opportunity to invest, for the richness of the bonanza makes it unnecessary to seek outside capital. It may in general be safely concluded that in nearly all the enterprises that are presented for public investment comparatively low grade material is to be exploited. Such material yields only a small advance over the cost of mining. Therefore not only should the value of the metallic content be accurately determined by proper prospecting, but all conditions that influence operating cost should be carefully investigated.

The investigation of placer deposits is not a simple matter, particularly when accurate determination of the gold content and volume of large areas of low-grade material must be made. Such investigations should be carried on by one familiar with the conditions peculiar to the region. A mining engineer whose work has been done in other regions, no matter how capable, efficient, and experienced, is at a great disadvantage in the Far North, where the conditions encountered are in great part unique.

There are a large number of deposits that can be easily prospected by the average miner. Such are the small, rich, shallow placers that lend themselves particularly to one-man methods of operation. These can be investigated at a comparatively low cost, without expensive apparatus, and as the cost of operation is much less than the gold output, refined prospecting and engineering skill are not needed. It is lamentable that failures are being frequently made on such placers, for most of them can be easily avoided if a comparatively small amount of careful prospecting is done.

In lode mining it is usually difficult to determine the valuable content and volume of the lode without a large amount of costly excavating. In most placer mines, however, modern methods make it cheap to ascertain, within a comparatively small margin of uncertainty, the amount of gold in the ground to be exploited. This makes placer mining less of a speculation than lode mining, provided the necessary money is spent to prospect the ground thoroughly. Unfortunately the public at large is slow to realize this fact and the conscienceless or ignorant promoter too often procures financial backing for placer-mine equipment where only a most cursory and superficial examination has been made.

Proper prospecting involves the determination of the following more important factors: (1) Volume of pay alluvium; (2) extent, value, and distribution of pay streaks; (3) character of alluvium; (4) its degree of induration; (5) distribution and character of bowlders; (6) distribution and character of clay; (7) depth of alluvium; (8) depth to ground water; (9) character of bed rock. In addition to these, in Alaska, there is the prime necessity of investigating the distribution and character of ground frost, both permanent and seasonal. All the above factors influence working cost.

It is somewhat difficult to give average costs, for the expense for labor, transportation, fuel, and other items varies greatly in different parts of Alaska. It is safe to assume that in most Alaska placer camps labor and supplies will cost at least 100 per cent more than in the States. It is probable that the figures given elsewhere in this paper may not include the lowest or the highest figures, but they are presented with the hope of emphasizing the great importance of detailed investigation as a preliminary to any mining operations in this region, where, although rich gravel is often found, the working cost may be so great as to prevent success.

To obtain information concerning the various factors which have been enumerated above as influencing the cost of mining, it is necessary to penetrate the placer deposit and thus learn its thickness, condition, and contents. This may be done in one of two ways—by drilling a hole through the gravels or by sinking shafts.[a]

By the drilling method small samples are obtained. Briefly, out of each drill hole a cylinder of material about 6 inches in diameter is obtained from grass roots to bed rock. A prospecting shaft 3 by 6 feet has a cross-sectional area about 50 times as great as that of the drill hole. Thus the volume of material obtained from the shaft is often 50 times as large as that from the drill hole. As a matter of fact, the usual proportion of samples is very much less than this, for often but a small part of the material excavated from shafts is tested. The writer has seen a sample taken from a shaft 10 by 10 feet and 20 feet deep that was actually smaller than would have been obtained in a drill hole in the same ground.

OPERATION OF CHURN DRILLS.

The essential features of the drill method of prospecting are sinking a pipe to bed rock and extracting and testing the material that is included within the pipe. Drilling may be done by machinery run by steam or gasoline engines, or by hand alone, or by combined hand and animal power.

POWER DRILLS.

The steam and gasoline drills are essentially alike in operation and equipment. Inasmuch as the gasoline engine is more delicate, less reliable, and less flexible in operation than the steam engine, it is from these considerations alone inferior, although it may, on account of difficulty of transporting fuel and supplies, be preferable in some places.

[a] For convenience of treatment all openings that permit the entrance of a man, such as vertical shafts, inclined shafts, drifts, upraises, winzes, vertical, inclined, and horizontal cuts, are included under the head of shafts.

The actual drilling with a power churn drill involves three operations—(1) driving a pipe to obtain a core, (2) drilling this core to prepare it for pumping, and (3) pumping and hoisting this drilled material from the pipe and discharging it into a receptacle for testing. Each of these operations requires changes of tools and manipulation, and they are continued until the hole is finished. First, a heavy 6-inch pipe (weighing 20 pounds or more per foot) is driven into the ground 1 foot at a time by striking it on the upper end with a pair of driving clamps. These are clamped to the stem of the drill, which hangs inside the pipe from a cable sustained on the derrick of the drill by which the driving is being done. The drills, stem, etc., weigh about 1,000 pounds and strike about 55 blows per minute, raising and dropping the tool about 3 feet at each blow, though the length of blow can be adjusted to 18, 24, or 36 inches. It is obvious that a heavy blow can be struck and that the pipe must be strong and well prepared for such hard usage. A drive shoe is screwed to the bottom of the pipe. This is extra heavy and of metal sufficiently tough to penetrate gravel. A driving head is screwed to the top of the pipe to take the blows delivered by the driving clamps.

The cable can be reeled in or out while the driving or drilling or pulling is being carried on. After the pipe has been driven a foot or so, the driving clamps are removed and the core is drilled within a few inches of the bottom of the pipe. The drill is a chisel-shaped tool. Its action is to crush rather than to cut, and it breaks hard material, which is generally brittle, at a rapid rate—1 foot in three to ten minutes in medium-sized loose to coarse indurated gravel. When the core has been drilled it is pumped from the pipe. The vacuum pump, hanging on a different cable from that of the drill, has a length of about 8 feet and an inside diameter of about 4½ inches. A piston operates inside the barrel of the pump in the following manner. The pump is sustained by a rope attached to the piston at the upper end. When the pump is hanging on this rope, the piston is against a stop in the upper end of the pump barrel. In using the pump it is dropped suddenly into the pipe and slack line is allowed to pay out. The piston thus drops to the lower end of the pump barrel. The slack rope is reeled in rapidly, the plunger in sliding up inside the pump barrel creates a partial vacuum, and material is thus sucked in through the bottom of the pump and held by a plain flap or clack valve. When the piston strikes the stop at the upper end of the pump barrel, the pump is picked up and then hoisted from the pipe with its content of water and drilled material. There is an opening in the side of the pump barrel near the top, at such a height that the piston passes above it as it is hoisted to its stop. The pump is then emptied into a receptacle through this opening.

The methods of separating the gold from the materials obtained by drilling will not be discussed here in detail. Ordinarily the sample is panned or rocked, the various characters of the alluvium are observed and noted, the metallic content is saved and weighed, and the average value per cubic yard of the alluvium is calculated.

After the hole is finished the pipe is withdrawn from the ground by pulling. A pulling head is screwed to the top of the pipe, being so arranged that as the drill cable is alternately shortened and lengthened an upward blow is struck by the pulling hammer, which works inside the pipe. A blow almost if not quite as strong as that given in driving is thus obtained and the pipe is pulled from the ground. This is the hardest work the drill has to do and most of the breakages occur during this operation.

Under average conditions, about 10 to 20 feet per day of ten hours can be drilled in this way. The cost of operating a steam drill per day in Alaska is approximately as follows:

Daily operating cost of steam drill in Alaska.

Drill runner	$11 to $12
Panner	6 to 8
Fireman	6 to 8
Pumpman	6 to 8
Man and team	20 to 25
Total labor	49 to 61
Repairs, renewals, and fuel [a]	10 to 30
	59 to 91

A frozen condition of the alluvium makes peculiar operation necessary. Sinking with a drive pipe in frozen ground is often conducted by drilling about 8 to 10 inches below the drive shoe, driving for 12 inches, and then pumping. As it is difficult to drive in frozen ground and extra heavy pipe must be used, water heated by live steam from the boiler is kept in the drive pipe to prevent its freezing solidly in the ground. The pulling of the drive pipe from frozen ground is difficult and chain blocks are often used.

Frozen ground is frequently drilled by steam drills without using a drive pipe. Such procedure is justifiable only when the drilling is merely to locate a channel. It is not good practice to drill without a drive pipe if accurate determination of the gold content is to be made, as material is sloughed off the sides of the drill hole by the water thrown into the hole during the drilling, and thus inaccurate sampling is done. Drilling without a drive pipe can be done at a cost of

[a] About half a cord or its equivalent of other fuel is used per day. Wood costs on the Yukon $6 to $12 a cord; coal at Nome $20 a ton. In one steam-drill investigation on Seward Peninsula coal cost $120 per ton. Transportation governs cost of steam drilling, having a direct effect upon the cost of labor, supplies, repairs, and renewals.

less than $2 per foot[a] and as much as 75 feet is said to have been drilled in ten hours.

HAND DRILLS.

The hand-drilling outfit consists of a casing (lighter than drive pipe) with a toothed cutting shoe screwed to the lower end. A platform is placed on top of the casing and men standing on the platform operate one of a variety of tools inside the casing, alternately raising and dropping the tool as in churn drilling. At the same time other men rotate the casing by means of poles attached to the platform, or a horse harnessed to a sweep. The casing with its cutting shoe, by its own weight and that of the platform and men standing on it, cuts into the ground, there being but little friction to overcome, as it is kept loose by rotation. A tool which drills and pumps material into its barrel simultaneously is generally used. Thus the casing is sunk and the material is drilled and pumped at one operation, with the same result that is obtained in the three operations of the power drill. Several kinds of pumps are used, equipped with ball or flap valves. The pump fits the casing and as the pump is dropped it causes a rush of water into the barrel from below, the drilled material being carried into the barrel and held there by the ball valve.

The casing is pulled from the ground by leverage; a pole 25 feet or more long can be used. As a matter of fact, it is seldom necessary to use much force, for the casing is rotated while being pulled and it is customary to pull it at the rate of 30 feet or more per hour. It is obvious that there will be less wear, tear, and breakage while using this device than with a steam churn drill. The means of sinking and withdrawing the pipe are easy and effective and they subject the pipe to much less severe usage; moreover, the process is more rapid. The hand churn drill is essentially a combination core and percussion drill. The cutting shoe obtains the core like a core drill, partly preparing it for drilling and pumping, while the tool works simultaneously by percussion on the core and as a pump.

This type of hand drill is well suited to prospecting in Alaska. When equipped to drill 30 feet deep the whole outfit weighs about 1,000 pounds. It makes up into one-man packs with a maximum weight of less than 75 pounds each and so is particularly advantageous in inaccessible districts. It will sink from 20 to 40 feet of 5-inch hole through medium-size gravel in ten hours if not working at too great a depth. It does not work at depths of more than 75 feet without a spring pole or other device to help support the weight of the rod and tool. It requires five to seven men or five men and one horse to run it, depending on the depth being drilled and the method of

[a] This figure is said to be correct for the district near Nome.

rotating the casing. Its cost of operation per day, roughly estimated, is as follows:

One panner, \$6 to \$8; 5 to 6 men, \$30 to \$48; total, \$36 to \$56; or, when a horse is used to rotate the casing, 1 panner, \$6 to \$8; 4 men, \$24 to \$32; 1 horse, \$3 to \$10; total, \$33 to \$50.[a]

COMPARATIVE MERITS OF POWER AND HAND DRILLS.

Both of these drills have merits in their application to prospecting in Alaska. Rapidity, cost, and accuracy are the three prime considerations in any drill test.

The churn drill operated by steam works more rapidly when actually drilling, and so is well adapted to deep ground where moves are infrequent. Where there are many moves to be made, as in drilling shallow alluvium, particularly where the surface is rough or swampy, the hand churn drill, because of its mobility, will often drill a greater number of feet in a given time than the steam churn drill. the hand drill, however, will not penetrate as large bowlders as will the steam drill.

The cost of operation per day of a hand churn drill in Alaska will be generally less than that for a steam churn drill and the expense for wear and tear and breakage is very much less.[b] There is very little lost time for breakage when using the hand drill.

The more inaccessible the deposit under investigation the greater will be the advantage in favor of the hand churn drill in operating cost.

The first cost of the hand churn drill at the factory is less than one-half that for the steam churn drill. Moreover, freight charges are much greater on the steam drill, which weighs with its equipment ten to fifteen times as much as the hand drill. Transportation into inaccessible districts in Alaska is very costly and a steam drill at its destination may cost several times its factory price.[c]

The core obtained by the hand churn drill with rotated casing is probably more nearly representative of the material being sampled

[a] These figures are based on wages paid in Alaska in 1907. The cost of a horse can only be approximated, as prices vary; the figures given are about the maximum and minimum. These estimates are for Seward Peninsula and the Yukon-Tanana region. In the Pacific coastal regions the cost of labor, etc., is less.

[b] The writer has used this drill where there were no blacksmith shops. A grindstone and files were used occasionally to sharpen tools when necessary, and this was not frequent.

[c] Freight charges at Fairbanks are \$75 to \$90 per ton; cost of transport to the mines is \$30 per ton in winter and \$120 in summer. It may be many times this high figure, as much as 20 to 25 cents per pound having been paid. Alfred H. Brooks, in the National Geographic Magazine, says: "Translated into terms more familiar to the average man, this means that the mine operator may have to pay a rate on all his heavy machinery equivalent to the charges for express between New York and San Francisco. In fact, I have known mining enterprises to be carried on in localities to which the transportation charges were greater than letter-rate postage."

than that obtained by driving the pipe of a steam drill. The hand drill needs but infrequent driving to sink the casing and as the driving is done while the casing is being rotated it has a maximum effect and therefore less is required.

It may be said in general that where the deposit to be investigated is deep and accessible to supplies and machine shops and the surface is not very swampy the steam churn drill will do the cheaper and more rapid work; where the ground is shallow, swampy, or inaccessible the hand churn drill will give better results. Even if the hand drill were more costly to operate per day or per foot, it would still be a better and cheaper device for prospecting inaccessible areas where the expense for transportation, renewals, and repairs is very high.

NECESSITY OF ACCURACY IN SAMPLING.

The prime object of the drilling method in testing placer ground is to obtain a sample which is a cylinder of material of a known diameter from the grass roots down to and into bed rock as far as ore[a] is found. A pipe is used to penetrate the deposit ahead of the drilling and pumping tools, being kept far enough in advance so that only the material subtended by the shoe on the pipe will be included in the core. The main essential of any sampling with a drill is to get only the material that is properly the core, neither more nor less. The whole operation must be conducted with this feature in mind, and all else should be sacrificed to attain accuracy in this respect. Any phase of operation that results in getting too much or too little core material introduces errors. The ratio of the volume of a sample from a drill hole to the volume of the material represented by the sample is about 1 to 100,000 when one drill hole per acre is sunk. Any errors are thus largely magnified in the calculations of average gold tenor. In sampling a lode the ratio of the volume of the sample to that of the lode is often 1 to 5,000.

Suppose that the drill operation is being conducted in 50-foot ground. Then the volume of the sample will be about one-third cubic yard, or about 50 pans of material. If the drilling is so done that each of 45 of these pans contains 1 milligram of gold, worth 0.06 cent, which ran in from outside the pipe and does not belong to the core, and if the other 5 pans of material indicate a gold tenor of 10 cents per cubic yard and this is the true average for the sample, then the apparent gold content will be 18 cents per cubic yard. If this hole were supposed to test an acre, it would indicate a gross gold content of $14,520, instead of $8,067, the true figure. This error results by obtaining an excess of gold of a total value less

[a] Ore in its mining sense is material that has a valuable content sufficient to make it profitable to work it.

than 3 cents in a drill hole 50 feet deep. Thus a small error in testing ground may lead to a very large error in estimating the value when calculations are made. Such errors have been made in actual practice.

When large bowlders are encountered while prospecting with either steam or hand drills, it is necessary to drill below the pipe before it can be sunk. When this is necessary the pipe should be sunk through the drilled material before pumping is done, to insure against obtaining material not properly a part of the core.

DRILLING SEASON.

Prospecting by drilling can be done at all times of the year, even in winter. Areas that are marshy in summer can be more easily tested with a steam drill in winter, for then the surface is frozen and the heavy drill can be moved without miring. It is easier to drill a stream bed from the ice when the stream is frozen than to test it with the steam drill from a scow.

Seasonal frost interferes with drilling in winter, but ground permanently frozen can be drilled in winter as rapidly as in summer. Very cold weather is liable to cause inaccuracies in handling material from the pipe. A small tent warmed with a stove affords shelter for the panner and should be used.

RELIABILITY OF DATA PROCURED BY DRILLING.

If extensive work has been done in Alaska at any place where exploitation was preceded by close drilling, the information obtained, so far as the writer knows, has not been published, and therefore figures comparing prospecting and operating results in that Territory can not be given. It is possible, however, to give some data of value from other regions where drill holes have been checked by subsequent exploitation. In regions where ground has been tested by close and systematic drilling, the results of extensive subsequent mining have shown the reliability of this method of prospecting. A great amount of care must be exercised in any prospecting of alluvium in Alaska. Gold occurs generally in extremely irregular pay streaks. Any prospecting, to be reliable, must be of such scope as to delineate these pay streaks and to determine their bearing on the average gold content of the total volume of alluvium under investigation.

When the drill method is used to locate bonanzas and not to make a fair test of large areas of low-grade alluvium, the results give false averages. When prospecting with drills is properly done the results are reliable. Accuracy, however, has been sacrificed to speed in many tests, as where the drilling has been done without a pipe. The drill method has been badly abused and much of the information so acquired will prove unreliable; but there is no reason why drill prospecting should not be as trustworthy in Alaska as in the States, where results attained by well-conducted drilling are accepted without question.

SHAFT PROSPECTING.

Shaft prospecting consists in making openings of such size as permit a personal inspection of the alluvium. Under this general head will be included, for convenience, shafts, inclines, winzes, upraises, drifts, and horizontal, vertical, or inclined open cuts. The advantage of shaft prospecting is obviously that it permits a close inspection of the alluvium and the obtaining of large samples. Any peculiarities of the alluvium and bed rock can be examined in detail. Large samples tend to compensate for irregularities in the distribution of the metallic content and thus are more likely to indicate a true average of the material being tested. The material excavated from the openings is panned, rocked, or sluiced, and its metallic content is saved.

No average can be given for the cost of shaft prospecting, as it depends on the characteristics of the material being investigated. In Alaska [a] it may cost about $1 per foot under the most favorable conditions, or it may cost more than $50 per foot where the conditions are difficult.

The reliability of the shaft method of prospecting is treated elsewhere in this paper (pp. 66–67). Some incongruous work has been done by the advocates of shaft prospecting, many of whom claim that it is a far superior method to that of drilling. They have sunk shafts and other openings of considerable size and then merely panned a very small proportion of the excavated material. The samples so panned were taken with little regard to the requirements for obtaining a fair average, and in a generally unsystematic and irregular way. Such inconsistencies are often seen and the advantage possible in getting large samples by shaft prospecting may be entirely lost by careless sampling of the excavated material.

CHOICE OF PROSPECTING METHOD.

Without regard to the geology, all Alaskan placers may be classified as shallow or deep. For convenience of consideration in this paper, all placers less than 25 feet deep are arbitrarily called shallow. Such placers, at or near sea level, if so wet as to require pumping, can be investigated with shafts while the pump is set on the

[a] In the Fairbanks district shafts about 4 by 6 feet and about 100 feet deep cost on the average about $8 per foot. In frozen ground very little timbering is required, only a few sets being necessary at the collar of the shaft to prevent caving of the surface material under the influence of thawing.

surface of the ground. The practical limit of suction at sea level is about 25 feet. Placers deeper than 25 feet or of less depth and at higher altitude, if wet, must be drained by sinking pumps to the necessary depth. This necessitates a larger shaft to accommodate the pump, pipes, etc., and obviously will increase the cost per foot.

The choice of prospecting method is governed by a number of considerations, some of which are influenced by conditions foreign to the actual prospecting. For instance, a deposit well adapted to investigation by the steam drill may be so inaccessible as to make it good practice to use hand drills or shafts instead. The rapidity, cost, and accuracy are the governing factors in making a choice of method. Many deposits have features that make one method particularly applicable. In some places conditions are such that either the shaft or the drill method may be employed with equally good results; both may be used advantageously. The frozen condition of many of the Alaskan placers makes it possible to use the shaft method in alluvium which, if unfrozen, could be tested by shafts only at a large cost for pumping and timbering.

Where shallow, narrow creek beds are to be prospected it is often good practice to make open cuts clear across the bed, or far enough to delimit the pay streak. Such creeks generally have extremely irregular pay streaks, and cuts of this character would determine the distribution of gold content with thoroughness. Work like this may be costly, but the compensating advantages often justify it.

In a shallow placer less than 10 feet deep and containing no water, or so little water that it can be easily bailed, prospecting can generally be more cheaply and rapidly done with shafts or open cuts than with drill holes sunk with a steam churn drill. Material can be thrown out of a shaft 10 feet deep and no timbering is ordinarily required if the shaft is kept free of water during the sinking. Only one man per shaft is required if there is only a small amount of bailing and if the gravel is unfrozen and easily broken down. At the wages prevailing in 1907 in the Yukon and on Seward Peninsula, 5 feet or more can be sunk per day at a cost of about $1 per foot. Under such conditions the steam churn drill is at a disadvantage, for much time may be consumed in frequent moving from hole to hole. This is particularly true if the surface is so rough or marshy as to make moving difficult. The hand drill, being mobile, can be used advantageously in such shallow gravels, where it can generally drill 25 to 40 feet or more per day, at a cost of about $1 to $2 per foot.

If the alluvium to be tested has a depth of about 25 feet and is so wet as to require a steam pump drill methods are more applicable than shafts. Such unfrozen gravel is generally loose or becomes loose on exposure to the air or by reason of water running into the shaft.

Shaft sinking will be slow and costly, as close timbering and breast boarding or sheet piling may be necessary. Samples taken under such conditions are likely to be inaccurate, for running ground may enter the shaft. The fact that the material from the shaft is shoveled under water, possibly from a rough bed rock or from a soft bed rock which may become sticky by reason of the man puddling it as he works, also introduces inaccuracies. Such conditions are not exceptional; on the contrary, they are generally encountered in prospecting the loose, low-lying gravels of stream beds. When greater depths are attempted in such ground, the same difficulties are encountered in greater degree; the cost of the work may be prohibitive and the samples so unreliable as to be worthless. Under such conditions the churn drill method is preferable. The circumstances that cause slow and costly progress and inaccurate sampling with shafts have no bad effect on steam or hand churn drills. In general, where the gravel is dry, as accurate or more accurate sampling can be done with shafts as with drill holes, but the presence of water in such volume as to require pumping makes drilling preferable.

It is often good practice to use both drill holes and shafts, the idea being to use only enough shafts to allow inspection of the physical character of the gravel, bed rock, etc., and to depend on the drill holes for the determination of the tenor, extent, and thickness of the gravel. If a certain sum is allotted for an examination, this sum will generally, on account of the greater cost of shaft prospecting in wet gravel, pay for the sinking of fewer shafts than drill holes. It is a question whether it is better to have a few large samples or many small samples from a deposit. The peculiar conditions of the alluvium under consideration must therefore be the determining factor.

The irregularity of gold distribution in the alluvium of Alaska makes careful prospecting necessary in order to determine the limits of the pay streaks. Many samples may thus be needed. As a general rule, drill holes are better suited to this work, for they can ordinarily be sunk more rapidly and more cheaply.

Where bench gravel is to be tested, cuts can be easily made. Vertical sampling is thus done, and this method has been used with good results. It is assumed that gravel in the same stratum or at the same perpendicular height above bed rock has the same general tenor and characteristics.

Prospecting has so far in this paper been treated as the obtaining of samples merely. Sometimes it may be conducted as a working test. This is particularly applicable where there is an available water supply. Thus cuts may be ground sluiced through bench gravel and considerable amounts of material washed. Such cuts also permit subsequent sampling of the gravel section to good advantage. Inasmuch as this is a working test, data relative to operating cost may thus also be obtained.

A governing factor in the choice of the prospecting method is the kind of information that is required. Thus in testing alluvium thought suitable for hydraulicking, information concerning the section of gravel from grass roots to bed rock is desired, and generally this can best be obtained by sinking shafts or drill holes. In testing alluvium for drift mining little information is required in regard to any part of the gravel section except that adjacent to bed rock. Openings that follow this lower stratum will, of course, give a maximum of information with a minimum of excavation.

HYDRAULIC MINING.

Hydraulic mining consists in excavating, transporting, and sluicing gold-bearing material and disposing of the tailings by water power. The deposit must be so situated not only that abundant water is obtainable under pressure, but that ample grade for boxes and ground for dumping tailings is procurable. Topography like that of the Sierra Nevada of California and that of the Alaskan coast region is favorable to hydraulic mining. The water supply is not large in most of the great placer districts of Alaska, and ditches must generally be built for considerable distances and over extremely unfavorable ditching ground. Good reservoir sites are few, and dams are difficult and costly of installation and maintenance.

Any installation of mining equipment on a large scale, involving the expenditure of large sums of money, is much more handicapped by the hostile conditions encountered in Alaska than smaller enterprises. This is particularly true of new camps, where the cost of labor, supplies, and transportation is high. In general, before costly equipment of any sort is installed in Alaska placers, it is well to investigate carefully all methods requiring only cheap equipment which may be applicable to the ground under consideration. Only close prospecting can determine what method is most suitable, and it should therefore be done very carefully. Some mistakes have been made in installing expensive water-supply systems without first determining the volume of the alluvium to be worked. It has been found, after beginning operations, that much less material that could be profitably worked was available than was expected. This smaller amount was insufficient to warrant the installation of the plant. Such disasters are the result of inadequate prospecting.

It should be noted that small hydraulic plants have been successfully used in many places to supplement other mining methods. Even when these could be operated only during a part of the season, they have often been made to pay.

Pumping water for hydraulicking has been done in Alaska and the Klondike by means of steam power, but apparently not with financial success. From 1903 to 1906 the operating cost alone for hydraulicking in this way in the Klondike, where it was done on a large scale, was over 50 cents per cubic yard. Fuel cost $15 per cord at the boilers. Where cheap water power is available, electricity may be generated and transmitted to a pumping plant. Under these conditions mining with water may be done profitably, but few plants of this kind have been installed anywhere and these have not been an unqualified success. The use of a large volume of water under a low head to pump a relatively small volume of water against a relatively high head has been tried in but few places and it does not seem to have been entirely successful. Pumping for hydraulicking, or indeed for any kind of placer mining, is a difficult and costly operation, and particularly so in Alaska.

Hydraulic elevators have been installed in some localities where the topographic features are generally unfavorable to ordinary hydraulicking. Although some of these operations have been successful it seems likely that in several of them a more economical method of utilizing the water might have been used. It is well known that the hydraulic elevator is an extremely wasteful machine. It has an efficiency of only about 10 per cent; that is, it generally requires 10 feet of head to elevate the material 1 foot, and of all the water used about two-thirds goes to run the elevator, the rest being available to break down and transport material to it. It is obvious that where but one-third of all the water used is applied to excavating and transporting material (generally under unfavorable conditions resulting from low banks, flat grades to the elevator, and a lack of bed-rock cuts) only a small duty is attained. A duty of less than 1 cubic yard of material moved per miner's inch per twenty-four hours is not exceptional. Similar material favorably located for hydraulicking is handled in other districts at the rate of about 5 cubic yards per miner's inch per twenty-four hours.

Certain factors are conducive to economical work with the hydraulic elevator. They are, first, a fairly deep bank of gravel, say 18 to 25 feet, for in such places the elevator has to be moved a minimum number of times; second, wash of such size that nearly all will pass through the throat of the elevator without necessitating the breaking of large bowlders; third, abundant water; fourth, a deposit so situated that dump must be obtained artificially; and fifth, a deposit carrying much water which would by another method need to be pumped from the pit.

Unfortunately, where water is abundant, as in the regions of high relief, the bowlders are so large and so numerous that the use of elevators is precluded. Therefore this method of mining usually involves the construction of long ditches and consequently large investments, so that extensive gravel deposits of determined value are necessary to obtain profitable returns. In spite of the obstacles, hydraulic elevators are being used, and the operators report success. In a number of localities they have been applied to the removal of the finer overburden, the auriferous gravels being later shoveled in by hand. This procedure is due probably to the fact that the elevator is more or less mobile; at least it can be moved with more facility than can many other forms of equipment which handle gravels on a large scale. In deep ground a large amount of material can be handled at one setting. In one instance on record 180,000 cubic yards were moved from one setting.

OPEN-CUT MINING.

Open-cut mining on a small scale generally includes a considerable expenditure for hand labor, though modified hydraulic mining of some sort may also be used in conjunction with it. Machinery is also often used in excavating, transporting, and sluicing material. The following list of operations shows the great variation in open-cut practice in the Far North: Shoveling to platforms and then to sluice; shoveling into wheelbarrow, wheeling to bucket, and raising on inclined cableway to sluice; shoveling into buckets and hoisting by derrick to sluice; shoveling into cars and hauling on inclined track to sluice; steam shoveling into skip and hauling on cableway to sluice; steam shoveling into sluice sustained on same car with shovel; steam shoveling into sluice sustained on another car; hand shoveling into a troughed belt and conveying to sluice; excavating by ground sluicing or with water under pressure from gravity or from a pump, and sluicing to chain of elevator buckets or a dredging pump raising to sluice; steam scraping to sluice; hydraulicking to hydraulic elevator and raising to sluice.

It is obvious that all these methods can not be described here, nor can their merits and faults be considered. Attention will be called to certain conditions which make some of these methods unsuitable for some localities. Thus steam shovels are not well adapted to mining frozen ground when steam thawing is necessary. The use of belt conveyors or bucket elevators or dredging pumps for transporting material in mining shallow frozen gravel is generally bad practice, because they are heavy to move and costly. In general, in Alaska bulky and heavy machinery should be avoided so far as possible. In the opinion of the writer, as a general rule the steam scraper is the best machine for use in excavating shallow frozen alluvium and where steam power must be used. This conclusion coincides with the statement made by Purington in 1905.[a] Where water power is available, it can be used for scraping.

The inclined cableway and derrick are generally the best machines to transport material to the sluices. Any device that is difficult to move is unsuited for such work, because there is constant need of keeping the means of transportation abreast of the advancing excavation. There is some difficulty in moving mechanical lifts, and for this reason they are not kept near the excavations and there is consequently a loss of time and power. The factor of mobility is an all-important one in placer mining; any mechanism that is not easily mobile must have great compensating advantages to make its use advantageous. Too much emphasis can not be laid on this point.

DREDGING.

GENERAL CONDITIONS.

The success of dredging in California during the last decade has resulted in a widespread tendency to apply this method in a rather unthinking way. Probably 100 dredging machines of various kinds, including those intended for Nome beach mining and not all of the floating type, have been installed in Alaska and all but a few have been failures. This emphasizes most forcibly the prime importance of proper prospecting before installing dredges. It is not the object of this paper to treat gold dredging in detail, but some of the conditions peculiar to Alaska affecting such work will be discussed.

The factors that influence the actual operation of a dredge can be divided into two groups—those intrinsic and those extrinsic to the deposit. Both of these groups influence working cost, and any prospecting to be comprehensive must include consideration of them.

The principal intrinsic factors are: Degree of induration of the gravel; distribution and character of bowlders, clay, and buried timber;[b] occurrence and character of bed rock; average depth to bed rock; average depth to ground water; superficial conditions; average distribution of values and peculiarities of metallic content; by-products, such as platinum; distribution and character of frost, both permanent and seasonal.

The extrinsic conditions are climate, water supply, power possibilities and fuel, labor, cost of supplies and transportation, and installation cost.

Transportation to Alaskan placer fields, which naturally affects operating cost in a great degree, is generally difficult and costly. Climatic conditions are in the main unfavorable. The working

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[a] Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905, pp. 63–65.

[b] Buried timber is not common in Alaska. In the gravel of a bench on a tributary of Kougarok River a log estimated to be 80 feet long was found.

season is seldom over 125 days a year. Water supply, for power, is commonly insufficient. Fuel is usually scare and costly. Installation cost is so high that a dredging plant in most parts of Alaska will cost about twice as much as a similar plant in the States. Ground frost (see pp. 55–56) is a prime factor affecting dredging in most parts of Alaska.

To dredge successfully there must be a sufficient volume of auriferous alluvium, and how great this should be is not easy to state. The life of a dredge is about ten years, so there should be at least enough ground to last that length of time. Generally, the richer the alluvium the less bulk is required. The large dredges, with buckets of 10 to 16 cubic feet capacity, handle over 6,000 cubic yards per day; the small ones, with buckets holding 3 to 5 cubic feet, handle 250 to 1,500 cubic yards per day. Thus in dredging alluvium 30 feet deep the large dredges dig about 3 acres per month and the small dredges from one-sixth to 1 acre per month. The ratio of gold content to the volume of the deposit under consideration must be accurately determined.

The capacity of the dredges should be determined by the character of the ground. It is not good policy to build very large dredges for the Far North, partly on account of the difficulty of transporting heavy pieces; on the other hand, dredges that are too small have such low capacity and such high operating cost that they are not profitable.

DREDGING IN FROZEN GROUND.

There are millions of cubic yards of auriferous alluvium in Alaska that could be very profitably worked were it unfrozen, or were it possible to thaw it cheaply. The principal problem in dredging deposits of this type is that of thawing. At present not only is the problem unsolved, but the chances of an early solution are not encouraging. Dredging can now be carried on in frozen ground only where a very high gold content will warrant the cost for steam thawing.

Frozen ground is very much like concrete in hardness. It is not mechanically impossible to excavate it, but the wear and tear and breakage are so great and the capacity of machines working it is so small that such work can not be done economically. Even were it practicable to excavate frozen auriferous alluvium, it would still be impossible to extract its metallic content without first thawing it to disengage the gold. It can be blasted, but it immediately reunites along the lines of fracture by regelation where there is contact between the fragments. Blasting with shallow holes is often done and with moderate success, for then the broken material may be so shattered as to allow air spaces, so that it can not freeze again by regelation. Frozen ground of homogeneous structure, like some rock, breaks badly in blasting. A vertical blast hole will often break only a conical mass, the apex being at the bottom of the hole. Blasting frozen ground is therefore very costly.

In 1903 an attempt was made in the Klondike to blast frozen alluvium preliminary to dredging. Drill holes were put down with a steam churn drill to bed rock, a depth of about 15 feet, and blasting powder containing 40 per cent of nitroglycerin was used. It was hoped that, after blasting, water would run into the fractures and thus induce thawing, but it was found that the fractured mass reunited by regelation, and thawing had to be done by steam. Frozen alluvium above the present water level contains a smaller percentage of ice and thaws much more rapidly than that below the present water level. Seasonal thawing has been observed by the writer in well-drained bench gravel to a depth of more than 20 feet. Thawing progresses very slowly below water level, for the temperature of the ground water is generally only little above the freezing point.

Thawing ground for dredging has been tried in two ways—(1) by the use of steam, or (2) by stripping the nonconducting surface layer of soil and moss, etc., with mechanical or hydraulic methods and thawing by exposure to the sun and air. Attempts are being made to evolve an electrical thawer, but it has not been used on a commercial scale.

Steam thawing for dredging is not as simple as when drift gravel is attacked. It generally involves sinking the steam points 15 feet or more in order to reach bed rock. This is difficult, for if a steam point strikes a large, hard bowlder, it will be deflected into the ground that a neighboring point is expected to thaw, while its own ground will be left frozen and thus interfere with subsequent dredging. It is impossible to drive steam points to depths much greater than 5 to 8 feet in gravel containing hard round bowlders. To thaw such gravel with steam it would first be necessary to drill a hole before the point could be used, and this would probably make the cost prohibitive.

Steam thawing for a dredge in the Klondike, operating in ground previously worked by drifting or open cutting, is estimated to have cost 25 to 40 cents per cubic yard. This ground, as a result of the previous working, was irregularly frozen, parts of it requiring little or no thawing. Great difficulty was experienced where old open cuts had been partly filled with "muck," which when frozen yields very slowly to a steam thawer. The cost of steam thawing dredging ground in Alaska will not generally be much if any below these figures.

Thawing by stripping and exposure to the air has been successfully done in some places, but so far as known to the writer the attempts to prepare dredging ground in this way are yet chiefly in the experimental stage. Where shallow gravels are so located as to drain while the interstitial ice melts, ground can be thawed in this way. It is evident that this method is best adapted to thawing gravel located above water level. In places where there is abundant water and sufficient grade the muck and moss can be stripped for less than 10 cents per cubic yard, but where the grade is low the overburden generally can not be removed so cheaply.

Plans are under way for exploiting the tundra gravels lying between the sea and the hills near Nome by hydraulic stripping and by exposure to the sun and air. It is thought that progressive thawing will continue and that after several years the total gravel section, in places more than 100 feet deep, will be thawed. The plan outlined is as follows: The moss and soil will be stripped as far down as convenient by ground sluicing and the underlying material will be exposed to the sun and air and allowed to thaw until just before the freeze-up, when the ground will be flooded to a depth of several feet. When the freeze-up comes the ground will be covered with ice, which it is assumed will prevent more than slight superficial freezing of the material below it. The ice will melt early next season, and then the gravel will thaw again, to a greater depth. This will be continued for several years until the thawing has reached bed rock. There are many undetermined factors involved in this plan, but we may disregard all except two. It has not been definitely established that the ground thawed in summer will remain thawed during the winter, even if covered with a blanket of nonconducting ice. It has been observed in some localities that ground thawed in summer, either by steam or otherwise, freezes again even during the summer if at a considerable depth and away from the influence of sun and air. This seems to be caused by the adjacent frozen ground abstracting heat to such a degree as to freeze the thawed mass. It would appear, therefore, that the temperature of some of the frozen ground is somewhat below 32° F., though there are no accurate observations on this point. Another important factor in this mode of thawing is the physical character of the material. If it is gravel or sand, it will thaw to considerable depth when the surface coating is stripped. If, however, loose material is interbedded with impervious clay or humus—a condition that exists in some places—these may have to be stripped before the heat can reach the underlying loose material.

DREDGING IN UNFROZEN GROUND.

The capacity of the Alaskan dredges operating in unfrozen ground is about the same as that of similar dredges working in the temperate zone. The material, when unfrozen, is generally more favorable to rapid handling than that dredged in California and Montana. The dredges may be thoroughly overhauled each winter and therefore they can run through the entire working season without extensive repairs, and there is consequently a smaller amount of lost time. Some instructive data bearing on this point may be given. Two dredges of exactly the same capacity, design, and construction have been working for several years—one in the indurated gravel at Oroville, Cal., the other in unfrozen gravel in the Klondike. At Oroville the working season extends throughout the year; in the Klondike it covers one hundred and fifty days. The Oroville dredge has averaged about 2,900 cubic yards per day; the Klondike dredge about 3,400 cubic yards.

COST OF DREDGING.

On Seward Peninsula, with a well-designed steam dredge and with coal at $20 per ton, the cost of dredging is probably about 20 cents per cubic yard. This cost is for gravels which are fine, generally unfrozen, and of medium depth, lying upon a generally favorable bed rock. Gravel of similar character is dredged in more accessible regions in the States for less than 8 cents per cubic yard, but for most of Seward Peninsula the figure given above will probably be little, if any, reduced under present conditions.

Dredging costs more in the interior than on the coast on account of the greater expense of transportation, etc. A dredge with buckets of 7.5 cubic feet capacity is working in generally unfrozen and favorable ground in the Klondike. Wood costing about $8 per cord is burned and a steam turbine is used to generate electricity for the dredge. The operation is said to cost about 12 cents per cubic yard, but it is likely that even with these favorable conditions the real cost is little, if any, under 20 cents per cubic yard.

Dredging cost in frozen ground is increased by thawing cost, which may range from about 25 cents to 40 cents or more per cubic yard; it may even be as it has been in certain places in the Klondike, more than 80 cents per cubic yard. It is not likely that dredging frozen ground requiring steam thawing can ever be conducted for less than 50 cents per cubic yard unless a new means of thawing shall be evolved. This means that inasmuch as it is exceptional to find extensive deposits of alluvium of such high tenor, frozen ground in general can not be dredged profitably.

DEPTH OF DREDGING.

Dredging can be prosecuted to as great depth in Alaska as elsewhere. In California excavation is now being carried to a depth of about 65 feet below the water level of the pond in which the dredge is floating. This is the greatest depth yet attained, but it is by no means the limit, and it can not be predicted what the mechanical limit really is. The greatest depth yet dredged in the Far North is about 35 feet.

Shallow gravel can be dredged if it can be flooded to a depth sufficient to permit floating the dredge over the bed rock. Such thin gravels may be impracticable to dredge, for the dredge must move ahead very frequently and it is difficult to fill the buckets constantly. Many deposits of this nature may be more advantageously worked by other methods. A large area of such material would be needed for dredging, as if the material were, say, 2 feet deep, and if it were dug at the rate of 3,000 cubic yards per day, about 1 acre a day would be exhausted. It may be said, however, that dredges to operate in shallow gravel need but short ladders and stackers, and thus small hulls are sufficient. Such dredges are cheaper to construct and operate than those that mine to a great depth.

DRIFT MINING.

Drift mining will continue to have a wide application in the northern placer fields. It generally requires only inexpensive equipment and it is therefore well suited to the inaccessible parts of Alaska. In this northern field there is generally a concentration of gold content near, on, and in the bed rock, so that a large percentage of the total gold tenor in gravel can be extracted by drifting. As a matter of fact other methods have been applied where drifting should have been undertaken. For instance, if the ground is 21 feet deep, and if 95 per cent of the pay is concentrated in the lower 2 feet of the gravel and the upper 2 feet of bed rock, it will be cheaper to drift than to handle the ground by a hydraulic elevator, on the assumption that the cost of handling gravel with an elevator is $1 a cubic yard and that of drifting is $4 a cubic yard. With the elevator each square yard of bed rock cleaned would cost in ground of this depth more than $7. With drifting the cost would be less than $4 per square yard of bed rock. The gain by the elevator method of the 5 per cent of the entire tenor which is carried in the upper 19 feet would generally not make up for the difference in cost.

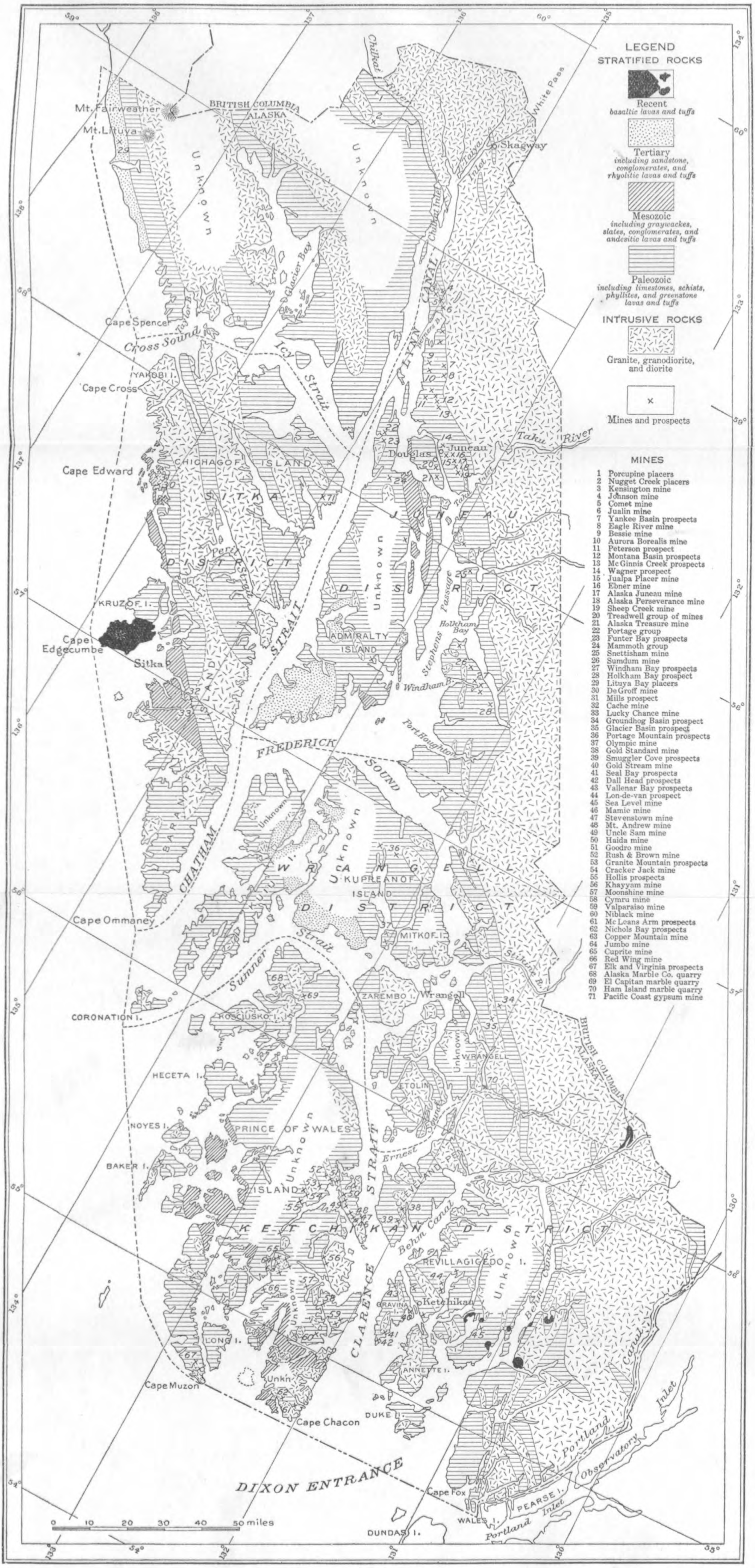
There is nothing spectacular in drift mining and it has no such seemingly powerful fascination as is presented by the mighty streams from the hydraulic nozzle, excavating and caving gravel banks; but a practical man can see that drift mining should have a much wider application than at present. It is reported by Mr. Prindle that under present conditions in Fairbanks [a] ground with gold content less than $2.75 per cubic yard can not be mined at a profit. This is where the drifts are about 6 feet high. It is almost impossible to arrive at

[a] At Fairbanks over half of the operations consist of drifting in alluvium 50 to 200 feet deep.

any exact figures, because very few operators have any definite knowledge of the cost of their work. As a matter of fact, the miners in the Fairbanks district have been so accustomed to mining very rich ground that they are inclined to disregard the lower-grade gravels, some of which could in some cases be profitably mined even with the present cost of labor, supplies, etc.

The cost above given compares very favorably with that of drift mining in some parts of California, which has been more than $3 per cubic yard. The maintenance of long tunnels in swelling ground, the use of much timber, extensive pumping, long haulage, hardness of gravel, etc., are some of the many reasons for costly operation in parts of California. It is interesting to note the operating cost of mining gravel at the Hidden Treasure mine, Placer County, Cal., where economical work has been done. The gravel is of the "white channel" type, which is similar, not only in color but in other features, such as hardness, to that of the "white channel" of the Klondike. It is generally worked without blasting and the breasts must be closely timbered. The working tunnel is about 2 miles long and gravel is trammed out by electric locomotives operated by power generated by water from the mine tunnels. The cost per ton of mining with electric haulage is about 84 cents, haulage 5 cents, total 89 cents. When animal traction was used the mining cost was 90 cents and the haulage cost 12.6 cents, a total per ton of $1.026. At times over 15 men were employed in the upkeep of the main tunnel, which is for a part of its length in swelling bed rock.

The effect of frozen ground on the cost of drift mining has been indicated on page 55. It is interesting to note that there are extensive deposits in the Tanana region that could not be mined by drifting were they unfrozen, for then the expense of pumping and timbering would be excessive. Neither could many of these deposits be mined by dredging, as the depths are in places too great and there is usually insufficient gold in the upper gravel to pay for dredging. The cost for timber varies greatly and no average can be given. Seward Peninsula is generally treeless. Timber is imported from Puget Sound at a heavy cost; therefore near Nome it is usual to abandon mining when unfrozen material is encountered in drifting. At many places in the interior, also, mine timber is scarce and costly.



GEOLOGIC RECONNAISSANCE MAP OF SOUTHEASTERN ALASKA.

LODE MINING IN SOUTHEASTERN ALASKA, 1907.

By CHARLES W. WRIGHT.

INTRODUCTION.

The mining industry in southeastern Alaska has not advanced materially during the last year, and the total metal production was not as great as that for 1906. This slight decrease is attributed to unfavorable conditions of labor and transportation and the fall in the market value of copper. These adverse factors have affected the mining interests not only of southeastern Alaska, but likewise of many of the Western States.

Before considering the ore bodies and mines under development in detail, a brief discussion is given of the general geology of southeastern Alaska and the distribution of the ore deposits within this area. To present the matter more clearly a map (Pl. II) has been compiled showing the general distribution of the rock formations and more particularly the larger areas of intrusive rocks. The scale of this map is about 30 miles to the inch and on it the positions of the mines and prospects are indicated. As the mapping was confined largely to the vicinity of salt water, the geology of many of the inland areas has been inferred and does not represent actual observation.

A striking feature shown on the map is the proximity of the ore bodies to the intrusive areas, thus suggesting a genetic relationship of the mineral deposits of the igneous rocks. The greater occurrence of gold in the northern districts and of copper to the south in the Ketchikan district is also noteworthy.

Detailed statements of the known geologic facts and the character of the ore deposits of the principal mining districts in southeastern Alaska are set forth in the reports on the Juneau gold belt [a] and on the Ketchikan and Wrangell mining districts.[b]

[a] Spencer, A. C., The Juneau gold belt: Bull. U. S. Geol. Survey No. 287, 1906.

[b] Brooks, A. H., The Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902. Wright, F. E. and C. W., The Ketchikan and Wrangell districts: Bull. U. S. Geol. Survey No. 347, 1908.

The investigations of the United States Geological Survey in southeastern Alaska during 1907 were confined to a study of the copper deposits on Kasaan Peninsula, and the preliminary results of this work are set forth in a separate paper in this bulletin. At the close of these investigations the writer visited the principal mines in the Ketchikan and Juneau districts, and notes on their progress during the last year are contained in this report.

An outline of the general geology of southeastern Alaska, with a geologic map, has been presented each year in the Progress Report,[a] but as each successive year reveals new facts it seems advisable to republish in the present report a brief sketch of the general geology of the region, and to add the more complete accompanying map, representing the distribution of the rock formations so far as known. Inasmuch as a large portion of the territory still remains unexplored, and as most of the geologic investigations have been of a reconnaissance nature, some of the statements and conclusions in this, as in former reports, may be modified by more detailed studies.

GEOLOGIC SKETCH OF SOUTHEASTERN ALASKA.

The geologic distribution of the rocks along the southeastern coast of Alaska is on a broad scale, and in their strike they follow the general northwest trend of the mountain ranges. The rocks may be divided into two main groups—(1) stratified rocks and (2) intrusive rocks, both having about the same areal extent.

The stratified rocks include those of sedimentary and volcanic origin, which, except the more recently formed rocks, are in general intricately folded and usually show a high degree of metamorphism. As indicated on the map, these rocks are subdivided according to their age: The Paleozoic, including crystalline limestones, quartzites, schists, phyllites, and greenstone lavas and tuffs; the Mesozoic, including slates, graywackes, conglomerates, some limestones, and andesitic lavas and tuffs; the Tertiary, including sandstones, shales, conglomerates, and rhyolitic lavas and tuffs. The stratigraphic succession of these rock strata is complex, and nearly all the geologic periods, from early Paleozoic to the present, are represented.

The intrusive rocks are made up of a complex of coarse granular rocks, mostly granitic in character. They form the great mass of the Coast Range bordering the mainland and occupy wide areas in the central portions of many of the islands. Their mode of occurrence is at many places directly related to the geologic structures, and the

[a] Wright, F. E. and C. W., Economic developments in southeastern Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 47–68; Lode mining in southeastern Alaska: Bull. No. 284, 1906, pp. 30–53. Wright, C. W., Lode mining in southeastern Alaska: Bull. No. 314, 1907, pp. 47–72.

longitudinal axes and lines of contact of these intrusive masses are usually parallel with the strike of the bedded rocks. These intrusive rocks, the most dominant geologic feature of the mainland, have been discussed by Brooks[a] in the report on the Ketchikan district, and by Spencer[a] in the report on the Juneau gold belt; their occurrence in British Columbia, where conditions similar to those along the mainland of Alaska prevail, has been carefully considered by Dawson.[b]

The Coast Range massif consists of many separate interlocking batholiths intruded at successive epochs but during the same general period of invasion. At the close of this period pegmatite, aplite, and granite porphyry dikes were intruded into the outer portions of the granitic masses and adjacent schists, and contemporaneous with or just subsequent to the intrusion of these dikes the mineral-bearing solutions were introduced. Both dikes and mineral deposits were probably derived from the same igneous magmas, which were the source of the granitic intrusives near which the dikes occur. This general invasion is believed to have occurred during early Mesozoic times.

The later intrusive rocks consist of felsite, diabase, and basalt in the form of dikes cutting both the older and younger stratified rocks and the Coast Range intrusives. These apparently have no direct bearing on the ore deposits.

That the different masses of intrusive rocks are not surrounded by similar metamorphic phenomena and that the apparent metamorphism caused by the mainland intrusive belt is quite different from that effected by the smaller intrusive masses on the islands are facts that have been frequently noted. The stratified rocks flanking the Coast Range along the mainland are intensely folded and metamorphosed and were without doubt deeply buried at the time of the granitic invasion. Deep-seated metamorphic processes were already active and had probably altered these rocks to such an extent that the igneous intrusion did not disturb their equilibrium greatly, its chief effect being to accentuate the processes of crystallization already in force rather than to replace them by others.

The occurrence of innumerable pegmatite dikes along the margins of the Coast Range batholiths is a significant indication of the immense quantities of pneumatolytic solutions given off by the invading crystallizing magmas. These magmatic solutions, containing dissolved metallic sulphides as well as silicates and other minerals, penetrated the adjacent schists, where the temperature permitted the deposition of minerals composing the pegmatite dikes, but was evidently too intense for the precipitation of the metal-bearing min-

[a] Op. cit.

[b] Dawson, G. M., Report on an exploration in the Yukon district and adjacent portions of British Columbia: Geol. Nat. Hist. Survey Canada, vol. 3, pt. 1, 1887–88, pp. 1–277 B.

erals. Farther away from the granitic intrusion magmatic solutions given off by these igneous masses encountered conditions more favorable to the precipitation of the metallic sulphides, and as a result the principal ore bodies along the mainland are found in the slate and greenstone strata 3 to 10 miles from the contact of the Coast Range intrusive mass.

On the islands the stratified rocks, though much altered, do not show the intense metamorphic character expressed in those of the mainland, and the contact-metamorphic influence of the intrusive masses is therefore in greater evidence. The contact metamorphism is confined in great part to areas within a few thousand feet from the intrusives, the amount of alteration being largely dependent on the distance from the igneous mass and the character of the intruded rock strata. The alteration of slates and quartzites to hornfels, the recrystallization of limestone to marble, and the development of garnet, epidote, wollastonite, scapolite, and other minerals in the rock strata are direct evidences of such metamorphic action.

ORE DEPOSITS.

GENERAL STATEMENT.

The distribution of metallic mineralization in southeastern Alaska is confined to certain rock formations, and in these the mineral deposits occur to some extent along certain zones which have been more or less satisfactorily determined. Because of the rough topography and the dense growth of forest and underbrush, investigations of such belts have necessarily been limited to the vicinity of salt water, where the rock formations and mineral belts are clearly exposed.

Some of the facts that have been set forth in previous reports are the following: (1) The metallic minerals usually occur in the proximity of granitic intrusives; (2) for the most part, the ore bodies were deposited subsequent to the granitic invasion; (3) the rocks of post-Paleozoic age are practically barren of valuable mineral deposits; and (4) the ore deposits are genetically related to the granitic intrusives. From these facts it is evident that the areas occupied by Paleozoic rocks and in proximity to the granitic intrusive masses are the most favorable for the occurrence of ore deposits.

PRINCIPAL CHARACTERISTICS OF ORE DEPOSITS.

Three general types of ore deposits are prominent in southeastern Alaska—vein deposits, lode deposits, and contact-metamorphic deposits. Deposits at variance with these types are the breccia veins in limestone, at Dolomi, and the mineralized diorite at the Treadwell mine, which have been discussed in previous reports.

The vein deposits include any mineral mass or aggregate occupying a fissure or fracture in the rocks. In this region they are usually made up of auriferous quartz and calcite, with a small percentage of metallic sulphides, though veins of nearly massive sulphide ore, rich in copper and in some places carrying lead and zinc, are also present. They range from 1 to 10 feet in width and usually crosscut the inclosing rock. Such deposits occur in practically all the older rocks of the district, including the intrusives, but are rarely found in the Mesozoic rocks and have not been observed in the Tertiary sedimentaries or eruptives. These facts and a lack of evidence suggesting mineral deposition previous to the invasion of the intrusive masses indicate the intrusive rocks as the probable source of the mineral solutions from which these veins were deposited.

The lode deposits consist of bands of schistose rock, in places including dike rocks, which are intersected by veinlets of quartz and calcite and impregnated with metallic sulphides. These lodes range from 5 to 50 feet in width and are usually of great persistence both in length and depth. Gold is the principal metal in them and is confined largely to the quartz and calcite veinlets. The lateral limits of the lode deposits are in few places sharply marked, and in the inclosing country rock the mineralized portion gradually changes to the unmineralized rock. Such deposits are prominent in the Juneau district, where they occur in the slates and greenstones, and they are also present on Gravina Island in the Ketchikan district.

The term contact-metamorphic deposits is here restricted to those mineral bodies which have been formed by contact-metamorphic agencies and which carry the minerals characteristic of such action. Such deposits occur mostly in limestone or calcareous rocks, usually within 1,000 feet of the intrusive bodies. The mineral solutions given off from the igneous masses previous to their entire solidification penetrated the adjacent limestone and quartzite beds and ascended along the intrusive contacts, dissolving channels, though in many places taking advantage of preexisting fissures in both the intrusive and intruded rocks. During their ascent the thermic and other conditions of the aqueous solutions changed and their mineral contents were precipitated, gradually filling the channels and fissures. As carbonate of lime is a ready precipitant of these mineral solutions, the largest ore masses were usually formed at points where limestone is the intruded rock. The contact-metamorphic deposits are composed of a massive garnet and epidote gangue in which chalcopyrite, pyrite, pyrrhotite, and magnetite occur in disseminated grains and masses. Such deposits are largely developed at several localities on Prince of Wales Island. They range from 25 to 200 feet in lateral dimensions and are confined to the contact aureoles of the larger intrusive masses.

DISTRIBUTION OF MINERAL DEPOSITS ALONG THE MAINLAND BELT.

Within the mainland belt, which includes the adjacent islands, mineralization is scattered both in the granitic intrusives and in the adjacent stratified rocks. Along certain lines or zones and in certain rock formations this mineralization is greater than at other points, and such zones are termed "mineral zones." As noted above, the highly metamorphosed schists adjacent to the Coast Range intrusive belt are less favorable for the occurrence of valuable ore deposits than the slates and greenstones which border the coastwise channels.

The most extensive and productive zone is the Juneau gold belt, which has been irregularly traced along the mainland from Windham Bay to a point 10 miles north of Berners Bay, where it enters Lynn Canal. It has a total length of 120 miles and a width of less than 10 miles. In this zone gold is the dominant metal present and occurs in varying amounts disseminated with sulphide minerals in bands of schistose rock 10 to 60 feet wide; in altered diorite dikes, where it is associated with stringers of quartz; and in quartz veins, 1 to 10 feet wide, cutting either the intrusive or schistose country rock. These ore bodies within this zone are discussed at length by A. C. Spencer in his report on the Juneau gold belt.[a]

In the Wrangell district the concentration of metallic minerals along definite zones has apparently not taken place, though a number of mineral prospects have been found, namely, in Thomas and Le Conte bays, along Bradfield Canal, and in Groundhog and Glacier basins. At the last two localities silver and lead ores, occurring in quartz veins inclosed in the crystalline schists, are prominent; at the others gold is the dominant metal.

Within the mainland belt of the Ketchikan district, which includes Revillagigedo Island, quartz veins and mineralized schist bands are found locally, but they are too widely separated to permit the definition of a mineral zone like that in the Juneau district. The slates and greenstones contain the largest percentage of metallic minerals, and in them deposits have been developed on Gravina Island, along the west shore of Revillagigedo Island, and on Cleveland Peninsula. In the slates and schist nearer the Coast Range intrusives vein deposits have been found at the head of Thorne Arm and in George Inlet. For the most part the deposits in the mainland portion of the Ketchikan district consist of simple veins in fissures and lode deposits of complex composition, containing only moderate values in gold.

[a] Op. cit.

DISTRIBUTION OF MINERAL DEPOSITS ON THE LARGER ISLANDS.

On the larger islands of southeastern Alaska the regularity of the rock structure and the continuity of the formations is locally interrupted by intrusive areas of granitic rocks and wide channels separating the islands. For this reason it is not possible to trace for any great distance mineral zones comparable with those along the mainland. The occurrence of the deposits on each island differs somewhat, and the islands are described separately in this paper. In general, the ore bodies appear to be closely connected with the intrusive rock masses, many of them lying at or near the contacts of the intrusives.

On Admiralty Island valuable mineral deposits have been found at two localities. The central and southern portions of the island are occupied by Tertiary rocks comprising sandstones, conglomerates, lavas, and tuffs, in which no mineralization of importance occurs. The northern portion of the island is made up of Paleozoic beds which are metamorphosed and locally intruded by granitic masses. The areas of intrusive rocks, so far as known, are small, and the occurrence of valuable mineral deposits is relatively rare. A poorly defined mineral zone starts at a point just north of Windfall Harbor, on the west side of Seymour Canal, and is traceable northwestward to Funter Bay. It is about 30 miles long and 2 miles wide and includes several prospects but no producing mines. Other prospects are located on the west coast of the island a few miles north of Kootznahoo Inlet.

The two seaward islands, Baranof and Chichagof, which constitute the Sitka mining district, are made up of a central core of intrusive rock. These intrusives invade Paleozoic limestones, quartzites, and schists, which are overlain by greenstones and graywackes of late Paleozoic or early Mesozoic age. A poorly defined mineral zone occurs in the metamorphic schists flanking the west side of the intrusive belt, starting at Red Bluff Bay, on the east side of Baranof Island, and extending northwestward, including the prospects at the head of Silver Bay and in the vicinity of Cape Edward, north of which it enters the ocean. Auriferous vein deposits are the principal type of ore body in this mineral zone. Another zone of mineral-bearing schists was noted along the east side of this intrusive belt, extending from Hooniah Sound to Lisianski Strait and northwestward on the mainland from Cape Spencer to Lituya Bay, where it flanks the St. Elias Range. Only a few prospects in the vicinity of Rodman Bay and at the head of Hooniah Sound have thus far been located in this mineral zone.

Kupreanof and Kuiu islands may be described together. They differ from the other islands in their lack of intrusive areas and in having relatively low topographic relief. Their central and southern portions are covered by basaltic lavas and tuffs overlying the Tertiary coal-bearing formations exposed in Hamilton Bay, all of which are barren of minerals. Triassic beds appear in Hamilton Bay and overlie Carboniferous limestones. A succession of slates and greenstones, probably of Carboniferous age, occupies the eastern portion of Kupreanof Island, and in these rocks mineral deposits carrying both gold and copper ores occur and have been developed at several points along Duncan Canal and Wrangell Narrows. Along the western and southern shores of Kuiu Island is a great thickness of quartzites and graywackes, which underlie beds of Silurian limestone exposed at Meade Point on the north end of the island. In these rocks no important mineral deposits have been found.

The distribution of mineralization on Prince of Wales Island, like that on the other islands, is dependent on the intrusive areas. Here the direct relations of the ore bodies to the intrusive rocks are more evident because the ores occur in many places along the contacts of the intrusive and intruded rocks. The intrusive areas are irregular masses and are most prominent along the eastern and southern portions of the island. Limestones, greenstones, and phyllites are the principal stratified rocks. Copper is the dominant metal in many of the deposits. It is present within the contact aureoles of the intrusive masses, as on Kasaan Peninsula and in the vicinity of Hetta Inlet, and occurs as lenticular masses or veins along shear zones in a greenstone schist country rock, as at Niblack and Copper City. Gold accompanies the copper deposits as an accessory constituent and is found in vein deposits inclosed in limestones at Dolomi and in black slates or phyllites in the vicinity of Hollis.

GOLD MINES AND PROSPECTS.

GENERAL STATEMENT.

The gold mines of southeastern Alaska are few and scattered and only a small number of the many gold prospects have been developed to the producing stage. Although this metal is widely distributed in all the older rock formations in the form of both veins and lodes, it is rarely found in deposits sufficient in size and grade to constitute valuable ore bodies, and those localities where the ore bodies are being mined are necessarily situated but a short distance from tidewater, where transportation facilities and water power are available. The ore produced from these mines is for the most part free milling—that is, an ore from which the greater percentage of the gold content can be extracted by amalgamation. It is therefore most advantageously treated in a stamp mill by amalgamation and concentration, and the concentrates alone should be shipped to the smelter for treatment. However, in certain instances, where a siliceous ore is in demand, the gold ore has been sold direct to the smelter. In general the vein deposits contain the largest values per ton, but the lode ores, though lower in grade, are present in greater quantity. Deposits of both types are being mined with profit.

GOLD PRODUCTION.

The 1906 production from the gold mines in southeastern Alaska is given in the following table:

Production of the gold mines in southeastern Alaska, 1906.

Ore mined.	Gold.		Silver.		Average per ton.			
					Gold.		Silver.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
Tons. 1,399,456	*Ounces.* 159,634.68	$3,298,943	*Ounces.* 23,532	$15,772	*Ounces.* 0.115	$2.38	*Ounces.* 0.017	$0.011

The production for 1907 has not been as large as that for 1906, though the decrease is slight. The exact figures can not now be given, as the statistics are not complete. To obtain the total gold production of southeastern Alaska, that from the copper mines, which amounted to $62,831 in 1906, should be added to the above figures. It is to be noted that nine-tenths of the gold output was from the Treadwell group of mines on Douglas Island.

JUNEAU MINING DISTRICT.

Operations have been in progress at most of the mines within the Juneau district, though there are few mining developments to be noted. Prospecting has advanced along the gold belt to the north of Eagle River, and at the head of Gold Creek, where auriferous quartz veins are being explored. On Douglas Island and to the south of Juneau no new finds are reported. The production for 1907 from these mines was somewhat less than it was for 1906.

MINES ON DOUGLAS ISLAND.

The Treadwell group of mines on Douglas Island, which is the principal gold producer in southeastern Alaska, has been fully discussed by Spencer [a] and Kinzie,[b] and only a brief statement of the recent developments will be made here. An interesting improvement at this group of mines is the introduction of the use of oil in place of coal for steam-producing purposes. This economizes both in labor

[a] Op. cit.

[b] Kinzie, R. A., The Treadwell group of mines, Alaska: Trans. Am. Inst. Min. Eng., vol. 34, 1904, pp. 334–386.

and the initial cost of fuel, and has greatly reduced the costs for power. The available water power has also been increased by enlarging the dam at the head of Fish Creek and building a small dam on Bullion Creek.

At the Alaska Treadwell mine the principal developments were advanced on the 1,450-foot, 1,250-foot, and 1,050-foot levels, and on these the ore body has been opened for a width of 450 feet. The shaft has been extended to the 1,650-foot level. The ore extracted was derived principally from the 750-foot and 900-foot levels. On the adjoining property, the Seven Hundred Foot claim, the 990-foot level was extended to connect with the 1,050-foot level of the Treadwell mine, and developments were advanced on the 880-foot and 990-foot levels. The ore mined is sent to the mill at the Mexican mine for treatment, though the old 100-stamp mill on the Seven Hundred Foot claim is being remodeled and will be used to treat the ore from this claim in the near future.

At the Mexican mine development work has consisted essentially in the opening up of stopes from the 550-foot and 770-foot levels on the hanging-wall ore body. On the 880-foot and 990-foot levels stopes have been extended into the main ore body. The 1,100-foot level is being extended to the east and west and will undercut the workings on the Seven Hundred Foot claim.

The Ready Bullion mine workings, which extend well out under Gastineau Channel, have attained a depth of 1,650 feet, the principal developments having been extended on the 1,500-foot level. The character of the ore body was not found to change materially at this depth. Most of the ore mined was derived from the 1,300-foot, 1,200-foot, and 1,000-foot levels.

The other properties on Douglas Island have been idle during the year.

GOLD CREEK MINES.

The development of the mines along Gold Creek did not advance to the extent anticipated in 1907, and has been hindered considerably by litigation difficulties. Plans have been made for large improvements during 1908.

The mines, the Ebner, the Alaska Juneau, and the Perseverance, are developing low-grade lode deposits within a mineral belt 800 feet wide, extending from the west side of Gold Creek southeastward over the divide to Sheep Creek, a distance of 6 miles. The lodes, usually from 10 to 50 feet wide, are the richer portions of this mineral belt, within which the black slates and dike rocks are intersected by numerous quartz stringers and the rock itself is impregnated with sulphide minerals.

The Ebner mine was in continuous operation the first half of the year, and during this period the 15-stamp mill was running most of the time. In the second half of the year work was suspended.

Operations at the Alaska Juneau mine were renewed the first week in June and continued till the first of November. The weather conditions during the winter months are unfavorable to the open-pit method of mining employed at this property. The 30-stamp mill was in continuous operation during this period. A tunnel and raise was extended to undercut the west end of the upper pit, and a hoist and tramway were installed at lower pit No. 2, from which one-half of the ore milled was derived.

At the Perseverance mine underground developments were in progress throughout the year. The ore was stoped largely from the main raise extending from the adit tunnel to the surface, a distance of 920 feet. The ore body, which at this point is from 60 to 80 feet in width, has been developed by a drift 1,100 feet in length, and from this drift at intervals of 20 feet chutes are being extended to an intermediate drift 25 feet above. From this intermediate level stoping of the ore has begun over a length of 150 feet to each side of the raise. A stamp mill below the mine began operations with 30 stamps on June 1 and two months later 50 stamps were put into use. In November 100 stamps were ready for use, but the weather necessitated the discontinuance of milling operations for the year. With the completion of the proposed improvements for water-supply and power purposes, it will be possible to operate the 100-stamp mill during the greater portion of the year. Small developments were made by the Alaska Perseverance Mining Company at the adjoining Sheep Creek mine.

Placer mining in Silverbow Basin was advanced by the Silver Bow Hydraulic Company from May 25 to July 15. A hydraulic elevator was then installed, and was operated until August 7, when increased rainfall caused a flooding of Icy Gulch and Gold Creek, which filled the placer excavations and caused a suspension of operations. No further work was done at this locality.

MINES NORTH OF JUNEAU.

At only a few of the mines and prospects north of Juneau have developments been in progress throughout the year. The Salmon Creek, McGinnis Creek, and Montana Basin prospects have been idle, except for the completion of assessment work. At Windfall Creek no attempt was made to operate the placer deposits, and only a small amount of prospecting was done on the quartz veins at the head of the creek. The Peterson Creek prospects were developed in a small way throughout the year by the owner, and the ore mined was treated in a 2-stamp mill on the property.

At the Eagle River mine developments were vigorously advanced during the year in search of the main vein, which is displaced by a fault. The workings now show both the character and the extent of this comparatively wide zone of faulting, and extensive developments are being advanced on this vein deposit at points farther into the mountain beyond the folded zone. The displacement caused by this fault amounts to a lateral throw of 400 feet and a downward movement of 200 feet. The fault plane has a general northeasterly strike and a dip of 30° SE. The strike of the ore body is to the northwest and the dip to the northeast. The vein ranges from 1 to 15 feet in width. Developments are also being advanced on the hanging-wall vein 150 feet northwest of the main vein and parallel to it. This vein ranges from a few inches to 8 feet in width. Similar parallel veins have been prospected by short tunnels at other points on the property. A total of 12,000 feet of drifts, crosscuts, and raises has been opened at the Eagle River mine. The 20-stamp mill on the property has been in continuous operation throughout the year.

Considerable interest has been shown in the prospects to the north of the Eagle River mine, at Yankee Basin, and at the head of Cowee Creek, where auriferous quartz veins are being explored. The Dividend lode was undercut at a depth of 350 feet by a 900-foot tunnel, which is being extended to a length of 1,700 feet, at which distance it is estimated that it will undercut the Cascade vein. The Dividend lode, which is being explored at the tunnel level, is said to have a width of more than 60 feet and to contain gold values. The Cascade is a 6-foot quartz vein developed on the surface by two prospect shafts and open cuts. The Julia, Puzzler, Noonday, and other claims adjoin the above-named prospects and include some promising vein deposits. About 1½ miles northwest of Yankee Basin is the Cottrell-Spalding group of claims, on which a vein is reported to be exposed over a length of 1,500 feet, averaging 2½ feet in width and carrying gold values. A crosscut tunnel 160 feet long undercuts the vein 100 feet in depth. On the Black Chief claim, to the northeast, vein deposits parallel to the Cottrell vein are being explored. Other prospects which have been developed during the year are the Maud S. group, on which an 80-foot tunnel crosscuts a 4½-foot vein 50 feet in depth; the Joyce-Jensen-Johnson group, which is supposed to include the northwestern continuation of the Cottrell vein; the Blue Jay claim, on which a vein deposit is opened by a 25-foot drift tunnel; and the Yankee Boy and Yankee Girl claims, which may be an extension of the Blue Jay vein. On the Gold Standard group, adjacent to Echo Inlet, considerable work was done during the latter part of the year, and favorable results are reported.

In the Berners Bay region the Jualin was the only mine where developments were in progress. This property was operated under a lease, work having begun the first of June and continued until October. During this period the 10-stamp mill was in operation for fifteen weeks. Developments were carried on principally on the 220-foot level, a crosscut being extended for 280 feet from the shaft to undercut the north vein, which at this level was found to be 6 feet wide, and along it 80 feet of drifting was done. The ore mined was taken from the west vein, along which the drift has been carried for 350 feet. Above the 220-foot level most of the ore has been stoped out. Only a few men will be employed during the winter to continue the developments.

The other mines in the Berners Bay region have been idle because of litigation difficulties which still remain unsettled.

MINES SOUTH OF JUNEAU.

Mining progress at the mines and prospects south of Juneau has not been extensive, and at only one locality has there been any gold production. Small developments have taken place during the year on the Bach group of claims at Limestone Inlet, where a quartz vein averaging 2½ feet wide and inclosed in granitic country rock has been exposed over a length of 500 feet.

At Snettisham work was advanced in the Crystal mine from early spring until late in the fall, and a considerable tonnage of ore was treated in the 5-stamp mill on the property. The upper tunnel was connected with the second level by a raise and from the second level a shaft has been started.

At the Holkham Bay group of claims, located on the south side of Endicott Arm, small developments were made during the summer and a right of way for an aerial tramway was cleared from the beach to a point at an elevation of 1,500 feet and 4,500 feet from tidewater. From this point a crosscut tunnel has been started to undercut the vein deposit 400 feet in depth at a distance of 420 feet from its mouth.

No attempt was made to renew operations at the Sumdum mine. Except a small amount of assessment and prospect work, there was no mining activity in the vicinity of Windham Bay.

ADMIRALTY ISLAND.

There has been no noteworthy mining progress at the prospect on Admiralty Island. Small improvements have been made on the properties adjacent to Funter Bay, and assessment work is reported to have been done at the Mammoth group of claims near Young Bay.

SITKA MINING DISTRICT.

The only active mining operations during the year within the Sitka mining district have been at the DeGroff mine, owned by the Chichagof Gold Mining Company. At this mine a 2-stamp mill with a Wilfley concentrator was erected and a steam plant and a 2-drill air compressor installed. The drift along the vein at the upper tunnel level was extended for 260 feet, and at a point 156 feet lower, on a level with the ore bin in the mill, a second tunnel has been started to develop the vein at this depth. The mill began operations the first of September and was run to its full capacity the rest of the year. On the Mills prospects, just above the DeGroff mine, a 300-foot drift tunnel was extended along the vein, and below this a 70-foot drift tunnel, and encouraging results are reported.

The vein and lode deposits adjacent to Silver Bay, on Baranof Island, some of which were extensively developed in former years, have received little attention this year, no work, except assessment work on some of the properties, having been in progress.

WRANGELL MINING DISTRICT.

There has been little progress within the Wrangell district during the last year and no new discoveries are reported. The Olympic Mining Company renewed operations with a small crew of men in May and continued until August, work being done on the Helen S. group of claims. No important developments were accomplished on the gold-copper prospects at the head of Duncan Canal.

KETCHIKAN MINING DISTRICT.

Gold plays but a minor rôle in the mining interests of the Ketchikan district, and its production has been largely from the copper ores, which carry from 50 cents to $2 in gold per ton of ore. In this district gold deposits occur locally, but are too widely separated to permit the definition of a mineral zone. The most general distribution of this metal is in the slates and greenstones bordering Tongass Narrows and extending northward on Cleveland Peninsula, where the gold occurs in lode deposits. On Prince of Wales Island it is found in vein deposits inclosed in limestones, as at Dolomi, and in black slates or phyllites in the vicinity of Hollis.

PRINCE OF WALES ISLAND.

Mining progress near Dolomi has been confined principally to the Valparaiso and Paul claims. On the former there are two shafts 150 and 225 feet deep, and from the deeper one three levels at depths of 90, 150, and 200 feet have been extended along the vein for 175, 350, and 250 feet, respectively. The Valparaiso vein ranges from 4 to 10 feet in width, trends N. 55° W., and dips 30° to 50° NE. On the Paul claim, along the north shore of Paul Lake, several shafts have been sunk from 10 to 80 feet on the vein, and from the bottom of these shafts drifts are being extended. A tramway from these properties to the beach was also completed during the year. No work was accomplished at the Golden Fleece property, just north of Dolomi.

The developments near Hollis were principally on the Julia claim, which was sold early in the year. An inclined shaft 220 feet deep was sunk on the vein deposit, and from this shaft drifts were extended. At the Crackerjack mine operations were in progress from March until June. The other prospects near Hollis were idle during the year.

Gold deposits are being prospected at other localities on Prince of Wales Island and on Dall Island; but as yet they have not become producers.

GRAVINA ISLAND.

Developments at the Gold Stream mine, owned by the Irving Consolidated Mining Company, were in progress during the summer months, but they were not extensive and the 5-stamp mill on the property was idle. The deposit consists of a lode 4 to 8 feet wide inclosed in greenstone schist, and within the lode the principal values are confined to an ore shoot 50 feet in length pitching at an angle of 60° SE. It is developed by a 115-foot shaft and about 600 feet of drifting. A second and wider lode deposit, 100 feet southwest of the first and parallel to it, has been prospected by a shaft and surface trenches, though the ore values in it are lower than those in the smaller deposit. The other prospects on the island were developed to but a slight extent.

CLEVELAND PENINSULA.

Mine developments on Cleveland Peninsula during 1907 were confined to the Gold Standard group of claims at Helm Bay. The deposit at this locality consists of quartz veins in a narrow belt of greenstone schist carrying seams and pockets of rich free-gold ore. The mine is developed by a shaft 115 feet deep and by 700 feet of drifts and tunnels. The surface equipment consists of a compressor plant and a 5-stamp mill. At the other prospects on Cleveland Peninsula assessment work alone was done.

REVILLAGIGEDO ISLAND.

On Revillagigedo Island prospecting has been advanced in a small way at the gold deposits along the shores of Tongass Narrows, George Inlet, and Thorne Arm, though no important developments are noted.

The Sea Level mine, at the head of Thorne Arm, remained idle, though small investigations were in progress on some of the adjoining prospects.

COPPER MINES AND PROSPECTS.

GENERAL STATEMENT.

The occurrence of copper in southeastern Alaska is confined principally to Prince of Wales Island, where it is found in the form of contact-metamorphic deposits adjacent to the granitic intrusives, as at Copper Mountain and on Kasaan Peninsula, and as irregular lenses and masses along the shearing zones in the greenstone schists, as at Niblack. The bulk of the copper ore is chalcopyrite, accompanied by pyrite, magnetite, pyrrhotite, and other sulphide minerals. With one exception, namely, on Copper Mountain, carbonate and oxide ores are practically absent, and the zone of secondary concentration or secondary enrichment is wanting or is too small in extent to be important. In general, it may be stated that where copper ores are being mined in southeastern Alaska the values in the ore will not decrease with increasing depth, though, because of the irregularity of the ore bodies, the rule to observe in exploitation is to follow the ore and not to drive long crosscut tunnels with the expectation of undercutting the deposit in depth. For the most part, the copper ores carry but a small percentage of copper and less than a dollar per ton in gold and require exceptional mining and transportation conditions to insure profitable extraction.

PRODUCTION.

The following table shows the amount and value of the copper, gold, and silver produced from the copper ores in southeastern Alaska during 1906 and the average contents per ton of ore mined:

Production of copper ore in southeastern Alaska, 1906.[a]

	Ore mined.	Copper.		Gold.		Silver.	
		Amount.	Value.	Amount.	Value.	Amount.	Value.
	Tons.	*Pounds.*		*Ounces.*		*Ounces.*	
Total	85,160	4,350,571.00	$839,660.00	3,030.970	$62,851.00	27,152.000	$18,102.00
Average per ton	--------	51.09	9.86	.035	.713	.318	.213

[a] Computations based on average price of copper ($0.193) and silver ($0.67) for 1906.

For 1907 the copper production from southeastern Alaska is estimated approximately at 4,750,000 pounds, valued at $950,000.

KETCHIKAN MINING DISTRICT.

HETTA INLET.

On the west coast of Prince of Wales Island all the important mines and prospects are contiguous to Hetta Inlet, a deep embayment which is connected with the Pacific Ocean through Cordova Bay. The principal mines are centered around Copper Mountain within an area about 8 miles in diameter. An intrusive mass of granodiorite occupies the central portion of this area, and surrounding it are the intruded sedimentary rocks, consisting of limestone and quartzite. At the contacts these sediments are highly altered, and at many localities they have been replaced by ore-bearing minerals, such as garnet and epidote, in which the ore occurs in irregular masses. Overlying the limestone and quartzite and forming the shore outcrops along the east shore of Hetta Inlet are slates and greenstones in which copper deposits occur in the form of veins occupying shear zones parallel to the trend of the inclosing rock. Subsequent to the deposition of the ore there were intrusions of numerous diabase dikes which crosscut the ore bodies and apparently have no genetic bearing on the ore deposits.

The mines and ore bodies have been described in previous reports, and it remains only to discuss the latest developments. At the New York and Indiana mines, on the south slope of Copper Mountain, work was suspended in the fall of 1906, and the properties were idle during 1907. The Jumbo mine, on the north side of the mountain, has been actively developed throughout the year. The aerial tramway from the mine to the wharf was completed early in the year, and ore shipments were begun to the Tyee smelter in British Columbia. The copper deposits under development consist of an irregular body of chalcopyrite ore, 30 to 40 feet wide, 120 feet long, and about 140 feet in depth, occupying a nearly vertical position. The contact zone in which this ore body occurs is 200 feet in length at this point, granite forming the foot wall and limestone the hanging wall. The mine workings consist of four tunnels between 1,500 and 2,000 feet in elevation, the main tunnel being at 1,700 feet elevation and 280 feet long. At a point 180 feet from its mouth a 130-foot vertical raise connects the level with the stopes in the ore body. A lower tunnel has been started at a point 1,570 feet in elevation, on a level with the ore bins at the upper terminal of the aerial tramway, and is to be extended to undercut the present mine workings. To the northeast of the mine, on Jumbo claims Nos. 1, 1A, and 2, a large deposit of magnetite ore carrying copper has been developed, though as yet transportation facilities have not been extended to this locality.

At the Houghton group of claims, owned by the Cuprite Copper Company, which adjoin the Jumbo claims on the east, explorations were in progress during the greater part of the year. The mine workings are at an elevation of 1,600 feet, and an ore body included in the contact zone between the granite and limestone is being developed.

The Corbin mine, owned by the Alaska Metals Company, was operated during the first few months of the year, after which work was suspended and the mine has since been idle. The ore body is a vein deposit, 1 to 3 feet wide, of nearly massive sulphide ore, inclosed in a greenstone schist country rock. It has been developed by a drift tunnel 210 feet in length and a shaft 100 feet deep. From the bottom of the shaft crosscuts were driven to investigate deposits at this depth, but the results are reported not to have been favorable.

The Copper City mine, also known as the Red Wing group, has been developed throughout the year. The ore body is similar to that of the Corbin mine, though the ore contains a higher percentage of copper. The mine is developed by an inclined shaft 120 feet deep, from which two levels at 50 and 100 feet in depth have been extended. From the 100-foot level a winze has been sunk for 60 feet, and from this a third level is being started. Most of the ore above the 100-foot level has been mined.

At the other prospects near Hetta Inlet, namely, the Green Monster group, Hetta Mountain prospects, Gould Island prospects, and Sultana group, little or no development work was accomplished during the year.

KASAAN PENINSULA.

On Kasaan Peninsula are located the principal mines on the east side of Prince of Wales Island, and because of their importance a detailed topographic and geologic survey was made of this area during the last summer. A statement of the results of this work and a description of the mines is contained in a separate paper in this report. (See pp. 98–115.)

NIBLACK ANCHORAGE.

The Niblack mine, on the south side of Niblack Anchorage, has been operated steadily throughout the year. The shaft has been extended to a depth of 320 feet, and from this the 300-foot level is being opened and investigations are being advanced on the 225-foot level. The total underground workings at the close of 1907 were estimated at 5,500 feet. Three large ore bodies have been opened in this mine, besides smaller veins and masses. The north or foot-wall vein is 200 feet in length, averages 20 feet in width and about 100 feet in depth, and has been developed on the 50-foot and 100-foot levels. The south vein, exposed on the 150-foot level, is similar in character, but not so large. The third important ore body has been developed on the 225-foot level and is exposed for 90 feet in length and 15 feet in width. Recent discoveries of new ore bodies containing higher values in copper are reported from the 300-foot level and are being developed. The other properties in Niblack Anchorage were idle except for the assessment work accomplished.

NORTH ARM.

The Cymru mine is located on Mineral Creek, three-fourths of a mile from the head of North Arm. Developments at this mine were in progress the first half of the year, but were then discontinued. The property is developed by a 100-foot shaft from which two levels, at 50 and 100 feet, have been extended. From the mine a tramway 4,200 feet long has been built to the beach, where ore bunkers and a wharf have been erected. The ore bodies are vein deposits from 1 to 10 feet in width, inclosed in a limestone country rock which is interstratified with beds of quartzite and greenstone schist. The ore consists of pyrite and chalcopyrite in a quartz-calcite gangue.

SKOWL ARM.

At the head of McKinzie Inlet, a south branch of Skowl Arm, is the Khayyam mine, owned by the Omar Mining Company. The mine is located 3 miles from tidewater, at an elevation of 2,600 feet. In July, 1907, operations were renewed and were in progress until October, and ore shipments were made to the Tyee smelter in British Columbia. The ore bodies are elongated lenses of sulphide ore coinciding in strike and dip with the schistosity of the inclosing gneissoid diorite country rock. They have been exposed on the surface by open pits and trenches and are crosscut in depth by the Powell tunnel, 220 feet in length. Four ore bodies are exposed in this tunnel, from 6 to 20 feet in width, and have been developed by 350 feet of drifting. The ore is composed principally of pyrite, with a small percentage of chalcopyrite and accompanied by pyrrhotite, sphalerite, and some magnetite.

SILVER, LEAD, AND ZINC PROSPECTS.

Deposits of silver, lead, and zinc ores are not plentiful in southeastern Alaska. They are being developed at only three localities, and from these the metal production has been slight. Silver is present in amounts ranging from one-fifth of an ounce to 3 ounces per ton in the copper ores,[a] and in the gold ores[b] its content is dependent on the amount of gold present, the ratio being approximately 2 ounces of silver to 1 ounce of gold. Lead occurring in the form of galena is

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[a] See table for copper production, p. 93.
[b] See table for gold production, p. 86.

being mined in small quantities from the prospects on Coronation Island and the Moonshine prospect in Cholmondeley Sound. Zinc is not known to occur in commercially valuable amounts, though in its sulphide form it accompanies both the copper and gold ores.

The Moonshine prospect is located on the west side of the south arm of Cholmondeley Sound, at an elevation of 2,400 feet. Developments were energetically prosecuted on this property during the year from May until November, though the results attained were not so favorable as was expected. The ore body is a vein deposit occupying a fissure cutting obliquely across limestones and schist country rock and traversing the top of the mountain ridge. Where it crosscuts the limestone it is apparently a replacement deposit, ranging from a few inches to several feet in width; but in the inclosing schists the vein is smaller and is in many places represented by a narrow gouge seam. Throughout the vein the ore occurrence is irregular, the ore being found in scattered masses. It has been developed by a shaft 100 feet deep and at a point 550 feet farther west by a drift tunnel 200 feet in length which is being driven to connect with the shaft at a depth of 225 feet.

Narrow, irregular vein deposits of galena ore have been developed at Egg Harbor, on the north end of Coronation Island. These deposits occur in a limestone country rock, forming small masses along slipping planes, and have been developed by short tunnels at points between 700 and 1,000 feet in elevation.

The silver-lead prospects in Glacier Basin, on the mainland east of Wrangell, are located 7 miles from tide water, at an elevation of 2,200 feet. The ore deposit consists of well-defined quartz veins traceable for long distances along the surface and ranging from 4 to 20 feet in width. The veins are heavily mineralized with galena, zinc blende, pyrite, and chalcopyrite, the principal values being in silver and lead. The properties at this locality were bonded early in the spring and investigation was carried on during July and August, after which period work was suspended.

COPPER DEPOSITS ON KASAAN PENINSULA, PRINCE OF WALES ISLAND.

By Charles W. Wright and Sidney Paige.

INTRODUCTION.

The geologic studies of Kasaan Peninsula carried on during the summer of 1907 by the writers and the topographic map of this area made by D. H. Witherspoon and J. W. Bagley represent the first detailed investigations by the United States Geological Survey in the Ketchikan mining district. The area embraces about 65 square miles between latitude 55° 25′ and 55° 40′ and longitude 132° 5′ and 132° 35′. During the geologic investigations special attention was given to the occurrence of the copper ores and their relation to the different rock formations, and it is expected that the knowledge gained by these studies will indicate where practical exploration may be most advantageously extended in the search for new ore bodies. In this preliminary report only an outline of the geologic facts, tentative conclusions regarding the ore deposits, and brief descriptions of the mines and prospects are presented. The final conclusions may be at variance in certain particulars with those here set forth, inasmuch as the areal mapping was not completed and the notes and collections have not been studied in detail.

GENERAL DESCRIPTION.

Kasaan Peninsula is a promontory on the east side of Prince of Wales Island, 18 miles in length and from 3 to 6 miles wide, projecting into Clarence Strait and sheltering Kasaan Bay. (See fig. 1.) It is a steep, heavily timbered mountain ridge with summits reaching altitudes of 1,000 to 3,000 feet. Near the center of the peninsula a valley nearly separates the mountain range and extends from the "Hole in the Wall" to a point 3 miles southeast of Kasaan. At the northeast end of the peninsula there is also a broad, low, marshy valley 4 miles in length, extending from the head of Tolstoi Bay to a point 3 miles northwest of Kasaan, and another valley 3 miles in length extending from the head of Thorne Bay to the east side of

Karta Bay. The upper limit of timber on the peninsula is from 1,500 to 1,800 feet above sea level; the valleys and gulches contain a dense growth of shrubbery, which renders prospecting difficult. The summits of the ridges are open, except for small clusters of scrub pine.

The relief of the peninsula is typical of the more mature topography of the islands as compared with the rugged, more abrupt topography of the mainland. The mountain summits are dome-shaped and on them lie large erratic bowlders, an evidence of glaciation.

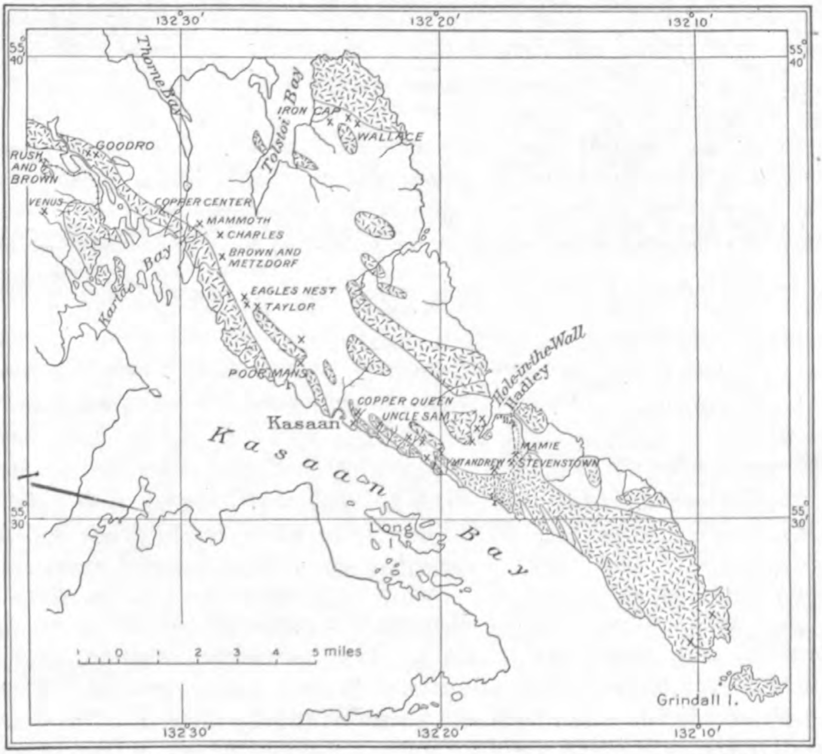


FIG. 1.—Map of Kasaan Peninsula, Prince of Wales Island, showing distribution of intrusive rocks, mines, and prospects.

The valleys, which extend northward from points near the head of Kasaan Bay, are broad and contain many lakes; they are occupied by deep deposits composed of large and small bowlders embedded in glacial clay. The islands and shoals at the entrance to Karta Bay are made up largely of these glacial deposits and represent the terminal moraines left by former ice fields.

The occurrence of copper on Kasaan Peninsula was known to the Russians as early as 1865, but not until 1900 did active mine developments begin. It is now the principal copper-producing area in southeastern Alaska.

PRODUCTION.

The first production of copper from Kasaan Peninsula was made in 1905, the year in which the smelting plant at Hadley was completed. This production continued, gradually increasing in amount, until the autumn of 1907, when all the mines ceased operations. The following tables show the total metal production of the ores derived from the copper mines on Kasaan Peninsula, and the average content per ton of ore.

Production from copper mines on Kasaan Peninsula, 1905 to 1907.[a]

Year.	Ore mined.	Copper.		Gold.		Silver.		Total value.
		Amount.	Value.	Amount.	Value.	Amount.	Value.	
	Short tons.	*Pounds.*		*Ounces.*		*Ounces.*		
1905	20,659	1,194,917	$186,407	932.1	$19,266	5,946	$3,502	$209,175
1906	68,399	3,318,633	640,496	2,413.5	50,078	17,244	11,554	702,128
1907	52,177	2,307,578	461,516	1,282.1	26,500	14,055	9,276	497,292

[a] Average price of metals: 1905, copper, $0.156 per pound; silver, $0.604 per ounce; 1906, copper, $0.193 per pound; silver, $0.67 per ounce; 1907, copper, $0.20 per pound; silver, $0.66 per ounce.

Average content per ton of ore from copper mines on Kasaan Peninsula, 1905 to 1907.

Year.	Ore mined.	Copper per ton.		Gold per ton.		Silver per ton.		Total value per ton.
		Amount.	Value.	Amount.	Value.	Amount.	Value.	
	Short tons.	*Pounds.*		*Ounce.*		*Ounce.*		
1905	20,659	57.8	$9.02	0.045	$0.90	0.29	$0.18	$10.10
1906	68,399	48.7	9.40	.035	.70	.25	.17	10.27
1907	52,177	44.2	8.84	.025	.50	.26	.17	9.51

GEOLOGY.

The rocks which compose Kasaan Peninsula are of intrusive, extrusive, and sedimentary origin. The intrusives include granodiorite, syenite, hornblende diorite, and, more rarely, granite. These rocks invade limestone beds and strata of highly altered sedimentary and pyroclastic rocks ranging from greenstone tuffs to sandstones and conglomerates composed largely of igneous material.

STRATIFIED ROCKS.

The stratified rocks include those of sedimentary and volcanic origin. They occur principally on the northern portion of the peninsula and adjacent to Tolstoi and Thorne bays, and are made up of metamorphosed bedded rocks, usually epidotized and containing amphibole and pyroxene crystals and in places altered to hornfels, quartzite, and mica schists. These range in texture from fine-grained tuffs, slates, and sandstones to conglomerates containing pebbles 2 inches in diameter. The conglomerates are made up of fragments of igneous rocks, as well as of limestone and quartzite. The sandstones and greenstone tuffs are composed largely of volcanic material, and because of their induration they closely resemble massive igneous rocks, though in most places their fragmentary character can be recognized. The limestone beds exposed on the peninsula are entirely recrystallized and both evidence of structure and organic remains are lacking. They are of importance because of their association with and relation to the ore deposits. On Long Island, which occupies the central portion of Kasaan Bay and lies 1 mile southwest of Kasaan Peninsula, occur limestone beds conformably underlain by feldspathic sandstones. Interstratified in these limestone beds near their contact with the underlying rocks are thin beds of sandstone and conglomerate, most of the pebbles in the latter being of porphyry. In the limestone beds themselves Devonian fossils are abundant, and collections at this locality were first made in 1901 by A. H. Brooks, and in 1905 a more complete collection was made by E. M. Kindle. Because of the analogy of these rocks to those on Kasaan Peninsula the latter are provisionally considered to be Devonian.

The structure of the sedimentaries exposed on Long Island is of interest because of the two systems of folding represented—an older system of small folds with a northeasterly strike, and a later system of broader folds which trend to the northwest and belong to the main system of the Coast Range. On Kasaan Peninsula the structure of the bedded rocks has been so greatly interrupted by the intrusive masses that no persistent lines of strike and dip could be followed, though the most prominent direction of the bedding planes was from northwest to west, with a steep dip to the southwest. Two prominent jointing systems are also present on the peninsula—one striking N. 15° to 25° E. with a dip of 60° to 80° SW., and the other striking N. 50° to 70° W. with a steep dip to the northwest.

INTRUSIVE ROCKS.

The intrusive rocks occurring on Kasaan Peninsula all invade the sedimentary strata and are, therefore, of more recent age. (See fig. 1.) The principal intrusive is the granodiorite which forms the entire southern portion of the peninsula and occupies wide areas in the central and northwestern portions. But little is known of the rocks that were intruded into this area previous to the granodiorite, this being the oldest intrusive rock recognized. The granodiorite intrusives, however, vary considerably in composition and probably represent several periods of igneous invasion during one general epoch, though in some of them this difference can undoubtedly be attributed to segregations within the igneous magma during solidification.

After the granodiorite invasion granite and syenite dikes, some of them many hundred feet in width, were intruded, besides numerous dikes of pegmatite and aplite. Somewhat later, or possibly during the same period, rocks more basic in composition intruded the area, also in the form of dikes. These were followed by felsitic dikes from 1 to 100 feet in width. Still more recent are the diabase and basaltic dikes, both of which are later than the ore bodies.

ORE DEPOSITS.

The occurrence of ore on Kasaan Peninsula is similar to that in the vicinity of Hetta Inlet. The ore bodies are contact-metamorphic deposits, occurring usually at the contact of an intrusive syenite mass with limestone or, in some places, with greenstone tuff or conglomerate. They are included in a garnet-epidote gangue and are generally associated with magnetite, this mineral forming in many places half of the gangue. The principal mineral zone defined on this peninsula follows the contact of a syenite intrusive mass with a narrow belt of limestone, and is traceable from the east side of Mamie Creek for 2 miles in a westerly direction. This zone ranges from 100 to 300 feet in width, though, because of its flat dip and its conformity with the contour of the mountain slope, it appears locally to be much wider. The Mamie, Stevenstown, and Mount Andrew mines are included within it. Another smaller zone, with a diorite intrusive on the southwest side and both limestone and greenstone tuff to the northeast, extends along the western side of the peninsula about 1 mile inland, beginning 3 miles northwest of Kasaan and continuing northwestward to Karta Bay. The Sea Island, Haida, and Copper Center prospects are included in this belt. Besides the contact-metamorphic deposits, copper ores associated with quartz occupy shear zones in the greenstone tuff and conglomerates at the head of Karta Bay, being found in the Rush & Brown mine at the Venus prospect. On the east side of Karta Bay bornite and chalcopyrite occur in small masses and disseminated throughout a basic diorite intrusive belt on the Goodro and Stevens prospects.

The extent of these various ore bodies depends largely on the type. The contact-metamorphic deposits are generally irregular masses of small extent, as a rule no more persistent in depth than they are laterally; but where the contact zone is more extensive, investigations within it will probably reveal similar ore masses both laterally and in depth. The copper-iron-sulphide deposits occupying shear zones in the stratified rocks are more persistent than the contact ore bodies and will probably extend to a considerable depth.

The principal copper mines in the region are developing deposits of a low-grade copper-iron-sulphide ore which can be profitably exploited only by extreme economy in extraction. At certain mines the accessory gold content of $1 to $2 per ton is depended on to raise the total value of the ore above the commercial limit. The copper ores generally contain high percentages of iron and lime and are classed as "base ores." To accomplish their reduction, therefore, it is necessary to mix them with siliceous or quartz ores. The lack of available siliceous ore has been a serious handicap to the smelters of the district. Increasing the value of the copper ores by concentration alone would as a rule be of little advantage, both because of the high percentage of iron minerals and because only the lighter siliceous minerals, which are necessary as a flux, would be separated. Some of the ores, however, might with advantage be ground and treated in a magnetic separator.

These facts are clearly brought out in the following table, which shows the composition of the gangue content of the ores from the principal mines as determined by smelter assays.

Smelter assays of ores from copper mines in the Kasaan Peninsula.

Name of mine.	Silica (SiO_2).	Iron (Fe).	Lime (CaO).	Sulphur (S).	Alumina (Al_2O_3).
Mamie:					
Siliceous ore	30.6	17.5	10.4	5.9	17.2
Base ore	10.6	47.8	2.7	6.3	7.7
Stevenstown	16.4	34.1	7.6	6.9	11.7
Mount Andrew	15.2	42.8	.4	4.3	
Karta Bay	16.5	35.6	6.8	6.2	
	19.6	28.3	7.0	8.0	

The preceding analyses, though incomplete, show the relative basic and siliceous content of the ores. The portion of the analyses not given represents the moisture (H_2O), the carbon dioxide (CO_2), the undetermined elements, including the alkalies contained in the ores, and also their content of precious metals.

MINES AND PROSPECTS.

MAMIE MINE.

Situation and development.—The Mamie mine, owned by the Brown Alaska Company, is situated 1¼ miles south of Hadley, in the central portion of Kasaan Peninsula, at an elevation of 700 feet. (See fig. 1.) The mine workings are connected with the smelter at Hadley both by an aerial tram 5,500 feet in length and by a horse tram 7,700 feet in length. The horse tram is used for the transportation of supplies. Mine developments in a large way were not begun until 1904. During that year the ore bodies were explored by numerous open cuts, tunnels, and diamond-drill holes. In the following year mining of the ore was begun from the open pits and new ore bodies were developed by tunnels and shafts. At the close of 1905 considerable ore was delivered to the smelter and throughout 1906 the production was large. In 1907 diamond-drill investigations were advanced, new ore bodies were located at greater depth, and the ore production continued with little interruption until late in September. In October all operations were suspended. The total developments consist of 5,000 feet of tunneling, drifting, and crosscutting and about the same amount of diamond-drill prospecting.

The smelter or reduction plant at Hadley, belonging to the Alaska Smelting and Refining Company, is controlled largely by the owners of the Mamie mine. It consists of a blast furnace of 350 tons daily capacity, a sampling mill, coal and coke bins, ore bunkers of 10,000 tons capacity, boiler house, engine house, electric-light plant, and other conveniences. The ores from the Mamie and Stevenstown mines first go through the samplers, next to the ore bunkers by gravity, and thence by gravity to the furnace. The slag from the furnace is granulated and carried by water to the beach. A cable tramway extends from the wharf to bins above the sampling mill, which have been built to receive custom ore. The plant is so arranged that its daily capacity may be doubled if necessary. Smelting operations began December 5, 1905, and in 1906 the furnace was in blast about twenty days each month. In September, 1907, this plant was closed.

Ore bodies.—The ore bodies at the Mamie mine are contact-metamorphic deposits included in a zone 400 feet wide lying between a syenitic intrusive and limestone. Within this zone the masses of valuable copper ore are defined either by such a decrease in the copper content of the inclosing rock as to prohibit profitable extraction or by fault planes. Garnet, epidote, and magnetite compose the contact rock, throughout which chalcopyrite is present in small quantities. The ore bodies, or portions of the contact rock where the concentration of the copper values is sufficient to make ore, are irregular masses ranging from 50 to 100 feet in length and thickness and from 10 to 40 feet in width, the major axis striking northward. Nine such ore masses are exposed in the mine workings. Some of them are included entirely in magnetite masses, forming basic ore; others occur in the garnet-epidote gangue, making a siliceous ore. Small veinlets of calcite, and rarely quartz, intersect the ore masses, thus indicating a later period of mineralization, though the main ore bodies are believed to have been deposited contemporaneously with the inclosing contact rock.

STEVENSTOWN MINE.

Situation and development.—The Stevenstown mine, owned by the Hadley Consolidated Copper Company, is situated just above and southwest of the Mamie mine, at an elevation of 1,000 feet. (See fig. 1.) From the mine a surface tram 700 feet long connects with the aerial tram at the Mamie mine, over which the ore is transported to the smelter at Hadley. A trail also leads from the mine down the south side of the peninsula to Boggs Landing, on Kasaan Bay, a distance of 1 mile. The mine has been developed by three "glory holes" or open pits connected by raises with a 550-foot tunnel penetrating the crest of the mountain. Actual mining developments were begun in June, 1905, previous to which prospecting alone had been carried on; and in September of that year ore shipments to the Hadley smelter began. A large amount of ore was produced during 1906 and until July 1, 1907, when mining operations were suspended.

Ore bodies.—The ore bodies on the Stevenstown property correspond both mineralogically and genetically with those at the Mamie mine. They occupy a relatively flat position on the crest of the mountain ridge and are apparently underlain by the syenite intrusive which forms the foot wall of the mineral belt and which is exposed throughout the tunnel that penetrates the mountain top. The hanging wall, as well as a large portion of the ore bodies on this property, has been removed by erosion and the contact zone is only from 20 to 40 feet in width, instead of 200 to 400 feet, the width on the Mamie property just below. To the northeast of the ore bodies strata of limestone and greenstone tuff occur and continue westward toward the Mount Andrew mine, forming the hanging wall of the mineral zone.

The mine workings are all surface pits connected by raises with the main tunnel, and in these several relatively flat-lying ore masses have been developed. These masses are included within an area 350 by 200 feet, the pit being from 20 to 40 feet deep. The central portion of this area is traversed in a southerly direction by a 40-foot felsite dike, which is of later intrusion than the syenite and crosscuts the ore body. Smaller dikes of diabase and basalt 1 foot to 5 feet in width were observed crosscutting the ore bodies and country rock at several points in the mine workings.

The ore is composed largely of magnetite, chalcopyrite, and pyrite associated with hornblende and calcite, all of which are included in a more or less banded garnet-epidote gangue.

Surface oxidation has produced considerable limonite and some malachite and azurite; small particles of native copper also occur along slipping planes. These secondary minerals are relatively unimportant.

MOUNT ANDREW MINE.

Situation and development.—The Mount Andrew mine workings are situated three-fourths of a mile from Mount Andrew Landing, on the southwest side of Kasaan Peninsula, and one-half mile west of the Stevenstown mine, at an elevation of 1,400 feet. A cable tramway 3,600 feet long leads from the mine over a 1,440-foot knoll just south of the workings to the ore bunkers and a wharf at Mount Andrew Landing. (See fig. 1.)

This mine is developed principally by a tunnel 620 feet long, undercutting the ore bodies from 60 to 100 feet or more in depth. From this tunnel several hundred feet of drifts and crosscuts have been driven, and upraises have been extended through the ore bodies to the surface. The ore is mined out of large underground stopes and from surface pits or "glory holes," and is delivered through chutes at the tunnel level to the ore bunkers at the head of the aerial tram and thence carried to the wharf, where it is loaded for shipment. Developments in a large way were not begun until late in 1905, and during 1906 the aerial tram was erected, the wharf built, the compressor plant installed, and considerable ore developed. The first ore shipments were made in October, 1906, and production continued until October, 1907, when operations were suspended.

Ore bodies.—The ore deposits on this property are included in the same mineral belt as those at the adjacent Mamie and Stevenstown mines, with which they are in every way comparable. Six ore bodies consisting of irregular magnetite-chalcopyrite masses associated with the garnet-epidote contact rock have been developed and mined to a considerable extent. These bodies of ore are 10 to 50 feet wide, 40 to 80 feet long, and 100 feet or more in depth, and have a general northerly strike and pitch. They are separated by barren areas of contact rock cut by dikes 20 to 60 feet wide of altered syenite porphyry. The mine workings consist essentially of surface pits which are undercut by a crosscut tunnel running east and west. This tunnel with connecting drifts and raises includes 2,200 feet of underground developments. Numerous gouge seams and slickensides indicating faulting were observed in the mine workings, and lateral displacements of the ore bodies for 1 to 6 feet were also noted. Dikes of diabase and felsite 2 to 12 feet wide crosscut the ore bodies and country rock in various directions and were evidently intruded later than the formation of the ore deposits.

At other points on Mount Andrew large masses of magnetite carrying but a small percentage of copper, insufficient in amount to make a copper ore, have been developed. These deposits, though not valuable for copper alone, may at some future time be of importance as a source of iron ore.

RUSH & BROWN MINE.

Situation and development.—The Rush & Brown property includes eight claims extending northwestward from the "Salt Chuck," the principal mine workings being located on the Iron Cliff claim, about 2 miles from the wharf at the head of the bay, at an elevation of 300 feet. (See fig. 1.) In 1904 this property was prospected by long trenches and open cuts, and a shaft 25 feet deep was sunk on the ore body. In 1905 it was leased by the Alaska Copper Company, and a new shaft was started 120 feet south of the old shaft and sunk to a depth of 100 feet. From the bottom of this shaft the principal ore body, the magnetite deposit, was developed by drifts and crosscuts and a drift was extended to a second ore body, the sulphide deposit, 160 feet farther northeast. At the close of 1907 the greater portion of these ore bodies had been stoped out and the shaft sunk for an additional 100 feet, to a point from which a 200-foot level was started. The ore from the mines is transported by a gravity tram to ore bunkers one-fourth mile below the mine, and thence by a railroad 2¾ miles long to the wharf at the head of the bay, where ore bunkers of 2,000 tons capacity have been built. During 1906 ore was shipped to the smelter at Coppermount, and in 1907 shipments were made to the Tyee smelter at Ladysmith, B. C.

Ore bodies.—Two ore bodies have been developed at the Rush & Brown mine. One is a contact-metamorphic deposit consisting of a copper-bearing magnetite body 100 feet long by 30 feet wide in a garnet-epidote-calcite gangue lying between granodiorite and an indurated greenstone tuff, the line of contact striking nearly east and west. The other deposit, 160 feet to the north, occupies a shear zone in the greenstone tuff and conglomerate beds and is a sulphide body composed of pyrite and chalcopyrite in a quartz-calcite gangue. It is from 4 to 8 feet in width and has been developed over a length of 85 feet. The strike of this sulphide deposit is northeastward and its dip 60° SE., toward the larger deposit.

UNCLE SAM MINE.

Situation and development.—The Uncle Sam mine, originally called the White Eagle group, lies 3 miles northwest of Mount Andrew Landing and half a mile from Kasaan, on the south slope of Kasaan Peninsula. (See fig. 1.) The mine workings are 430 to 550 feet in elevation and less than half a mile from the beach. Mining operations have been conducted on this property at various intervals since its discovery in 1899, and in 1901 an aerial tram, ore bunkers, and a wharf were built. Early in 1906 a shipment of ore was made, but no further work was done until March, 1907. At that time operations were renewed, continuing until July, when another ore shipment was made. The mine is developed by a tunnel and drifts amounting to about 800 feet in length, and by open pits exposing the ore body on the surface above the tunnel. From this working tunnel a surface tram, 1,150 feet long, conveys the ore to the wharf.

Ore body.—The ore body exposed in the tunnel consists of an irregular lens of chalcopyrite-pyrite ore 6 to 8 feet in width, striking north and south and pitching about 45° N. It is cut off to the north by an east-west fault dipping 80° N., which shows but a small amount of gouge. At the open cut above the tunnel similar masses of ore are exposed, but no large ore bodies have been defined. Garnet, epidote, magnetite, and calcite occur as gangue minerals and in many places form small geodes. The chalcopyrite ore contained in this gangue is irregularly distributed in small masses and not along definite lines. The country rock is made up of strata of chloritized and epidotized greenstone tuff, which is underlain by the intrusive syenite and crosscut by small dikes of diabase, of later origin than the ore bodies.

COPPER QUEEN GROUP.

The Copper Queen group of claims, which represents the first copper locations on Prince of Wales Island, lies about half a mile southeast of Kasaan. In 1898 these claims were sold to the Kasaan Bay Mining Company, which made additional locations. Small operations were in progress from 1899 until 1902, and 500 feet of tunneling was done besides surface excavations. Since 1902 the property has been idle.

The principal ore deposit is exposed along the side of a gulch at a point 300 feet in elevation. It consists of an irregular mass of chalcopyrite ore accompanied by pyrite and magnetite in a garnet-epidote gangue at the contact of an altered intrusive syenite with the greenstone tuff. Below these exposures a crosscut tunnel 400 feet in length has been driven in the altered syenite, but has failed to reveal any ore.

Other mineral exposures occur on these claims at points close to tide water and have been prospected by shafts and open cuts, but so far no important deposits have been discovered.

POOR MAN'S GROUP.

The Poor Man's group of two claims is located 2 miles northwest of Kasaan (see fig. 1), and the mine workings are connected with deep water by a surface tramway and wharf, having a total length of about 2,000 feet. The principal developments are at the head of the tramway and consist of a tunnel driven 90 feet in a southwesterly direction which crosscuts a 60-foot body of massive magnetite and 10 feet of garnet-epidote contact rock and at its face enters a dike of red felsite 20 feet wide. At a point 20 feet from the mouth of the tunnel is a vertical shaft extending 30 feet to the surface and 60 feet in depth. This body of magnetite is exposed on the surface above the tunnel and similar masses have been prospected by short tunnels and cuts and shafts at points along the tramway and on adjoining properties. Associated with the magnetite are large amounts of calcite and hornblende, some pyrite and chalcopyrite, and garnet and epidote. Although the magnetite deposit itself is extensive the chalcopyrite ore occurs only in isolated pockets or narrow veinlets and is not disseminated throughout the magnetite in sufficient amounts to make a copper ore of the entire body. It is noteworthy, however, that these ore bodies may be of value for their iron content. Minor displacements, due to faulting or slipping planes, and dikes of diabase and felsite crosscutting the deposits were noted.

EAGLE'S NEST GROUP.

The Eagle's Nest group of claims, situated 4 miles northwest of Kasaan, was first located in 1906 and in the same year was bonded to the Sea Island Copper Mining Company. Operations by this company were begun in October, 1906, and continued in a small way until September, 1907, when the property reverted to the owners.

The developments have been confined to the mineral exposures on the Alarm claim at an elevation of 400 to 500 feet. On the southeast end of this claim is a 70-foot tunnel essentially in a garnet-epidote rock in which a small amount of ore occurs near the face. Just above the tunnel a body of magnetite-chalcopyrite ore 8 feet wide and 20 feet long is exposed in an open cut, beneath which are beds of limestone. Above this, near the summit of the ridge, is an open cut and a shaft 12 feet deep exposing small amounts of ore associated with garnet in limestone. On the northwest end of this claim an open cut and a shaft 35 feet deep exposes masses of chalcopyrite associated with various contact minerals in a coarsely crystalline limestone. Below these workings diorite is exposed and forms the lower portion of the ridge. No large copper deposits have been developed on these claims, though further investigation may reveal important ore bodies.

TAYLOR PROSPECT.

The Taylor prospect, located early in 1907 as the It claim, adjoins the Eagle's Nest group on the east. On this prospect, at a point 600 feet in elevation, a body of chalcopyrite ore in a gangue of garnet and epidote has been exposed by surface cuts over an area of 20 to 40 feet. The ridge to the southwest, on the foot-wall side, is composed of diorite, and below the prospect to the northeast limestone beds are exposed.

MAMMOTH GROUP.

Situation and development.—The Mammoth group lies on the east side of Karta Bay, about 6 miles from Kasaan and one-third of a mile from tide water, on the top of a low hill 500 feet in elevation. This property was largely developed in 1904–5 by the original owners, and in June, 1906, was sold to the Haida Copper Company, which began active developments and made plans for the erection of a gravity tram 2,000 feet in length to the beach, and for a wharf and ore bunkers. In April, 1907, these improvements were completed, and the company made shipments of ore to the Hadley smelter. Early in the summer, however, operations were suspended, and the mine has since been idle. The mine is developed by a tunnel 120 feet in length connecting with a shaft 35 feet deep, which in turn connects with a surface pit on the ore body. Exploratory drifts have been extended from the tunnel, and prospect pits and short tunnels have been driven at other points on the property.

Ore body.—The ore body is an irregular magnetite mass carrying chalcopyrite in a gangue of garnet and epidote. The country rock in the immediate vicinity is altered greenstone, tuff, and conglomerate, though just below the workings a belt of intrusive diorite is exposed which forms the western half of the ridge and probably underlies the ore body. The deposit is developed by an open pit over an area about 50 feet in diameter. This is undercut by a tunnel at a depth of 30 feet, and, though the magnetite is exposed at this depth, chalcopyrite is not so abundant. To the northeast the ore body is limited by a fault plane striking nearly east and west and dipping 75° S. Other slipping planes striking at different angles were noted in the ore body and inclosing rock.

GOODRO CLAIMS.

The Goodro claims, also known as the Joker group, are located one-half mile from the head of the "Salt Chuck" entering Karta Bay. (See fig. 1.) The surrounding area is relatively low, the claims being located on a knoll about 400 feet in elevation. The copper deposit at this locality is of special interest because bornite is the dominant ore, and it is the only locality in southeastern Alaska where bornite has been found in quantity. This ore occurs in small masses and disseminated particles associated with epidote, feldspar, and biotite, and is inclosed in a basic diorite which is largely replaced by these minerals. Native gold and considerable chalcopyrite also occur with the ore, and near the surface small amounts of chalcocite and native copper were noted. The diorite forms an extensive belt half a mile wide striking in a northwesterly direction. Laterally this mineralization is exposed across a width of 60 feet and for about 100 feet in length. It has been developed by a surface pit 12 feet deep, by a cut 70 feet long, and by a tunnel 125 feet long which crosscuts the ore-bearing mass 90 feet below the surface and 90 feet from its mouth. Slipping planes were observed at several points, but do not appear to have caused any noteworthy displacements. In an open cut a diabase dike is exposed which is evidently younger than the ore deposit. Early in 1907 an ore shipment was made to the Hadley smelter and is reported to have yielded good values in both copper and gold.

TOLSTOI BAY PROSPECTS.

General description.—On the north end of Kasaan Peninsula adjacent to Tolstoi Bay, which forms a good anchorage to the west, considerable prospecting has been done and numerous locations have been made, but none of the properties have been developed beyond the prospecting stage. The small promontory here is composed largely of the granodiorite intrusive masses, which are exposed at Tolstoi Point and along the eastern slope of Tolstoi Mountain. On the western slope and along the east shore of Tolstoi Bay greenstone tuff, sandstone, and conglomerate and a few strata of limestone form the rock exposures. Both the bedded and the intrusive rock masses are crosscut by dikes of porphyry and diabase. The ore bodies are contact-metamorphic deposits similar in character to those at the mines on the southern part of the peninsula. They are lenticular masses of magnetite carrying chalcopyrite and associated with garnet, epidote, calcite, and quartz, inclosed in the bedded rocks near the intrusive granodiorite contact.

Iron Cap group.—The Iron Cap property, also known as the Mahoney group, consists of two claims located on the northwest slope of Tolstoi Mountain at an altitude of 1,000 feet, and is reached by a trail $1\frac{1}{2}$ miles long starting from a cove 2 miles southwest of Tolstoi Point. In 1901 the property was prospected to a considerable extent by open cuts along a gulch and by several hundred feet of diamond-drill holes, but since that time it has been idle. The country rock consists principally of greenstone tuff and a fine conglomerate intruded by syenitic dikes of considerable width, which are apparently related to the ore deposits. Three ore bodies have thus far been located, the largest being 20 feet in width and traceable for 50 feet in length, the major axis striking N. 45° W. A second ore body, separated from the first by a 30-foot dike of altered syenite, is 12 feet in width and is limited on the foot-wall side (to the southwest) by a fault plane showing a considerable gouge seam; toward the hanging wall it grades into a garnet-epidote contact rock. The third ore body, which lies just above the other two at an elevation of 1,080 feet, appears to be a flat-lying magnetite deposit only a few feet in thickness.

Wallace group.—The Wallace group includes four claims situated on the southeast slope of Tolstoi Mountain between 800 and 1,600 feet in elevation. At several points on this property small scattered masses of copper ore are exposed, but at no place have investigations been sufficient to determine the extent of these deposits. The uppermost ore exposures have been opened by a short tunnel in which a vein of garnet-epidote rock is shown containing chalcopyrite and striking N. 15° W. and dipping 20° SW. At the lower openings a magnetite-chalcopyrite ore is exposed, but the bodies do not appear to be extensive.

Tolstoi group.—The Tolstoi group of claims is located south of the Wallace group, just below the summit of Tolstoi Mountain. The ore bodies are low-grade magnetite-chalcopyrite masses similar to those on the Iron Cap group, but they have not been so extensively prospected. No developments more than the required annual assessment work have been accomplished on this property.

Big Five claim.—The Big Five claim lies half a mile east of Tolstoi Bay, on the trail to the Iron Cap group, at an elevation of 370 feet. A tunnel 50 feet in length and a shaft expose scattered masses of chalcopyrite, pyrrhotite, and pyrite in a gangue of garnet, epidote, and calcite, the deposit being 10 feet wide. This deposit is a replacement in limestone beds and many slipping planes defined by gouge seams traverse both ore body and country rock. Assessment work only is done on this claim each year.

OTHER PROSPECTS.

Venus prospect.—The Venus group of claims is located on Crow Creek 1¼ miles from the head of Karta Bay and about 1 mile southwest of the Rush & Brown mine. (See fig. 1.) This property was located in 1904 by a magnetic survey by U. S. Rush, and at the point of maximum attraction a pit was sunk and a trench 50 feet in length exposing the magnetic deposit was made through the overlying débris. Below these surface excavations, which are at an elevation of 250 feet, a tunnel 75 feet in length has been driven which crosscuts 50 feet of débris and 25 feet of country rock, and at its face exposes ore. The country rock is an indurated greenstone tuff with interstratified quartzite beds, the ore occupying a shear zone. Associated with the ore is considerable sphalerite and pyrrhotite, with quartz and calcite as gangue minerals.

Copper Center prospect.—The Copper Center prospect lies 1 mile north of the Mammoth group, at an elevation of 400 feet. It was located in April, 1907, and in July was bonded to mining men who undertook its development. Several shafts from 10 to 30 feet deep were sunk within an area 300 by 120 feet. In all these shafts and surface cuts a magnetite and chalcopyrite ore associated with a garnet, epidote, and hornblende gangue is exposed. The deposit is apparently flat lying, though the amount of work done is hardly sufficient to prove that it does not continue in depth. It is also probable that further investigations at a greater depth will reveal deposits at other points on the property. The country rock is largely conglomerate and greenstone tuff, which are underlain by granodiorite, exposed down the hillside to the southwest. The area is densely covered by undergrowth, which renders prospecting difficult. The dip needle has been successfully used within this area and the deposit just described was located by it.

Charles prospect.—The Charles property lies about 1 mile southeast of the Mammoth group and 5,000 feet from tide water, at an elevation of 380 feet. It was located in May, 1907, and only a small amount of work has been done on it. The mineral body exposed in a cut 20 feet long and 10 feet deep consists of chalcopyrite masses associated with some magnetite in a garnet gangue which replaces the greenstone tuff country rock. Granodiorite occupies the hill just west of this prospect, but was not exposed near the mineral body. Dikes of diabase crosscut the ore body and are evidently of later origin. Besides the copper, the ore is said to carry high values in both gold and silver.

Brown & Metzdorf prospect.—The Brown & Metzdorf prospect is located three-fourths of a mile south of the Charles prospect and one-half mile from Kasaan Bay, at an elevation of 310 feet. The ore body is a mineralized mass of garnet rock carrying chalcopyrite and pyrite exposed for a width of 10 feet, showing a banded structure and evidently replacing the bedded quartzite and greenstone tuff country rock. A wide belt of limestone is exposed in bluffs along the trail just below this prospect.

Peacock and Tacoma claims.—The Peacock and Tacoma claims, about 3 miles southeast of Kasaan post-office (see fig. 1), are the property of the Grindall Mining and Smelting Company. The Tacoma claim is located along the beach, where open cuts have been made on ore exposures that are covered at high tide. The ore is confined to a garnet-epidote rock and occurs in irregular patches or finely disseminated particles. In the beach cuts a small amount of ore is exposed, and above it, at an elevation of 50 feet, is a tunnel 60 feet in length entering the hill in a northeasterly direction. This tunnel crosscuts a wide belt of garnet-epidote rock containing some chalcopyrite. Other open cuts expose small amounts of ore at several places, but no large ore masses have been developed.

The Peacock claims adjoin the Tacoma claim on the north and extend to the center of the peninsula. At 600 feet from the beach and 120 feet above tide a tunnel 45 feet long exposes a belt of garnet-epidote contact rock containing magnetite and a small amount of chalcopyrite. Still higher, at 325 feet, a second tunnel 30 feet long, following the contact of a diabase dike, exposes a similar mineral-bearing rock. Here also dikes of felsite and basalt occur, and slipping planes were observed faulting the mineral body in various directions. The amount of development on these properties has not been sufficient to disclose ore bodies large enough to justify mining, but systematic prospecting may open up deposits of value.

"*Hole in the Wall*" *prospects.*—The small cove known as "Hole in the Wall" lies on the north side of the harbor at Hadley, and along its shores and west of it a number of claims have been located, among which are the Plumley group and the Eureka, Sunrise, Pennsylvania, Venus, and Pelaska claims. (See fig. 1.) On the Hilma claim of the Plumley group, at a point one-half mile northwest of the head of the cove and 310 feet in elevation, a tunnel 25 feet in length has been driven along the contact of an altered limestone belt with a dioritic batholith, in which small masses of chalcopyrite are exposed in a garnet-epidote-calcite contact rock. On the Eureka claim, at tide water, similar contact deposits are being developed and are reported to be of considerable extent. The Sunrise claims, three in all, are located west of the "Hole in the Wall," and on these claims at points along a gulch small ore masses occur replacing limestone beds at or near their contact with granodiorite. At 1,050 feet elevation this contact aureole is 25 feet in width and contains considerable magnetite and chalcopyrite ore which shows much surface alteration. On the south slope of the hill at 950 feet elevation is an open cut exposing a highly crystalline marble, slightly banded, striking N. 65° E. and dipping 60° NW. This marble overlies the contact rock, which carries small amounts of the copper ore. On the Pennsylvania claims, southeast of the Sunrise claims, an open cut following a felsite dike at 850 feet elevation exposes a small vein 2 to 3 feet wide consisting of pyrite with small amounts of chalcopyrite. The prospects on the Venus claims show contact deposits similar to those exposed on the Sunrise claims to the north and are apparently along the same intrusive contact. The Pelaska claim, extending from the head of the cove westward, has been developed by a tunnel over 100 feet in length following a belt of altered limestone intruded by a diabase dike, along which occurs the garnet-epidote contact rock carrying some chalcopyrite. This deposit is interesting geologically, but the amount of ore exposed is small.

PRACTICAL DEDUCTIONS.

From the foregoing considerations it is evident (1) that the ore bodies should be sought along or near the contacts of the intrusive diorite and syenite masses; (2) that the contacts of large intrusive masses are more favorable for ore deposits than those of small masses; (3) that the limestone beds are more likely to be replaced by the ore-bearing minerals than the other intruded rocks, because of their solubility; (4) that the largest deposits are found at the contacts of limestone with the intrusives, as the lime carbonate acts as a precipitant to the ore minerals; (5) that the felsite, diabase, and basalt dikes are later than the ore bodies and have no genetic relation to them; and (6) that ore bodies may be found at considerable depths within the contact zones as well as near the surface.

Though large areas on Kasaan Peninsula still remain unprospected, there is little to indicate that deposits of much higher grade or of greater extent than those that are being mined at present will be found.

The question as to the extent of the copper-bearing masses is possibly the most vital one. That outcrops may fail altogether to indicate the value of the ground underneath has been shown at several localities, and that the ore may occur in masses of moderate size, which can be mined out in a short time, is shown at several mines, though at these localities further investigation has usually revealed new ore bodies. Under exploitation on the scale which prevails in this district the problem of new ore reserves must inevitably come to the front, and the search for new ore bodies should be vigorously continued by both prospector and mine operator. Such investigations have been satisfactorily prosecuted in the ore-bearing rocks by the use of diamond drills, which are especially adapted to the search for scattered ore masses.

Under existing conditions, with the price of copper at 15 cents a pound, it is not possible to mine profitably ore containing less than 60 pounds of copper and the usual gold content of 75 cents to $1.25 per ton. However, ore containing as low as 40 pounds of copper per ton was mined and shipped at a profit early in 1907, when the market value of copper was 25 cents a pound. The present mining costs average from $1.50 to $2 per ton, including haulage to the wharf; transportation to the smelter at Tacoma or in British Columbia costs from $1.50 to $2 per ton, depending on the tonnage shipped; smelting charges are from $3 to $5 per ton, including the losses in treatment. When the ore is smelted in Alaska, the cost of transportation is somewhat reduced, though the smelting charges are necessarily increased, as the coke required must be shipped to Alaska and the copper matte or smelter product shipped to Puget Sound.

Large bodies of magnetite containing from 0.5 to 1.5 per cent of copper have been developed in the mines and on several prospects. Such deposits can not be mined as copper ore with profit. It may be possible, however, by a method of concentration, by fine grinding and magnetic separation, to produce a marketable product from this low-grade material. The value of these magnetite deposits as iron ore should also be considered. Analyses show that the magnetite is practically free from phosphorus and contains very little sulphur or other impurities. It might therefore be placed on the market as a Bessemer ore.

THE BUILDING STONES AND MATERIALS OF SOUTHEASTERN ALASKA.[a]

By Charles W. Wright.

GENERAL STATEMENT.

The only stones of value in southeastern Alaska, so far as known, are the marbles and granites. The market for these stones is in the cities along the Pacific coast of the United States, 600 to 1,000 miles distant. They must, therefore, be of more than ordinary quality to bear the expense of freight, as good stone is found in the vicinity of most large cities, and builders, as a rule, prefer to use a known rock which is near at hand and can be readily obtained.

To place the Alaskan product on the market, it will be necessary to establish supply stations with dressing and cutting plants in the larger seaboard cities, where cheaper and more efficient labor may be obtained than in Alaska. To supply these points the rough granite and marble could be transported in hulks or barges carrying several thousand tons at a low freight rate, and the necessity of careful handling during the shipment would be avoided.

To determine the structural value of a building stone, microscopical, chemical, and physical tests should be made. This is more necessary for marble and cement stone than for granite. Most university laboratories are equipped for such tests and will make them at a reasonable cost.

Deposits of building materials, such as cement, gypsum, and clay beds, are not plentiful in southeastern Alaska, and gypsum alone is being mined at a profit. Both cement and clay deposits have been located, but no attempt has been made to place the material on the market.

[a] The substance of this paper was published in last year's Progress Report (Bull. U. S. Geol. Survey No. 314, pp. 73–81), but as the edition of that bulletin is almost exhausted it seems advisable to reprint here these statements, which are supplemented by descriptions of the progress at the mines and quarries in 1907.

MARBLE.

DISTRIBUTION.

Beds of marble are known to occur at points along the mainland portion of southeastern Alaska, as well as on many of the islands. They are invariably at or near the contact of an intrusive belt of granodiorite, which has been one of the principal factors in metamorphosing the original limestone beds to their present crystalline or marbleized condition. The age of the limestone beds is Paleozoic, and only in a few places could a more definite determination be made. The largest deposits of marble under development are at the northwest end of Prince of Wales Island near Shakan and on Ham Island south of Wrangell.

NECESSARY QUALITIES.

Commercially, marble includes all limestone rocks susceptible of receiving a good polish and suitable for ornamental work. It is not a simple matter to judge the value of a marble deposit, and this can not be done from mere tests of small samples, which, nevertheless, may often give significant results. Some of the more important factors governing the value of a body of marble are the quality and soundness of the stone as a whole, extent of the deposit, absence of fractures or joint planes, color, lack of objectionable impurities such as silica, pyrite, and bitumen, facility of extraction, and location of the deposit relative to the market and transportation.

ALASKA MARBLE COMPANY.

SITUATION AND DEVELOPMENT.

The properties of the Alaska Marble Company are situated on Marble Creek a few miles north of Shakan, Prince of Wales Island, bordering the coast for 2 miles and being over half a mile in width. They are located upon a belt of Devonian limestone about 3,000 feet in width flanking the west side of an intrusive granite mass which forms the low mountain ridge to the east and which is evidently the direct cause of the alteration of the limestone to marble. This deposit was first discovered in 1896 and finally located in 1905, the first work being done along the exposures in the creek bed half a mile from the shore. From 1900 to 1904 prospecting was extended up the hillsides and drill holes were sunk to ascertain the quality of the product in depth. Early in 1904 the Alaska Marble Company was incorporated, and developments on a large scale were immediately begun. At present the plant consists of a wharf equipped with derricks, a gravity railroad to the quarry, 3,200 feet in length, necessary channeling and gadding machines, and various buildings. At the quarry, located on the south side of Marble Creek at an elevation of 100 feet, an area 100 by 200 feet has been stripped and quarried to an average depth of 60 feet, measured on the mountain side.

A test shipment of 100 tons was made in 1902, but actual production did not begin until 1906. The marble is now being placed on the market in the cities along the Pacific coast. The manufacturing plant of the company is located at Tacoma, Wash.

THE MARBLE DEPOSIT.

The extent of the marble deposit at this locality has been investigated at a number of points on the surface by open cuts and trenches and in depth by 18 drill holes, and at all these places marble usually of good quality is exposed. As above noted, the marble belt is approximately 3,000 feet in width, striking in a northwesterly direction and dipping to the southwest. It is limited on the northeast side by an intrusive granite mass and on the southwest by the shore line. To the south it crosses the entrance to Dry Pass, but just back of Shakan it is cut off by a granite mass. To the northwest it extends into the channel and reappears at the entrance to Calder Bay, extending northward and overlying beds of conglomerate. Along the shore exposures and at the quarry small dikes of diabase, striking northeastward and much altered and faulted, were observed intersecting the marble beds. Apparently these dikes antedate the metamorphism of the limestone and therefore the intrusion of the granite. They are, however, but a foot or two in width and not sufficiently numerous to affect the value or expense of quarrying the marble. In the present opening at the quarry only one dike is exposed. Both surface cracks and slipping planes are present in the surface exposures of the marble, but in depth these are less numerous and will not materially interfere with quarrying.

Three distinct varieties of marble are found—pure white, blue veined with white background, and light blue much of which has a mottled appearance. The pure white, which has a finely crystalline texture, is the most valuable. All of the marble is free from the silica and flint beds common in most quarries, and though thin seams of pyrite were observed, they do not occur in a quantity detrimental to the stone. The following is a chemical analysis of the white marble made by E. F. Ladd for the Alaska Marble Company:

Chemical analysis of white marble from Marble Creek, Prince of Wales Island, Alaska.

Insoluble matter	None.
Oxide of iron (Fe_2O_3)	Slight trace.
Sulphuric anhydride (SO_3)	Trace.
Lime (CaO)	55.59
Magnesia (MgO)	.30
Carbon dioxide (CO_2)	43.67
Undetermined	.44
	100.00
Calcium carbonate ($CaCO_3$)	99.26

A qualitative test for magnesia in a sample collected by the writer was made by George Steiger, of the United States Geological Survey, who reports a content of less than 1 per cent.

To determine the crushing strength of the stone the Alaska Marble Company submitted samples to N. H. Winchell, State geologist of Minnesota, who reports an average strength of 10,521 pounds per square inch—a strength ample for all building purposes. Though not equal to the best Italian grades, this marble is better than most American marbles, and in the market will compete on at least equal terms with the product of Vermont, Georgia, and Tennessee.

METHOD OF QUARRYING.

At the quarry it was first necessary to remove the uppermost layers of the more or less fractured marble. This was done by channeling machines, a method which is preferable to blasting, as it does not injure the massive rock in depth. The machine used is mounted with a donkey engine on a truck and cuts a channel 2 inches in width at a rate of 7 to 8 square feet per hour. These channels are extended to a depth of 4 feet and are made at intervals of 4 or 6 feet in one direction and at intervals of 6 feet at right angles, so as to form blocks 4 to 6 feet by 6 feet in surface area and 4 feet in depth. These blocks are undercut by gadding machines, in which a drill is set so as to drill a series of holes under the block, and in these holes wedges are driven and the block is freed from its base. It is then lifted by a derrick to the car on which it is carried to the wharf. The blocks contain from 96 to 144 cubic feet of marble and weigh from 7½ to 11 tons each, the dimensions depending on the handling capacity of the machinery. The larger portion of the marble product is shipped in the rough state to a sawing and polishing plant at Tacoma, where it is prepared for the market. Small shipments have also been made to Chicago, Milwaukee, St. Louis, Cincinnati, and other points for trial tests.

EL CAPITAN MARBLE COMPANY.

The property of the El Capitan Marble Company is situated on the eastern side of a low mountain range 5 miles due east of the Alaska Marble Company's quarry and on the north side of Dry Pass. These locations, including 10 claims, were first made in 1901 and were sold to the El Capitan Marble Company in 1903. Except for a small amount of assessment work, operations were not begun until April, 1904. During that year a quarry consisting of a pit 12 feet deep was opened on a marble deposit close to tide water, a channeling and gadding machine was installed, and a cutting plant operated by steam power was erected. Some marble was quarried and shipped to Seattle at the close of the year, but since that time operations have been suspended.

The marble deposit flanks the eastern side of the granite mass represented on the geologic map (Pl. II) and from its relative position and general character is similar to the Marble Creek deposit farther west. The marble belt is exposed at tide water and forms high bluffs at 200 to 400 feet elevation one-fourth of a mile back from the shore. In these bluffs it has been prospected by trenches and open cuts. A number of diabase dikes crosscut the marble beds. The dikes are faulted and show in many places several feet of displacement, though this faulting, as well as the intrusion of the dikes, probably occurred previous to the metamorphism of the original limestone beds, as no trace of the fault planes could be seen, and the dikes themselves were much altered and sheared. The marble as exposed in the quarry is not of so good quality as that from the Marble Creek property, being less firm and more coarsely crystalline. Surface cracks and fracture planes are present in the surface exposures, but in the bottom of the pit these features are less pronounced.

AMERICAN CORAL MARBLE COMPANY.

The properties of the American Coral Marble Company are at two localities—(1) at the head of North Arm, where 12 claims have been located along the north shore of the inlet, and (2) at the north entrance to Johnson Inlet, where the company has several claims extending from Dolomi eastward to Clarence Strait. The principal developments have been made at the North Arm property, and at this point a post-office named Baldwin has been established. Active work at this locality began in 1904, and the marble deposits were prospected during that year. In 1905 a wharf was built, machinery was installed, and buildings were erected preparatory to quarrying the marble. During 1906, however, practically no work was done, and all the machinery was removed in 1907. At the Dolomi property a small quarry was started on the hillside, at a point a quarter of a mile northeast of Dolomi post-office and a few hundred feet from tide water on the Clarence Strait side, where buildings were erected. No operations were in progress at these localities during 1907.

The deposits at North Arm and Dolomi consist of marble beds interstratified with chloritic and calcareous schists, striking northwest with steep dips, usually to the southwest. The surrounding area is mantled by a dense growth of vegetation, and the limits of the deposits have not been definitely determined, though where the marble is exposed it is much fractured, variable in color and composition, and intersected by a few narrow dikes of diabase. The fracture planes were probably formed principally during the period of tilting and folding of the beds and existed before erosion exposed the present surface outcrops. Since that time weathering has accentuated and to some extent increased the number of fracture planes. It seems probable, however, that in depth these planes, although potentially present as lines of weakness, will become less numerous and will not interfere greatly in quarrying.

Although some parts of the deposits consist of pure-white, fine-grained marble of excellent quality, other parts are poorly colored, coarse grained, and of little commercial value, and it will probably be difficult to obtain large quantities of uniform grade. The better grade is reported to give the following analysis: Calcium carbonate, 94 per cent; alumina, 3.9 per cent; silica, 1.4 per cent; magnesia, 0.7 per cent. Pyrite is also present in small amounts, occurring in thin seams and finely disseminated in some of the marble.

MARBLE ISLAND.

Marble Island, a low wooded area of 9 square miles, is one of the larger islands in Davidson Inlet and lies 10 miles due south of Shakan, though by water it is nearly 30 miles distant. On the northwest side of this island marble was first discovered in 1899, and in 1903 a number of claims were located over this portion of the island and a small amount of stripping was done. Samples of this marble were quarried for test purposes and several varieties of good quality obtained. The total developments have not exceeded the assessment requirements.

The marble deposit is exposed in a cove on the northwest side of the island, and half a mile from the shore, at an elevation of 100 feet, it has been worked by an open cut. A considerable area is underlain by marble, though little is known of its extent or value. Along the eastern shore of the island an area of granitic intrusive rock was noted.

REVILLAGIGEDO ISLAND.

A well-defined limestone belt traverses the eastern portion of Revillagigedo Island in a northwesterly direction and is exposed in Thorne Arm, Carroll Inlet, and George Inlet. Its widest development is on the north side of George Inlet near the head, where marble claims known as the Bawden group were located in 1904. The deposit is included in the crystalline schist near the contact with the less altered slates to the southwest. The marble beds range from 10 to 20 feet in width and are separated by strata of calcareous schist. Their strike is northwest, with northeasterly dip. The marble is exposed in cliffs near tidewater and is of good quality, being relatively free from fracture and joint cracks, finely crystalline, and from white to gray in color. No large developments have been started on this property.

In Carroll Inlet to the southeast claims have also been located on the same belt, but at this locality the deposit is not so extensive as in George Inlet.

HAM ISLAND.

Ham Island lies at the junction of Blake Channel and Bradfield Canal, 25 miles southeast of Wrangell. It is about a mile and a half wide and consists largely of crystalline limestones with interstratified beds of calcareous schist striking N. 35° W. and dipping 75° NE. Intrusive dikes of basalt are common, and across the narrow channel on the mainland and on Wrangell Island wide belts of granite intrude these limestone and schist beds and have probably induced the present crystalline texture in the limestone and thus formed the marble.

Two distinct varieties of marble are found—one fine grained and pure white, the other very coarse grained and pale blue. Several systems of jointing planes traverse the deposits, but the joints are widely separated and will not interfere greatly in quarrying. Checks or surface cracks are practically absent and wide areas of massive marble have been found directly underneath the soil. Much of the marble appears to be free from impurities.

Two groups of claims have been located on this island, the Woodbridge-Lowery group on the west side and the Miller group on the east side. On the former the marble quarried is principally of a white, finely crystalline variety, but at the Miller property the deposit, exposed in a bluff 40 feet high and 100 feet long, is of a coarsely crystalline texture and a bluish color. On both of these properties considerable exploratory work has been done, and large blocks of the marble have been quarried, from which tombstones and small blocks have been chiseled and polished for local use. The properties are favorably located both for quarrying and transportation.

ADMIRALTY ISLAND.

Marble is known to occur at several localities on Admiralty Island, namely, at Marble Bluffs, on the west coast; at Square Cove, just north of Marble Bluffs; and in Hood and Chiak bays, south of Killisnoo. At these points some of the marble is of good quality, but most of the deposits contain silica and pyrite and the rock is not of much value. The deposits at Marble Bluffs are apparently more extensive and of better grade than those at the other localities.

GRANITE.

DISTRIBUTION.

The granitic intrusive rocks occupy about one-half of the aggregate land area of southeastern Alaska. In composition they range from granite to granodiorite or to quartz or hornblende diorite. The core of the Coast Range, as well as the central portion of many of the islands, is composed of this intrusive rock. The metamorphism in the granite, its nonuniformity in color, and the presence of joint cracks, so far as observed, make most of the stone undesirable for building purposes. However, granite masses of good quality, uniform in color and favorably located for purposes of quarrying, were observed along the mainland up Portland Canal, in Behm Canal, at Thomas Bay, in Taku Inlet, and at the head of Lynn Canal. On the islands numerous granite stocks occur, portions of which are of massive and uniform texture, though these stocks contain numerous segregations of the femic minerals, and pyrite is present in many places, rendering the rock less desirable for building purposes. Rock of good quality was observed at Gut Bay and Whale Bay, on the coast of Baranof Island.

All the granite masses in this region are similar in composition, having plagioclase feldspar as an essential constituent. Hornblende is the usual dark mineral, though biotite mica is present in much of the rock and in a few places exceeds in amount the hornblende. Quartz is commonly present, though usually in small amounts. The accessory components are apatite, titanite, and magnetite; secondary minerals, due to general metamorphism, are sericite, epidote, zoisite, chlorite, and calcite. Petrographically much of the rock is related more closely to the diorites than to the granites and is usually referred to as a diorite.

The prevailing color is light gray and in only a few places were pink or reddish masses observed. The grains of the component minerals are ordinarily of medium size, not varying greatly in the different localities. Evidence of the durability of the granite is afforded in many places where long exposure to the influence of weathering has caused little or no disintegration of the surface.

MARKET.

No attempt has yet been made to quarry or even to investigate the Alaskan granite. There is practically no market in Alaska for the stone, and along the Pacific coast to the south the demand has been supplied by the quarries in the States of Washington, Oregon, and California.

The long haul necessary to reach the market appears at first unfavorable to granite quarrying along this portion of the northwest coast, but the present freight rate of less than $3 per ton to Puget Sound is not greater than the cost of transportation from some of the quarries in California to the larger cities. The cost of quarrying the stone in the Western States is estimated at 35 cents per cubic foot, and the proportion of marketable rock obtained from the amount quarried is about 60 per cent. The average selling price per cubic foot for building purposes at the quarries in the coast States in 1906 was as follows: Rough, $0.85; dressed, $2.35; for curbing, $1. For monumental purposes the stone sold for $1 to $2 per cubic foot rough and for $3 to $6 dressed. These prices do not include the cost of transportation from the quarries to the cities, which is from 50 cents to $3 per ton. This adds from 5 to 30 cents to the cost of the stone per cubic foot.

GYPSUM.

THE GYPSUM DEPOSIT.

The only extensive deposit of gypsum known in southeastern Alaska is situated on Gypsum Creek a mile from its mouth, at Iyoukeen Cove, on the east side of Chichagof Island. The gypsum beds apparently overlie the Carboniferous rocks exposed along the southwestern shore of Iyoukeen Cove and forming the ridge southwest of Gypsum Creek, though the area of contact is buried under deep gravel deposits along the beach and in the valley. The mountain ridge to the northeast is made up of a granitic mass intruding the older limestone and quartzite. Structurally the gypsum beds are folded and steeply tilted and were probably laid down previous to the granitic invasion. They are at present regarded as of Permian or Triassic age.

The geology in the immediate vicinity of the gypsum beds is obscure and neither foot wall nor hanging wall of the deposit is exposed. Bluffs of a cherty limestone striking northwest and dipping to the northeast are exposed near the entrance to the tunnel at the lower mine workings on Gypsum Creek. The gypsum beds in the tunnel and lower levels have an east-west to N. 70° E. strike, with a northerly dip of 20° to 60°. Channels representing old water-courses and now filled with gravel wash are numerous throughout this deposit. These gravels resemble unconsolidated conglomerate beds and have been mistaken for both hanging and foot walls of the gypsum beds at points in the workings. A careful inspection of the gravels shows that the wash has the same character as that now in the creek bed. Of significance is the presence of cobbles of granite corresponding to the intrusive mass at the head of the creek, which invaded the area subsequent to the deposition of the gypsum beds.

MINE DEVELOPMENTS.

This gypsum deposit, the property of the Pacific Coast Gypsum Company, has been extensively developed during the last few years and large shipments of the rock are being made to the plaster mill at Tacoma, Wash., where it is prepared for the market. The developments consist of a wharf 2,000 feet in length extending to deep water, where rock bins of 1,000 tons capacity have been built, and of a railroad about a mile in length to the mine workings. At the mine rock bins of 1,500 tons capacity have been erected, thus affording sufficient storage capacity during intervals of transportation of the gypsum to the plaster mill. A vertical shaft has been sunk for 190 feet and from it two levels have been extended at points 90 and 160 feet in depth, both of which are almost entirely in gypsum. The main developments are on the 160-foot level and include 1,200 feet of workings, exposing the gypsum bed over an area 450 by 225 feet. Both the thickness and the lateral extent of the bed are still undetermined. At a point 800 feet west of the shaft investigations were made in former years of a gypsum exposure on the creek bank, where a short tunnel was driven and a 75-foot shaft sunk almost entirely in gypsum, but work at this point was discontinued.

MARKET.

Gypsum is in much demand along the Pacific coast as wall plaster and fertilizer and in the manufacture of cement. The Puget Sound market is supplied in large measure from the deposits in Kansas, Colorado, Wyoming, and Utah. The California market is supplied from local deposits and those in Nevada and Utah. Transportation from these points to the seaboard cities costs from \$4 to \$7 per ton, and the present market prices of first-grade gypsum products in these cities are as follows: Crude, \$5 to \$7 per ton; land plaster, \$6 to \$8 per ton; plaster of Paris, \$8 to \$11 per ton; wall plaster, \$9 to \$12 per ton.

CEMENT.

There are several kinds of cement, the principal kinds being Portland cement and natural cement. Portland cement is produced by burning a finely ground artificial mixture containing essentially lime, silica, and alumina in certain definite proportions. Usually this combination is made by mixing limestone or marl with clay or shale; such a mixture should contain about three parts of the carbonate to one part of clayey material. Natural cement is the product of an impure limestone containing from 15 to 40 per cent of silica, alumina, and iron oxide. Calcareous and argillaceous rocks suitable for cement making are relatively scarce in the Ketchikan and

Wrangell districts. They are metamorphosed, usually containing mica and some pyrite, and are not sufficiently fine grained to be of value. At only one locality—Long Island in Kasaan Bay—have rocks of this sort been located for the manufacture of cement. Here beds of limestone and siliceous shale are exposed around the shores of the island and are apparently of a quality suitable to make cement. The disposition of this product will, however, be confined to the local market, as it can not now be profitably shipped to compete with the cement manufactured along the Pacific coast. The reason for this, in the first place, is the high cost of the fuel necessary for its manufacture. The difficulty in obtaining efficient and cheap labor, as compared with the labor of the Puget Sound area and California, must also be considered, and the long haul necessary to reach the market is unfavorable to such an industry. To ship the cement rock as mined to a cement factory established somewhere near the point of coal supply and near the market would be the most feasible plan; but this would bring little or no profit, as vast areas of cement rock are exposed near all the larger cities and can supply the cement plants along the coast for many years to come.

CLAY.

Large deposits of clay are known to occur at the head of Vallenar Bay and along the banks and deltas of many of the glacial streams. These clays are fine grained to gritty, bluish in color, and semiplastic, and are usually termed "glacial mud." They are especially suitable for the manufacture of brick. For cement making the clay would require the addition of limestone and fine grinding, as coarse particles are scattered through it. The clay deposits are of only local value, and the material has little or no commercial importance.

THE MINERAL RESOURCES OF THE KOTSINA AND CHITINA VALLEYS, COPPER RIVER REGION.

By Fred H. Moffit and A. G. Maddren.

INTRODUCTION.

The four best-known and most promising copper-bearing regions of Alaska are the Kasaan Peninsula region of southeastern Alaska, the Prince William Sound region, the region included within the drainage area of Kotsina and Chitina rivers, and the region of upper Copper, Tanana, and White rivers. Of these four only Kasaan Peninsula and Prince William Sound have yet produced copper commercially and at the present time they furnish the entire production of Alaska, which in 1906 amounted to 8,685,646 pounds of blister copper—an increase of more than 3,500,000 pounds over the output of the previous year.[a]

The mines of these two regions are all located either at tide water or within comparatively easy reach of it, so that the matter of transportation does not present so great an obstacle to development as in the interior of Alaska, and they thus possess an advantage that has enabled them to reach the productive stage more rapidly than otherwise would have been possible.

The two remaining regions, each of which is sometimes referred to as the Copper River region, although the name is more often applied to the Kotsina-Chitina area (Pl. III), are really one, but are distinguished from each other because they lie on opposite sides of an almost impassable mountain range. They are situated in the interior, north of the high mountains forming the Coast Range, and can be reached only by long, hard journeys over trails which, although their value to the prospector and traveler can hardly be overestimated, still leave much to be desired. The cost of supplies and the time and labor required to carry them into the country have been

[a] Graton, L. C., The production of copper in 1906: Mineral Resources U. S. for 1906, U. S. Geol. Survey, 1907.

so great that little more than the assessment work required to hold claims or to obtain patents has been done. The whole of the interior region may be said to be still in the prospecting stage and must remain so until means are provided by which supplies and equipment can be brought to it more cheaply and by which the ore, when produced, can be taken out.

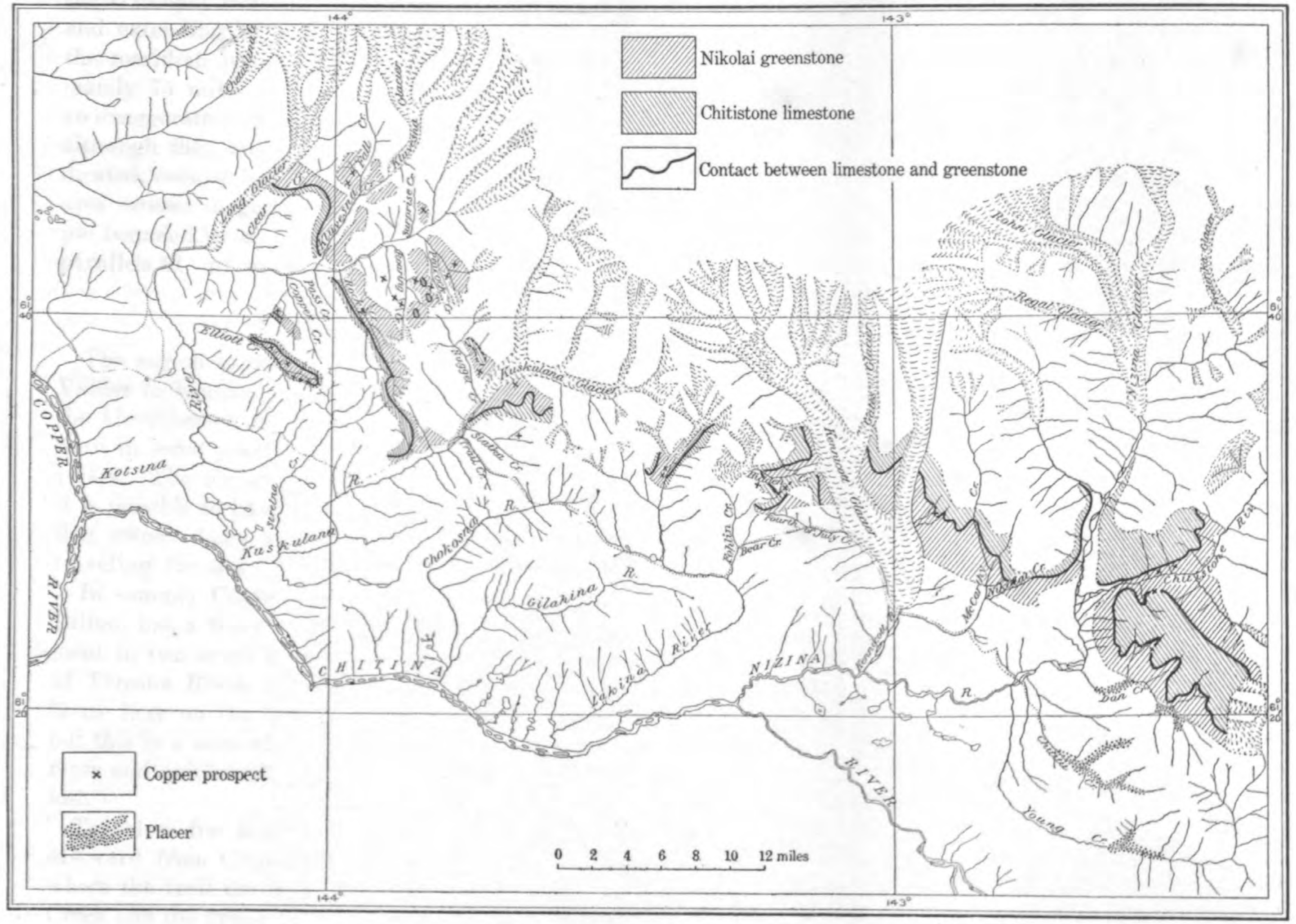
The first study of the copper deposits of Chitina Valley by members of the Geological Survey was made by F. C. Schrader and A. C. Spencer[a] in 1900. At the same time a topographic map of the region, including Hanagita Valley on the south and lower Copper River as well, was made by T. G. Gerdine and D. C. Witherspoon. Prospecting was then just beginning and very little work had been done on any of the claims, yet some of the important facts concerning the ores were established. Two years later (1902) W. C. Mendenhall[b] visited the west end of the area, including Kotsina River and Elliott Creek, but after that time no further work in the region was undertaken by the Survey till 1907, when public interest made it desirable to send another party into the field.

In this paper, which embodies the principal results of last season's work, the copper deposits of the Kotsina-Chitina region are described. Only enough of the general geology is introduced to give a clear idea of the relation existing between the copper ores and the rocks with which they are associated, as it is desired to lay emphasis on the economic side of the subject and to avoid confusing this with descriptions of formations and their relations that may more properly be taken up in another place. It is hoped that the facts observed are here presented impartially and in such a way as to give a proper idea of the type of ores occurring in this region and of the progress in developing them since they were last visited by members of the Survey.

Those seeking information in regard to the commercial value of the deposits here described may be disappointed in finding no definite statements in regard to values. It has become the established practice in the Alaskan investigations not to treat this subject, for it evidently falls within the province of the mining engineer who investigates a particular property. In the short time available for their study it would obviously be impossible for the Survey geologists to sample the deposits visited, and it also appears unwise to publish the results of assays furnished by property owners, because it is not always possible to learn how a given sample was taken.

[a] The geology and mineral resources of a portion of the Copper River district, Alaska, a special publication of the U. S. Geol. Survey, 1901.

[b] Geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41, 1905.



MAP OF KOTSINA-CHITINA COPPER BELT.

GENERAL DESCRIPTION.

LOCATION.

The principal copper deposits to be described in this paper lie east of Copper River, within an area included between the watershed of the Wrangell Mountains on the north and Chitina River on the south and extending eastward from Kotsina River and Long Glacier to the meridian passing through Skolai Pass, a distance of approximately 75 miles. (See Pl. III.) This description, however, gives an exaggerated idea of the extent of the copper-bearing rocks, which, although they are found from one end to the other of the area indicated, occupy but a small part of the whole. Geographically this area crosses diagonally, from northwest to southeast, the quadrangle bounded by meridians 140° 20′ and 144° 20′ west longitude and parallels 61° 10′ and 61° 50′ north latitude.

TRAILS AND TRANSPORTATION.

The region is reached by a trail from Valdez, the distance from Valdez to Kotsina River being not far from 125 miles. In summer the Government trail via Tonsina is used, but in winter supplies have in some years been taken in by way of Tasnuna and Copper rivers. The ice on Copper River furnishes excellent sledding and it is possible to haul very heavy loads over it, but the violent winds that sweep down the Tasnuna and Copper valleys often prevent traveling for days at a time.

In summer Copper River is crossed by boats. An Indian named Billum has a ferry license and transfers travelers with their equipment in two small boats at a place about 1½ miles above the mouth of Tonsina River, called Copper River Crossing. There is a road house here on the west side of the river. Horses swim the river, but this is a somewhat dangerous undertaking because of swift currents and quicksand, and it is not an uncommon thing for one to be lost.

Travelers for Kotsina and Chitina rivers follow the same trail eastward from Copper River Crossing for 8 miles to Horse Creek, where the trail divides, one branch going northeastward to Willow Creek and the upper Kotsina, the other southeastward up the Chitina Valley. From Willow Creek the northerly trail follows the right (west and north) bank of Kotsina River and crosses the lower end of Long Glacier. There is a bridge over Kluvesna Creek and another over Kotsina River near the mouth of Rock Creek, so that it is not necessary to ford these streams. The Hubbard-Elliott Company has built a bridge over Kotsina at the mouth of Willow Creek, on the trail to Elliott Creek. A bridge was recently built by the Government over Kotsina River at the point where the lower or Chitina trail crosses it, doing away with a dangerous ford at that place. From the Government bridge the trail continues eastward along the foothills of the Wrangell Mountains, crossing Kuskulana River 3 miles below the glacier and reaching the head of Chokosna River and the Lakina by way of Kuskulana Pass. Ascending Fohlin Creek, it leads through Kennicott Pass and down Fourth of July Creek to Kennicott Glacier and Kennicott River, which is crossed on the glacier ice. A good trail leads to the Bonanza property from the lower end of the glacier. Another trail follows McCarthy Creek for 4 miles and, crossing the ridge known as Sourdough Hill, extends to Nizina River, from which Chititu Creek, Dan Creek, and Chitistone River are easily reached. Nizina River must be forded—a task that may be difficult, if the water chances to be high. There are no bridges east of Kotsina River, and most of the streams, being of glacial origin, are very cold, but the only ones likely to cause trouble are the Kuskulana, Lakina, and Nizina.

It is a common thing for prospectors in the Nizina country to come out in the fall by way of Chitina and Copper rivers, either leaving the Copper at Tasnuna River and going overland to Valdez, or following the river to the coast and landing at Eyak or Orca. Several days' work is needed to whipsaw the lumber and build the boat, but the river trip is even then much quicker and easier than the overland trail. The distance from the mouth of Young Creek to Tasnuna River, over 115 miles, has been made in less than twenty running hours. A skillful boatman would meet with little or no difficulty on the Copper or Chitina, but the canyon at the lower end of Nizina River is dangerous, particularly at low water, and a number of persons have been drowned in trying to run through it.

In July, 1907, a small steamboat called the *Chitina* made her first run from Tasnuna River to Copper Center on Copper River and to the mouth of Nizina River on Chitina River. The material for her construction was hauled over the snow from Valdez during the previous winter, and she was completed early in July, but after the trip up the river was hauled out on the bank for the winter. She draws very little water, but will probably be unable to run after the middle of summer because the river is much lower in the fall than during spring and early summer. Boats can not descend Copper River farther than Abercrombie Rapids, 25 miles below Tasnuna River, and any freight the *Chitina* may carry up the river must be delivered to her either at the rapids or at Tasnuna River.

The building of a railroad from a point on the coast to the interior Copper River country is of prime importance in the development of the copper resources of the region. During the last few years various companies have been formed with this object in view, and railroad surveys have been made from Katalla, from Orca, and from Valdez by both the Tasnuna and the Tonsina routes. Construction work has been done in all these routes, but, except the Copper River and Northwestern Railroad and the Alaska Pacific Railway and Terminal Company, none of the companies were making progress last summer, although the Alaska Home Railway laid a few miles of track at Valdez.

The Copper River and Northwestern Railroad has its coast terminal 28 miles west of Copper River on the east side of Prince William Sound at Eyak, or Cordova Bay, as it is frequently called. The terminal was changed from Katalla to Eyak late last fall, probably because of the great difficulty experienced in lightering freight at Katalla and the expense and time that would be required in building a breakwater for the protection of ships while discharging cargoes. Eyak has a protected harbor and can be approached at any time. A wharf and a few miles of railroad embankment from Eyak village to Glacier River had already been constructed by another company, but were purchased by the Copper River and Northwestern. It is proposed to use the Katalla branch, which will join the main line in the vicinity of Childs Glacier, as a means of reaching the Controller Bay coal fields. Considerable work on this branch, originally intended as the main line, has been done at Katalla and in that vicinity. In October, 1907, construction trains were running between Katalla and Martin Point, a large part of the rock work along the coast from Martin Point to Softuk Bar was done, and most of the piling in the low ground on the east edge of Copper River delta as far north as Camp Seven, 7 miles from Palm Point, had been driven. Location surveys have been made up Copper, Chitina, and Nizina rivers to Kennicott River. Just how soon this railroad will reach the interior is difficult to say, in view of the progress during the last two years.

The Alaska Pacific Railway and Terminal Company starts from the coast at Katalla and contests the right of way through Abercrombie Canyon with the Copper River and Northwestern Railroad. In 1907 a trestle connecting Martin Point with the nearest of the Martin Islands was built, and when filled in with rock will be used as a breakwater behind which ships may be unloaded. Other work done by the company was directed largely toward the construction of a line to connect Katalla with the Bering River coal field.

The Alaska Home Railway is a railroad project started at Valdez in midsummer, 1907. This road was planned to connect Valdez with the Copper River region. It was to ascend Lowe River and reach the Copper River basin by way of Thompson Pass, whence it was expected to continue to Tonsina by practically the same route as the Government trail. Its motive power was to be electricity. A steam locomotive and some rails were shipped to Valdez, and a short stretch of track was laid, but work was soon suspended owing to lack of funds.

WORKING SEASON.

Inadequate and expensive transportation facilities have been the chief obstacle in developing the copper resources of Chitina River. Another adverse condition, which, however, affects prospecting more than it will mining, is the short summer season. Up to the present time practically all supplies have been taken in during the winter with sleds drawn by horses. In the earlier days dogs or man power were sometimes used, but of late years horses have been employed almost entirely. Sufficient feed to last till the grass starts in the spring is carried, but after that most horses "live on the country." The early snows begin about the end of August, so that a horse can not be expected to find his own feed longer than from about the first of June till the first of September. Grass is always abundant on the mountains near the timber line in June, July, and August, and good pasture is usually found at lower elevations after the timber has been burned off for a number of years. Some of the prospectors have provided their stock with fine feed by following this practice. In the timbered valley bottoms horses frequently have difficulty in finding enough to eat, even in midsummer, yet in the fall, after frost has killed the grass higher up, the river bars afford an excellent forage plant known as "pea vine," of which they are very fond. Since most prospectors use at least one or two horses for packing in summer, as well as for hauling supplies in winter, it is obvious that the matter of horse feed has an important influence in determining the number of available working days. The prospecting season is still further shortened owing to the fact that in the high mountains, where most of the copper ores have been found, snow often remains till the first or even the middle of July.

GENERAL GEOLOGY.

The major geologic features of the copper region may be briefly described as follows:

The geologic succession as determined by Schrader and Spencer, to confine the description to the rocks most closely associated with the copper prospects and gold placers, consists of four formations. These, named from the lowest to the uppermost, are the Nikolai greenstone, the Chitistone limestone, the Triassic shales, and the Kennicott formation. With these are associated igneous intrusives.

The basal formation of this succession—a slightly altered eruptive mass—is made up of a series of basaltic flows and is known as the Nikolai greenstone. It is conformably overlain by the Chitistone limestone, a massive limestone ranging in thickness from 200 feet on the Kotsina to 2,000 feet on Chitistone River and now known to be of Triassic age. Conformably overlying the Chitistone limestone is a succession of sedimentary beds whose lower part consists of banded limestone and shale, but whose upper part is made up almost entirely of shales. This limestone-shale series has a maximum thickness possibly greater than 4,000 feet and from fossil evidence is considered to be of Triassic age also. In places it was entirely removed by erosion before the deposition of the unconformably overlying Kennicott formation. Kennicott is the name applied to a body of rocks consisting of conglomerates, sandstones, limestones, and shales present in a few relatively small but widely distributed areas throughout the copper region. It is of Upper Jurassic or Lower Cretaceous age. These four formations and, more particularly, the lower three have been folded and extensively faulted. Some of the faults are of considerable displacement and horizontal extent, but readjustment, accompanying movements of the rocks, seems to have been brought about more by crushing and frequent faults of small displacement than by single movements of great amount.

In addition to the four formations thus briefly described, some small areas of coal-bearing rocks and the Pleistocene gravels should be mentioned. A thin bed of coal was seen not far west of the Kennicott Glacier, but a much greater amount is present near the head of Chitistone River. No fossils were collected from the coal-bearing rocks, but they are probably much younger than the Kennicott formation. Extensive Pleistocene gravel deposits occur along Chitina and Nizina rivers and extend into the valleys of their larger tributaries. Except on Dan and Chititu creeks they have nowhere proved of economic importance.

Igneous rocks other than the Nikolai greenstone are only locally abundant, but are found throughout the Chitina region. They include gabbro, diorite, porphyritic intrusives, and Tertiary volcanics. Of these the diorite and porphyritic intrusives are most closely associated with the copper-bearing rocks, and though of less areal extent, concern the present discussion more than the others. The largest diorite area is situated on the north side of Kotsina River near its head. It is surrounded by greenstone and has an areal extent of about 10 square miles. Dikes of the same material are found on the south side of the valley also. Light-colored porphyritic intruded rocks cut the Nikolai greenstone in a number of localities, but were not seen in the Chitistone limestone. They are most abundant in the Triassic shales of the eastern half of the copper belt and more particularly in the vicinity of Kennicott Glacier.

Because of the close and constant relation between the copper ores, on one hand, and the Nikolai greenstone and Chitistone limestone, on the other, it is necessary to give some further description of these two lower members of the rock series. The Nikolai greenstone, as mapped by Schrader and Spencer in 1900, includes a succession of basic lava flows of basaltic character, which, however, do not form a homogeneous whole, but show decided differences of texture and appearance in their vertical section. A flow or bedded structure is seen at many places and at first glance might suggest a sedimentary origin for the rock. This apparent bedding is much more evident in some localities than in others, and is most readily seen in the large cliffs which, in some places, constitute half a mountain side.

Directly beneath the limestone the Nikolai greenstone has much the same appearance wherever it was observed. It is a rough massive green rock whose individual crystals are generally too small to be distinguished by the naked eye. Lower down in the flow series the greenstone is usually found to be closer grained and denser, much of it with a fracture resembling that of quartzite. Amygdaloidal flows are numerous and the previously existing cavities are now filled with quartz or with dark minerals which in some specimens have been determined as chlorite and serpentine. Most of these flows are green in color, but a reddish hue is seen here and there, possibly the result of alteration or weathering. There is no evidence at hand to determine definitely the relation of the Nikolai greenstone to the more altered and probably older rocks occurring south of Chitina River, and so far as its age is concerned, we know only that it is older than the Chitistone limestone.

The Chitistone limestone is best developed in the vicinity of Chitistone River, where it attains its greatest thickness and is well exposed. Its outcrops, nearly always appearing as cliffs high up on the mountain, extend westward, however, all the way to Elliott Creek and Kotsina River and constitute one of the most conspicuous features of the topography. From a freshly broken fragment the color is seen to be bluish gray. A weathered surface, on the other hand, is light gray or dirty white, a fact which accounts in large measure for the striking appearance of the outcrops and in many places makes it possible to distinguish the limestone from associated rocks even at a long distance. Except where covered by talus from the limestone cliffs or by the unconformably overlying Kennicott formation, the contact of the Chitistone limestone and Nikolai greenstone can usually be traced without difficulty.

In the report of Schrader and Spencer the Chitistone limestone was tentatively correlated with limestone east of Skolai Pass, which at that time was considered to be of upper Carboniferous (now called Permian) age. Mendenhall, in a later paper, gave reasons for believing it to be still younger, probably Triassic, and his contention is established by fossil evidence collected last summer.

ECONOMIC GEOLOGY.

GENERAL OUTLINE.

The copper ores of the Chitina Valley are associated with the Nikolai greenstone and Chitistone limestone. In the western half of the copper-bearing area the copper minerals, with one exception, were seen only in the greenstone, and most of the prospects are at no great vertical distance below the limestone contact, yet this is not an invariable rule. In the eastern half of the area, on the other hand, the largest and most valuable copper deposits known are either at the limestone-greenstone contact or immediately above the contact, in the limestone. There are deposits of copper in the greenstone here also, similar to those farther west, but so far as they are now known they are of less importance than those associated with the contact.

A large number, perhaps a majority, of the copper prospects examined during the summer have a form which Mendenhall has described as "bunch deposits." This term, though an unsatisfactory one in some ways, probably describes as closely as any single term can the form of ore body most common in the Chitina Valley. A smaller number of the deposits occur as fairly well defined veins. The term "bunch deposit" does not necessarily refer to a mass of ore composed of copper minerals only, as most of the ore bodies to which the term could be applied are not such masses, but it does indicate that the length, breadth, and thickness of the body do not differ from one another greatly.

The copper minerals are chalcocite, bornite, chalcopyrite, native copper, and the oxidation products, malachite, azurite, and cuprite. The ores, as they appear on the surface, are chiefly chalcocite and bornite. Chalcopyrite is not as common as either of the other two sulphides, but forms an important part of the ore at several prospects. Native copper is present in the greenstone of all parts of the Chitina region and is surprisingly abundant in some of the stream gravels. Masses of several hundred pounds and one of more than 2 tons have been discovered. Wherever native copper was observed, it is associated with amygdaloid beds of the greenstone and consequently is some little distance below the limestone. More extended observation, however, might show that this is not always the case.

No considerable bodies of oxidized ores have been found in the Chitina region. Malachite and azurite, the green and blue carbonates, are merely surface alterations on the other copper minerals, and cuprite, the red oxide, is a common oxidation product. Azurite is the prevailing carbonate accompanying the copper sulphides associated with the heavy limestone or in veins with a calcite gangue. Malachite gives the green stain usually seen in the ores in greenstone.

The copper ore is composed in many places of country rock and copper minerals without any accompanying gangue. The copper sulphides fill fractures in the rock and also occur as a replacement of the rock. Where the country rock is greenstone, a careful examination is usually necessary to determine the limits of the impregnation, which is not marked by any definite boundary, the replacement becoming gradually less with increasing distance from the center of impregnation. In limestone areas, on the other hand, the transition from copper sulphides is abrupt and the bounding surface is more readily determined.

Faulting, as has already been pointed out, is a phenomenon observed at many localities in the rocks of the Wrangell Mountains. Zones of crushing and shearing show the same result as has been accomplished at other places by fault movements, the disturbing forces that produced them having led to a circulation of mineral-bearing waters through the rock. Most of the channels were exceedingly variable in form and direction, and this fact explains the rarity of definite, regularly formed, and clear-cut veins in the region. This is particularly evident from an examination of the ores in greenstone. Where the more regular vein deposits occur they are usually connected with fault planes and some of them are accompanied by other minerals, as calcite and quartz. Calcite is nearly always the predominating gangue mineral where such minerals are present, and is particularly prominent near the limestone-greenstone contact. The basic greenstone could furnish only a small amount of quartz to circulating waters, but calcite was supplied abundantly from the overlying limestone. The wide distribution of copper minerals in the Nikolai greenstone wherever it occurs has led to the belief that the greenstone itself is the source from which the copper was derived and that the ore deposits as they now exist have resulted from the concentration of copper minerals disseminated in small quantity through the rock.

Copper prospecting in the Chitina region is carried on from a few central localities, of which those receiving most attention are Kotsina River (including Elliott Creek), Kuskulana River, Kennicott River, and Chitistone River. These centers are named from west to east, the order in which they were visited, and the prospects will be described in the same way.

KOTSINA RIVER BASIN.

Kotsina River receives a large part of its water from snow fields and glaciers on the south slopes of Mount Wrangell and joins Copper River 2 miles above the Chitina. Much of the drainage area is occupied by Nikolai greenstone, but the limestone, shales, and conglomerate are all present. Prospecting is most actively carried on in the upper part of the basin and on Elliott Creek. The upper tributaries include Peacock Creek, Surprise Creek, Roaring Creek, Ames

Creek, Rock Creek, Kluvesna Creek, and Copper Creek. No work has been done here which can properly be called mine development, as there is no place where sufficient work has been done to demonstrate the presence of a mine.

KOTSINA RIVER.

Practically the only prospecting on the Kotsina itself is that done by the Great Northern Development Company. This company is the largest one carrying on operations on the Kotsina, to which, however, its interests are not confined. The headquarters of the company are on Kotsina River at the mouth of Roaring Creek, and its equipment includes a sawmill and telephone connection with the Government telegraph line at Tonsina. Probably 100 men were employed during the summer. The prospects on the river include five short tunnels, the nearest one of which is about one-half mile below the camp. They are within a short distance of one another on the south side of the river and almost on the same level as its broad gravel floor. No one of these tunnels had been driven farther than 20 feet in August, 1907. At the first a porphyritic dike 10 feet thick cuts a fine-grained greenstone. Its course is N. 30° W. and it is bounded on both sides by fault planes. A little copper-bearing pyrite was deposited along the faults in the fractured rock. At the second tunnel, a few hundred feet to the west, a quartz vein ranging from 4 to 6 inches in thickness contained a little copper pyrite. The vein has a strike S. 50° W. and cuts the greenstone in a perpendicular direction. At the other three tunnels a little pyrite is present in the greenstone. Its oxidation gave the brown stain by which the tunnels were located.

AMES CREEK.

Ames Creek is the first creek below Roaring Creek on the south side of Kotsina River. It is a small creek in a hanging valley and, like nearly all the tributaries of this river, owes the broad, round cross section of its valley to the work of glacial ice. The copper prospects include three tunnels, the property of the Great Northern Development Company, known as tunnels 6, 7, and 8.

Tunnel 6 is on the west side of Ames Creek and is at an elevation of 1,400 feet above its mouth. Early in August, 1907, it had been driven for 50 feet in a southwesterly direction in frozen slide rock from the hill above. Country rock in place had not been reached. One hundred feet above the tunnel a little pyrite is seen in a dense, hard, faulted greenstone.

On the east side of Ames Creek, and 50 feet higher than tunnel 6, is tunnel 7, which runs N. 30° E. for 70 feet through loose slide rock before reaching the undisturbed greenstone, which here is fine grained and stained with iron from the oxidation of pyrite.

Tunnel 8 is also on the east side of Ames Creek, one-fourth mile south of tunnel 7. It had been driven for 30 feet in amygdaloidal greenstone, but no copper had been found.

ROCK CREEK.

Rock Creek is one of the largest southern branches of the Kotsina and heads against Strelna and Nugget creeks, tributaries of Kuskulana River. A horse trail crosses the divide from Rock Creek to Strelna Creek and furnishes the shortest road from upper Kotsina River to the Chitina Valley. Active prospecting was confined to Lime Creek, a tributary of Rock Creek, which joins it from the east. The Warner prospect at the mouth of Rock Creek, which was visited and described by Mendenhall in 1902, is now patented and no further work has been done on it. Lime Creek flows near the limestone-greenstone contact, and the copper deposits, although mostly northeast of the creek on the opposite side from the southwestward-dipping limestone, are not far from it. The prospects are near the point where the Rock Creek trail crosses Lime Creek. In July, 1907, a tunnel was being driven in the greenstone just below the limestone, only a few feet above the creek, but no ore had been found at that time.

Several feet up the hill to the northeast was a tunnel 20 feet in depth, in jointed greenstone. The principal copper mineral is bornite, which occurs as lenses or irregular lumps in the greenstone, having diameters up to 1 inch or more. These patches, so far as the surface shows, appear to be unconnected. Bornite also fills fractures in the rock and forms small lenticular veins, but it appears principally in joint planes on whose surfaces it forms a veneer in places an eighth of an inch or more in thickness. There are small veins of calcite and quartz.

About 50 feet farther east is an open cut showing similar rock and ore, although here the ore is in greater amount. The bornite occurs in sheared greenstone cut by small faults striking N. 35° E. and dipping 60° S., and forms a lens-shaped mass 2 feet thick. The greenstone has nearly all been replaced by bornite.

At a point 200 feet still farther north and 100 feet higher is an open cut in amygdaloidal greenstone. The cavities are now filled with quartz or with a dark mineral, possibly chlorite. Several faults with gouge and zones of crushed rock up to 1 foot in thickness cut the greenstone with a strike of N. 15° E. and a dip ranging from 60° to 70° E. A little copper stain was seen along the crushed rock, but no other copper minerals, although bornite is found in the slide rock near by.

ROARING CREEK.

Roaring Creek is a southern tributary of Kotsina River, which it joins a short distance above the main camp. It heads in a small glacier and flows through an open valley several hundred feet higher than the level of the Kotsina. The country rock, with the exception of one small limestone area on top of the ridge between Roaring Creek and Peacock Creek, is greenstone, yet the greenstone is not of uniform character, for slaty beds and hard, fine-grained cherty-looking beds are intermingled with amygdaloidal flows. Most of the prospects are in the upper part of the valley.

The Great Northern Development Company has several prospects on Roaring Creek. One of these is located on the south side of a small gulch west of Roaring Creek, near the camp known as camp 3. A tunnel was started in gray and black mottled slates near a fault plane which separates them from the greenstone mass. The strike of the slate cleavage and of the fault plane is the same, N. 20° W., and the dip is high. The tunnel is perpendicular to the strike. There is some brown iron stain resulting from pyrite alteration, but no copper ore had been found.

Another tunnel was being started on the east side of Roaring Creek about half a mile above the tunnel just mentioned, but not enough work had been done to show the presence of ore. A piece of greenstone picked up near this place contained small particles of native copper.

Above camp 3 on the west side of Roaring Creek a tunnel 50 feet long had been driven by the California-Alaska Mining and Development Company. This tunnel is 2,600 feet above the mouth of Roaring Creek and at least 1,500 feet above camp 3. The country rock is greenstone and the ore consists of small calcite-quartz veins containing native copper and azurite. In a little gulch a few feet north of this tunnel, but some distance below it, a nugget of native copper, which from measurements was estimated to weigh between 500 and 600 pounds, was found in the slide rock.

The Kotsina Mining Company holds several claims on Roaring Creek. Among them is the Sky Scraper claim, located near the small limestone area previously mentioned. Several open cuts and short tunnels have been made and in July, 1907, the company was starting a tunnel on an exposure of copper minerals 350 feet below the base of the limestone at the north end of the area. This cut exposed a lenticular mass of chalcocite 6 inches thick and 3 feet long, as seen on the face, lying horizontally in the rough, coarse-grained greenstone that occurs immediately below the Chitistone limestone. In the vicinity there are several greenstone exposures in which chalcocite forms small patches or lenses. They are seemingly in no way related to one another.

PEACOCK CREEK.

Peacock Creek joins Kotsina River about 2 miles below the more southerly of the several large glaciers from which the river receives its water supply. There are two branches of the stream, one extending toward the east and the other toward the southeast. The eastern branch originates in a small glacier and the valleys of both branches were formerly occupied by glaciers. Greenstone is the country rock, with the exception of the limestone mass on the ridge between Roaring Creek and the more southerly branch of Peacock Creek. Dikes of diorite cut the greenstone, probably apophyses of the diorite mass on the north side of Kotsina River. The copper prospects of Peacock Creek are owned by the Alaska Kotsina Copper Company.

Rose claim.—The Rose claim is located on the point of the ridge between the two branches of Peacock Creek. It is a little more than 2,000 feet above the valley of Kotsina River. The greenstone is cut by a perpendicular fault striking N. 25° E. This fault is easily traced for a distance of nearly 400 feet and is indicated by a zone of crushed greenstone with a maximum width of about 12 feet in which the copper minerals are seen. Bornite, glance, chalcopyrite, and a small amount of native copper, with malachite and a little red oxide as alteration products, comprise the minerals associated with the fault.

White Dog and Mint claims.—Two claims on the west side of the more southerly fork of Peacock Creek have been partly prospected. The first of these, called the White Dog, is approximately 2,500 feet above Kotsina River. The country rock is greenstone and is cut by a fault plane striking N. 40° E. and dipping steeply westward. A crushed zone of rock along the fault ranges from 3½ to 4½ feet in width. The walls are well defined and clay seams show where the principal movements have taken place. An open cut 25 feet long has been made in the crushed rock. Chalcopyrite or copper-bearing pyrite is scattered through the crushed rock and clay seams and has strongly colored them with iron oxide. Green copper carbonate occurs as a surface stain, but the bornite and glance were not seen here. The fault is plainly marked along the steep mountain side for several hundred feet.

Two hundred feet above the White Dog and a little to the north is a claim called the Mint. A small fault with a strike of N. 15° W. and a dip of 60° W. cuts a grayish greenstone having amygdaloidal phases. The rock adjacent to the fault is broken and crushed, giving a zone with a thickness of 6 inches to 1 foot, which besides the greenstone includes a little quartz and calcite accompanied by bornite and glance. Chalcopyrite was not observed, but a heavy stain of iron oxide would indicate that either this mineral or pyrite had formerly been present. There is a parallel fault 4 feet from this main fault, and both are cut perpendicularly by a third poorly defined fault having the same strike and carrying a little bornite. The main fault was traced for a distance of 500 feet.

Mountain claim.—The Mountain claim is one of several on the north side of the east fork of Peacock Creek. It is about 2,600 feet above Kotsina River and consequently is at a greater elevation than the other claims described. In August, 1907, almost no work had been done on it and only a few small stringers of copper sulphides were exposed.

SHOWER GULCH.

A small stream joining Kotsina River a short distance below the glacier in which its southern branch originates is called Shower Gulch, from the waterfall near its lower end. Native copper is found near this fall in the amygdaloidal greenstone that forms the country rock. Copper occurs as thin leaves or films in fractures of the greenstone and as grains and small slugs in the greenstone and in the seams of the amygdules. It is in places associated with secondary quartz, filling irregularly shaped veins or cavites. Several claims have been staked on Shower Gulch, but little prospecting has been done.

SURPRISE CREEK.

Surprise Creek is a northerly tributary of Kotsina River and heads in the high mountain southeast of the lower end of Kluvesna Glacier. Most of its bed is cut in the diorite mass previously referred to and in a rude way follows the contact between the diorite and the greenstone on the east. It has a small easterly tributary, Sunshine Creek, which lies mostly in the greenstones. Tin is reported to have been found in the diorite of Surprise Creek, but such specimens of the supposed tin-bearing rock as were examined contained no tin and no reliable assay tests of the rock are known to the writers. All the copper prospects are in the greenstone east of Surprise Creek. They are the property of the Alaska Kotsina Copper Company.

Laddie claim.—Between Surprise and Sunshine creeks is a steep gulch running down from the north. On the west side of this gulch and nearly 3,000 feet above Kotsina River is the Laddie claim. A very close grained grayish "greenstone" forms the country rock and is cut by a fault striking N. 20° to 30° E. and dipping about 45° NW. Along the fault is a zone of crushed country rock ranging in width from 2 to 3 feet, in which is a quartz vein 18 inches thick. Besides quartz there is a small amount of calcite. The vein carries glance accompanied by a little bornite and chalcopyrite. In places the percentage of copper minerals in the vein is high, but they are not distributed uniformly through it. A line of prospect holes extends along the vein for a distance of 200 feet.

Sheehan claim.—At the Sheehan claim, 200 feet higher than the Laddie and a little farther east around the mountain side, the greenstone is cut by a fault striking N. 45° E. and dipping 45° NW. This fault resembles the Laddie fault in being accompanied by a zone of crushed rock, but the zone is here somewhat wider, ranging from 3 to 4 feet. A small quartz vein is exposed in which the copper minerals are glance, bornite, and a little pyrite. The small veins of glance cutting the quartz are in places half an inch thick.

Hubbard claim.—About 300 feet east of the Sheehan claim and a little higher on the mountain the vein of the Hubbard claim is exposed in two open cuts The vein is almost perpendicular and strikes N. 40° E. In the more southerly open cut there is a vein of white quartz ranging in thickness from 4 to 8 feet and carrying the copper minerals glance, bornite, and pyrite, which are named in the order of their abundance. A strongly marked fault with 3 inches of clay seam defines the north wall of the vein. Eight feet from the vein on the southeast is a second vein or lens of quartz 10 inches thick and also carrying glance. Between the two veins is crushed greenstone. Nearly 200 feet to the northeast along the strike an open cut 40 feet long and 25 feet deep has been made across the vein. The fault is seen again along the north wall, but the single large quartz vein exposed in the other cut is here represented by many smaller veins of lenticular form up to 12 inches in thickness. Glance and bornite are the copper minerals. Nearly 1,000 feet farther northeast a well-marked fault with a zone of sheared greenstone crosses the ridge between Kotsina River and the Hubbard claim and is said to extend as far as the glacier from which this branch of the Kotsina springs. There is little doubt that this fault is the continuation of that crossing the Hubbard claim.

KLUVESNA CREEK.

Kluvesna Creek and its tributary, Fall Creek, are the only streams besides Surprise Creek coming into Kotsina River from the north on which any prospecting or assessment work was done last summer. Kluvesna Creek drains the main lobe of Kluvesna Glacier, and the smaller western fork known as Fall Creek originates in a minor lobe of the same ice mass coming down from the snow fields of Mount Wrangell. The valley floor is a broad gravel flat and was once occupied by glacier ice, which has since retreated to its present position 7 miles from the river's mouth. The country rock is greenstone except that the Chitistone limestone forms the top of the ridge west of the southern part of the river and descends to the Kotsina River valley near its junction with that of Kluvesna Creek. Dikes of light-colored eruptive rock, mostly dioritic in character, cut the greenstones locally.

On the east side of Kluvesna Glacier, nearly three-fourths of a mile from its south end, copper minerals have been found in the greenstone several hundred feet above the ice. Three open cuts show a light-colored rock—possibly altered greenstone—cut by irregularly branching quartz veins. The light-colored rock contains chalcocite and chalcopyrite scattered through it in specks rarely larger than a pin head. There are besides this small veins of chalcopyrite. The greenstone country rock locally contains small particles of chalcopyrite, a fact that may have some bearing on the origin of the richer copper-sulphide ores.

West or a little southwest of the mouth of Fall Creek and nearly 1,800 feet above it is a short tunnel, the property of the Kotsina Mining Company. This tunnel is on the north side of a small gulch running down to Kluvesna Creek and is located at the contact of a fine-grained greenstone and a grayish amygdaloidal greenstone. The contact is parallel with several prominent fault planes cutting the country rock, strikes N. 35° to 45° W., and dips 50° SW. The fine-grained greenstone is much shattered and requires timbering to make it stand in the tunnel. Native copper appears as small particles in the amygdaloidal greenstone, both in the apparently unaltered rock and in portions that have been partly leached. It is also associated with small quartz and calcite veins in the greenstone. At many places where native copper is found there is a little red copper oxide. Several pieces of native copper and quartz weighing 20 or 30 pounds were piled on the dump, but nothing like them was seen in the tunnel or in the open cut above the tunnel.

A number of small open cuts and short tunnels in which copper minerals were seen, on Fall Creek or its tributaries, were examined. These small branches flow into Fall Creek from the west within the lower 2 miles of its course. Less than half a mile from the mouth of the most northerly one there is a short tunnel on the south side of the stream driven along a north-south fault in amygdaloidal greenstone. The greenstone is crushed and contains small veins of quartz and calcite. A green stain of malachite appears on the surface, but within the crushed country rock both green and blue copper carbonates are found in a way that suggests them to be the alteration products of some earlier copper mineral deposited along the fault. Between the rock fragments along the fault there is in places a soft black carbonaceous filling with which the copper carbonates are mingled. Very little copper is exposed by the tunnel.

South of this creek on the second tributary a short tunnel about 6 feet under cover was made along a perpendicular north-south fault plane in amygdaloidal greenstone. This tunnel is only a few feet above the creek and on its north side. The greenstone is cut by many small light-colored, fine-grained porphyritic dikes containing abundant grains or crystals of quartz. A very little bornite is associated with quartz veins in the greenstone.

Up the hill to the south and 1,375 feet above the short tunnel just mentioned is another tunnel 40 feet long, also in amygdaloidal greenstone. Here too the perpendicular north-south faulting is to be seen and green copper stains appear on the surface of the fractured rock. The tunnel was driven to strike the supposed downward extension of an outcrop of greenstone containing native copper exposed on the ledge 25 feet above the tunnel and about that distance to the south, but had not yet reached it. Bornite and copper carbonates in small amount were seen in a number of shallow open cuts a short distance southeast of this tunnel.

COPPER CREEK.

Copper Creek is the most westerly tributary of Kotsina River on which prospecting was done last summer. It drains a portion of the ridge between Kotsina River and Elliott Creek and joins the Kotsina 2 miles below Kluvesna Creek. All four of the geologic formations already named are present in the upper part of the basin—the Nikolai greenstone, Chitistone limestone, Triassic shales, and Kennicott formation. Their relations, however, are not simply those due to folding, for extensive faulting has accompanied the folding.

There are two principal branches of Copper Creek, but the westerly branch also forks at a point about 2½ miles from Kotsina River. Near this fork the limestone-greenstone contact crosses the two branches in a northwest-southeast direction and good exposures of the limestone are found between the branches as well as on each side of them. The greenstone, however, is not exposed on the slope from the fork to the limestone outcrops between the branches.

The workings of the Mullen claim are between the branches, about 1,000 feet from the place where they separate and 275 feet above it. Three open cuts have been made along the foot of a limestone cliff. The strike of the limestone at this place is difficult to determine accurately but is nearly north and south. It dips 45° W. In the northernmost open cut, which is 20 feet long and 10 feet in depth from front to back, a fault plane parallels the bedding and forms the west wall of the cut. The limestone is much broken, particularly near the fault, forming a zone of broken rock with a maximum width of 3 feet. In places the limestone is almost completely replaced by bornite and chalcopyrite. The best ore forms a poorly defined vein ranging in thickness from 12 to 18 inches but does not outcrop on the surface. Azurite is more abundant than malachite where the copper minerals are oxidized, and in places the bornite is completely altered to azurite. Small calcite veins are numerous, especially in the brecciated rock near the fault, where the fragments have been cemented together with calcite. There are minor faults or joint planes in which a green copper stain is seen, but this appears to be derived from the copper of the main vein.

About 75 feet south is another open cut where the fault planes are not prominent but where the limestone is much jointed. Bornite occurs in isolated bunches in the limestone.

A large open cut and shallow pit have been made 75 feet still farther south. Several faults may be seen here, but the most prominent ones strike east and west and dip at a high angle to the south. The north-south faults are present but are not continuous for more than short distances. Patches of crushed rotten rock stained with iron oxide and copper carbonates lie adjacent to the faults and joints. There are also small masses of high-grade bornite replacing the limestone and forming bunch deposits in the country rock. These deposits were probably connected by the joints and faults with the channels carrying the mineral solutions, but this is not evident at the surface. A little chalcopyrite and both malachite and azurite are present with the bornite. Malachite is the surface stain, but below the surface azurite is the alteration product of the copper minerals. The bornite is cut by many thin veins of azurite and in places contains small cavities lined with iron oxide or with azurite crystals. More work has been done in this place than in the first open cut, yet less ore seems to have been taken out, to judge by the amount piled near by.

ELLIOTT CREEK.

General description.—Elliott Creek is a tributary of Kotsina River and joins it approximately 17 miles above the mouth of that stream, or 12½ miles almost directly east of the Copper River crossing. It is reached by a trail which leaves the Kotsina trail at Willow Creek and crosses Kotsina River by a bridge about half a mile above the upper end of the canyon. This trail passes over the southwestern spur of Hubbard Peak and reaches an elevation of approximately 2,700 feet before the descent to Elliott Creek begins. A second trail, used for the first time during the summer of 1907, leaves Elliott Creek (at Five Sheep Creek) about 6 miles above its mouth and, crossing the west end of the ridge to the south, leads to the Nizina trail not far east of the new Government bridge.

Elliott Creek is approximately 10 miles long and throughout most of that distance flows in a direction about N. 30° W., but makes a sharp southerly bend before joining Kotsina River. More than 2 miles of the lower portion is through a narrow rock-walled canyon, but the upper part, along which the claims extend for a distance of 4½ miles, lies in a narrow V-shaped valley. Between the upper cabin, situated about midway between the upper and lower ends of the claims, and the lower cabin, a distance of 2⅛ miles, the creek descends 759 feet, or approximately 360 feet per mile. Above the upper cabin this gradient increases as the head of the stream is approached. Elliott Creek is fed in a large measure by melting snow, and although the stream is not a large one, with the head available it is capable of furnishing considerable power.

The lowest and the only one commercially important of the rock formations exposed in the Elliott Creek valley is the Nikolai greenstone. All the copper prospects so far discovered here are associated with this rock. The massive bluish-gray Chitistone limestone is conformably overlain in some places by the black and gray Triassic shales and thin-bedded limestones cut by light-gray porphyritic dikes and sills, and in other places is succeeded unconformably by coarse conglomerate of the Kennicott formation.

In an ascent of Elliott Creek the greenstone and overlying limestone appear for the first time on Magpie Creek and continue eastward from that locality to the head of the valley. These two rock formations form a great anticline, whose axis is approximately parallel with the course of Elliott Creek. It pitches under the younger rocks at the east and west ends and dips into the ridges on either side of the creek. North of Elliott Creek and at its upper end the Chitistone limestone forms a very prominent topographic feature. With the exception of the Copper King and Mineral King, the claims described are on the north side of Elliott Creek, and are owned chiefly by the Hubbard-Elliott Copper Mines Development Company. The description of the claims is given in the order of their location from east to west.

Copper King and Mineral King claims.—The Copper King and Mineral King claims, often spoken of as "the Kings," are the most easterly claims on Elliott Creek. They are located along the limestone-greenstone contact, at an elevation of over 4,000 feet above the sea.

On the Copper King claim there is an open cut in the greenstone a little more than 100 feet below the base of the limestone cliff, 1,390 feet above the upper cabin. The copper minerals are found along a shear zone in the greenstone. Bornite is the principal copper ore and is seen along fractures and between them replacing the country rock. Calcite veins are not so numerous as might be expected near the limestone contact. The shear zone, which so far as can be determined at this exposure runs parallel with the base of the limestone N. 60° to 70° E. and dips to the south, is mineralized for a thickness of about 10 feet, though the copper-bearing solutions have penetrated the country rock for a greater distance, as is shown by a slight alteration of the greenstone. There is some pyrite in the ore, and besides malachite a blue coating of copper sulphate appears in protected places. This open cut is reached by climbing over a steep rock slide.

The two open cuts on the Mineral King are reached by another hard climb over a steep snow-covered talus slope. These cuts are about 800 feet northeast of the cut in the Copper King. The lower one was filled with snow at the time of visit, but the ore piled up at one side consisted of bornite replacing greenstone. The second cut, 50 feet higher and about 100 feet farther west, is almost at the same elevation as the Copper King cut. The ore was found on the steep face of the cliff and consists of chalcocite with a small amount of bornite replacing the greenstone along a fault or shear zone. Numerous close perpendicular joints running approximately N. 60° E. cut the greenstone, and there are a number of fault planes which strike N. 35° E. and dip 30° S. The trend of the disturbed zone is the same as that of the faults mentioned. The best ore has a thickness of about 6 feet and is traced for a distance of 25 to 30 feet along the strike, although the boundaries and extent of the ore body are somewhat indefinite. On the south, however, a fault plane makes a fairly well-defined wall. There is some rich ore at this exposure, but the development work is not yet sufficient to determine whether or not the ore body has any considerable extent.

Claim at the head of Queen Creek.—On the claim at the head of Queen Creek a small open cut has been made in the greenstone about 50 feet below the base of the limestone and shows small veins of calcite and a little quartz containing copper.

Van Dyke claim.—Two open cuts on the Van Dyke claim were visited, one 15 and the other 25 feet below the base of the limestone. The greenstone is stained with the oxidation products of iron and copper and contains also a small amount of pyrite, but the cut shows very little copper.

Copper Queen claim.—The open cut on the Copper Queen claim is about 50 feet west of Kings Creek. It has an elevation of 965 feet above the upper cabin. The cut is nearly filled by the caving of the bank above, so that the face of the greenstone was not exposed. A large mass of the rock, however, which lay at one end was filled with a great number of tiny intersecting veins of iron and copper sulphide, either pyrite and chalcopyrite or, more probably, copper-bearing pyrite. The greenstone fragments were covered with the green copper coating.

Marmot claim.—A large open cut has been made on the Marmot claim, at the base of the limestone between 200 and 300 feet west of Pouch Creek. The greenstone is much broken, and slickensided surfaces are numerous. The most prominent fault planes strike approximately N. 60° W. and are nearly perpendicular. Small calcite veins carrying a small amount of copper-bearing pyrite occur along some of the openings. A malachite coating was seen on the greenstone, but is not prominent along the main fault planes. Bornite was not observed.

Louise claim.—The Louise open cut is on the east side of Rainbow Creek and 50 feet above it, or 390 feet above the upper cabin. The country rock is greenstone and is cut by faults and joints. Slickensided surfaces are common. The best-developed fault planes strike about N. 20° W. and dip 45° to 50° W. Small calcite veins, having a thickness in general not greater than 2 inches and containing a little quartz, cross the country rock in all directions. Such veins are more numerous here than in most of the other workings examined. Bornite and chalcopyrite are the copper minerals present, and of the two bornite is the more abundant. They appear in the calcite veins and disseminated through the greenstone. The ore is best developed, however, in the calcite veins and the greenstone adjacent to them. It is difficult to give any definite statement of the thickness of the mineralized zone. The ore extends parallel with the creek for a distance of about 30 feet horizontally.

Above the cut on the steep hill slope green copper stains can be traced for a distance of 150 or perhaps 200 feet. Such an exposure as this may be the surface indication of an ore shoot, but the rich ore can not be traced for any considerable distance on the surface, usually not more than 25 feet and rarely as much as 50 feet.

Lizzie G. claim.—The open cut of the Lizzie G. claim is in the bed of Rainbow Creek only a short distance from the Louise. The greenstone at this place is sheared and plicated, but many of the resulting openings have been filled by infiltration of quartz and calcite. Quartz veins reach a thickness of 2 inches and carry considerable chalcopyrite. Calcite filling is, however, the more abundant and in places the rock consists of about equal amounts of sheared greenstone and calcite similar to the knotty masses of schist and quartz in many regions where metamorphism has been greater than in this area. These calcite-greenstone veins, if such they may be called, carry a considerable amount of bornite and chalcopyrite and make a fine-appearing copper ore, but the open cut does not show how great a quantity may be present.

Goodyear and Henry Prather claims.—Directly opposite the Louise open cut, about 40 feet west of Rainbow Creek and 340 feet higher than the upper cabin, an open cut has been made in the claim known as the Goodyear. The amygdaloidal greenstone is cut by faults and is much jointed. The most prominent of these faults strike north and south and dip about 40° W. Another set of less well-developed faults has a more easterly strike and a lower dip to the northwest. Between two of the north-south faults is a mass of rock lighter in color than the greenstone outside the faults. This lighter rock is sheared or sheeted parallel with the faults and is filled with a great number of thin calcite veins containing chalcopyrite or copper-bearing pyrite and bornite, something like the leaves of a book made of coarse paper. In the lower part of the cut this ore body is between 4 and 5 feet thick and forms a lenticular mass about 20 feet long bounded by two north-south faults and a northeast fault. The upper north-south fault is not continuous, but the lower foot-wall fault extends to the north for some distance. On the south this body of ore is much crushed and is filled with iron oxide. It can not be traced farther in that direction than the limit of the cut. Besides the thin veins of copper minerals in the sheeted rock, there are small veins of calcite and ore throughout the mass.

Along the strike a short distance to the north, and a few feet higher, the light-colored copper-bearing rock reappears, but the upper boundary of the mass is the fault which forms the lower boundary of the lower body. The ore body has a maximum thickness here of not less than 8 feet. An irregular branching calcite vein containing small horses of the light rock or main ore body reaches a thickness of 14 inches and contains chalcopyrite and bornite. This body of ore continues for a distance of 50 or 60 feet toward the north. These two bodies are portions of a single ore body included between two north-south faults and cut by later faulting.

Almost directly above the Goodyear, on the hill slope to the west and not more than 100 feet away, is the open cut of the Henry Prather. Here a north-south fault dips 60° W. and is intersected by two parallel faults striking N. 40° E. and dipping 30° to 35° W. These faults inclose a lenticular mass of rock 30 feet long and 5 feet wide, whose weathered surface is lighter in color than the inclosing greenstone and which is similar in all respects to the ore body of the Goodyear. This lighter-colored rock is impregnated in a similar manner with copper sulphides, and through it runs a vein of coarsely crystalline calcite carrying chalcopyrite and bornite, very rich in places. The calcite vein has an irregular thickness, ranging from 8 to 12 inches, and in two places is offset by small faults for a distance of 10 inches.

The main north-south fault may be traced to the north for about 75 feet and shows much green stain and some sulphides, but the large calcite vein and main ore body end, apparently having been faulted off. Almost 50 feet from the ore body the large fault is intersected by a northeast fault. This also shows copper stain and both contain small calcite veins with the sulphides.

Although no direct proof was obtained, the similarity in character and appearance of these two ore bodies of the Goodyear and Henry Prather suggests that they are faulted portions of one mass.

Elizabeth claim.—The Elizabeth claim lies north of the upper cabin and has received more attention in the way of development work than any other claim on the creek. This work consists of a tunnel and one or two open cuts. The tunnel is located in a narrow gulch a little more than 1,000 feet above the cabin. It has been driven into the greenstone in a northeasterly direction for a distance of 250 feet, and some ore has been uncovered, but it is not believed that the main ore body which outcrops on the hill above has been reached, and the work is to be continued. About 75 feet from the entrance the first copper appears in some lenticular veins of calcite and quartz, but there is only a small amount of this. In the face of the tunnel the greenstone is impregnated with bornite and chalcopyrite. Small veins of calcite also are present and carry the copper minerals. These small veins follow joint and slip planes in the greenstone and are rarely over half an inch thick. There is no well-defined master vein; the mineral waters appear to have followed a zone of fracture and faulting that runs, as closely as it is possible to determine at the tunnel face, in a nearly north-south direction. The greenstone has undergone considerable movement and slickensided surfaces are numerous. The slip planes and joints follow no definite general direction or, at least, this direction was not determined, if they do. At present the tunnel does not reveal the thickness of the ore-bearing zone nor even its direction with certainty.

In the gulch directly above the tunnel to the north and about 100 feet higher is an open cut exposing the copper-ore-bearing fault zone, which the tunnel is expected to cut. The greenstone is much shattered and shows a number of fault planes, the most prominent of which range in strike from N. 10° W. to N. 30° W. Movement along some of these planes has been very marked, and the rock is greatly crushed. Bornite and chalcopyrite are present in small calcite veins and also impregnating the greenstone in and adjacent to the fault zone. The green stain due to oxidation is prominent here, as it is in all places where the copper minerals occur, and makes it possible to trace the copper-bearing zone from the open cut in a direction N. 12° W. for several hundred feet up the hill, where several other small open cuts have been made.

Marie Antoinette claim.—Copper ores are exposed in the Marie Antoinette claim in two open cuts on the top of a narrow ridge adjoining the Elizabeth claim on the northwest. These cuts are within less than 100 feet of each other and show shattered greenstone stained with the oxidation products of iron and copper. There are a number of faults which strike in different directions, and in the open cut on the west brow of the ridge a crushed vein of variable thickness, consisting of calcite and a small amount of quartz, is exposed. The greenstone also contains veinlets of calcite which follow joint or slip planes and carry copper and iron sulphides. The larger vein strikes approximately N. 30° W., a direction which would take it somewhat to the south of the other open cut. Near it a small perpendicular dike of fine-grained diorite from 2 to 2½ feet thick cuts the greenstone.

Albert Johnson claim.—The Albert Johnson claim and the Guthrie claim described below adjoin each other end to end and lie parallel to the greenstone-limestone contact, but slightly below it. Deception Creek crosses their common end line at an angle of about 45°. Some open-cut work has been done, and a tunnel has been driven on the Albert Johnson about 100 feet east of Deception Creek. The tunnel is 30 feet under cover and is not over 150 feet below the base of the Chitistone limestone exposed to the north in the creek.

Small, nearly horizontal faults cut the greenstone, and the rock is otherwise broken by joints, giving it a blocky character. Calcite veins are present, but not abundant. Copper ore is exposed in the tunnel and in the open cuts. When a piece of the copper-bearing greenstone is broken, bornite and chalcopyrite are found to be the copper minerals, the bornite predominating. The fault zone in which the copper sulphides occur can be traced by the green stain in a nearly horizontal plane almost around to the Guthrie tunnel, so that these two appear to form parts of one ore deposit.

Guthrie claim.—The tunnel of the Guthrie claim is on the hill slope west of Deception Creek, directly opposite the Albert Johnson tunnel and about 200 feet from it, but 10 or 15 feet higher. Above the tunnel for a distance of 40 or 50 feet the surface of the country rock has been cleaned off, exposing small veins of calcite in shattered greenstone; these veins carry the sulphides bornite and chalcopyrite. The freshly broken greenstone adjacent to these small veins is also seen to be impregnated with the sulphides. There is no well-defined vein, but the jointing or faulting has permitted the mineral-bearing waters to circulate through a shattered zone in the greenstone. The tunnel is not more than 100 feet below the base of the heavy limestone as it is exposed in the creek to the north, which would account for the considerable amount of calcite present in the greenstone.

Leland and Lawton claims.—The Leland and Lawton claims are located in the saddle between the heads of Five Sheep and Deception creeks, which here has an elevation of more than 2,500 feet above the lower cabin. They lie north of the main body of the Chitistone limestone, whose scarp forms the prominent cliff on the southern brow of the spur to the south. This unusual location apparently above the limestone is due to faulting, which brings the greenstone up against the Kennicott formation or, rather, against the large porphyritic dike which here separates these two formations. On the Lawton claim a fault which strikes N. 30° W. and dips 50° to 60° S. is seen between the greenstone on the south and the porphyry dike on the north. The dike here shows a thickness of 30 to 35 feet. Several open cuts have been made in the greenstone and show small amounts of pyrite and chalcopyrite impregnating the rock adjacent to joint or fault planes. Green copper stain and also copper sulphate were seen in a number of other places. The copper minerals where observed were all within a few feet of the porphyry dike, but any other relation between the two was not evident.

Cliff claim.—The Cliff claim is on the west side of Deception Creek. Two open cuts have been made at an elevation of 600 feet above the mouth of this stream. The greenstone is cut by numerous fault planes and slickensided surfaces are abundant, but perhaps the most prominent of the planes of movement strike nearly east and west and dip about 45° N. The green copper carbonate and the oxide of iron stain the greenstone. Small amounts of the copper sulphides also are exposed along joint planes, but no considerable exposure of ore has been made.

Chance claim.—The Chance is the most westerly of the patented claims and includes the prominent point of the limestone cliff which is seen on entering the valley. A small open cut only a few feet below the base of the limestone shows the green copper stain and a little bornite in the greenstone.

KUSKULANA RIVER BASIN.

GENERAL DESCRIPTION.

Kuskulana River receives its greatest supply of water from Kuskulana Glacier, an ice stream made up by the union of four principal branches coming down from the southwest side of Mount Blackburn. The river is a little over 21 miles long and in the upper half passes through a broad gravel-floored glacial valley between high, rugged mountains. After leaving the mountains it flows for more than 10 miles, most of the way in a narrow rock-walled canyon, across the broad valley of Chitina River and joins that stream 10 miles above Copper River. Strelna Creek is the largest tributary of Kuskulana River. It rises in the mountains about the head of Elliott Creek and joins the Kuskulana 3 miles from Chitina River, thus having a length of 12 miles.

Most of the copper prospects are in the vicinity of Kuskulana Glacier, where the Nikolai greenstone and Chitistone limestone are well exposed. There are, besides these two formations, some rocks of doubtful identity in the vicinity of Nugget Creek, a western tributary joining Kuskulana River just below the glacier. These rocks are probably the same as some at the head of Kotsina River which have been included with the Nikolai greenstone, but may be older. Triassic shales and limestones are well developed east of the Kuskulana and are also represented in a small area west of it.

The best-known copper properties of this area are on Nugget Creek, but there are other prospects on one or two neighboring streams tributary to the main river on the west side and in the vicinity of the glacier on the east side as well as on Slatka and Trail creeks. There are also a few prospects on the head of Strelna Creek.

NUGGET CREEK.

General outline.—Nugget Creek drains the southeast side of the mountain mass whose northwest side is drained by Peacock, Roaring, and Rock creeks of the Kotsina basin. Several of its branches are fed by small glaciers. The stream is about 6 miles long and joins Kuskulana River less than a mile below the glacier.

The country rock includes amygdaloidal greenstones and other greenish rocks which differ somewhat in appearance from typical exposures of the Nikolai greenstone and might be separated from it on closer study. A small area of Chitistone limestone outcrops on the mountain slope east of the upper part of Nugget Creek, and near it along the creek bed is a small exposure of gabbro.

Most of the copper prospects, of which there are a considerable number, are situated in the lower or southern part of Nugget Creek valley. Collectively they constitute the Alaska Consolidated Copper Company's properties, only a part of which were examined by the writers. The claims on which most work has been done are located on the small rounded hill between the lower end of Nugget Creek and Kuskulana Glacier. It was not possible in the short time available to visit any other properties than those on this hill, so that no description of claims in the Nugget Creek valley north of the hill or west of the stream can be given. A good trail leads from the creek's mouth to the camp, where several very comfortable cabins have been built.

Valdez claim.—On the south slope of the rounded hill referred to above is a claim called the Valdez. It is crossed by a fault or set of parallel perpendicular faults running N. 65° E., along which the ore is deposited. The continuation of the fault or faults for a distance of several hundred feet is shown by a line of test pits, but how much farther they extend was not learned. A tunnel run in toward the north and 30 feet under cover gives a cross section of the deposit. At the mouth of the tunnel is greenstone separated by a fault from a large calcite vein on the north. The calcite vein has a width of 24 feet, as measured along the tunnel wall. This wall, however, is not exactly perpendicular to the course of the faults. After passing through the calcite vein the tunnel penetrates a close-grained dark-gray rock, possibly one phase of the greenstone series, for a distance of 5 feet. This rock and the vein are separated by a fault, along which is a seam of blue and yellow clay, ranging from 2 to 3 inches in thickness and containing small crystals of chalcopyrite. All of the calcite vein as exposed in the tunnel is ore. Bornite is the principal copper mineral and is accompanied by chalcopyrite in minor amount. Movement has taken place along both faults since the ore was deposited, and the country rock as well as the vein matter is jointed and crushed. The greenstone is sheeted parallel to the fault, but the harder close-grained rock in the face of the tunnel was more resistant and broke in angular blocks. The calcite vein is also much broken and in places granulated.

A prospect hole or crosscut a short distance northeast of the tunnel did not expose the vein, but 300 feet still farther northeast an open cut shows greenstone faulted against a light-colored rock consisting chiefly of calcite and quartz, much shattered and impregnated with bornite and chalcopyrite.

Thirty feet to the southwest along the vein from the tunnel mouth is a shaft which in August, 1907, was partly filled with water, but was said to be 30 feet deep. The shaft is sunk in the vein matter, but here the vein has a thickness of only 8 or 9 feet. On the north side is greenstone, much sheared and containing thin calcite veins accompanied by bornite. It is not evident from the exposures why the position of the greenstone with reference to the calcite vein is here reversed. The ore is similar to that in the tunnel. No traces of the vein or fault were seen on the grassy hill slope southwest of the shaft nor were they expected since no test pits had been dug and the country rock was not exposed.

One Girl claim.—The One Girl claim is on the west slope of the hill between Nugget Creek and the lower end of Kuskulana Glacier. A tunnel called the "mud tunnel" has been driven on the south side of a small gulch and extends into the hill for 100 feet in a direction S. 75° W. Of this tunnel 91 feet is in frozen slide rock and is reported to have caved in sometime during the early fall. The remaining 9 feet of the tunnel is in amygdaloidal greenstone, the cavity fillings being calcite. No ore was observed in the face, but the tunnel had not been extended far enough to encounter the mineralized body of rock seen on the hill, nearly 300 feet higher than the tunnel, toward the southeast. This "lead" is amygdaloidal greenstone country rock impregnated with fine particles or grains of chalcocite in association with small calcite veins and epidote. Several open cuts extending along a line from southwest to northeast show the same copper-bearing greenstone, but no work has been done to indicate the width of the zone or any of its other dimensions.

This ore, if the copper content is sufficient to warrant the use of the term under the conditions prevailing in Alaska, is similar in many respects to that of the Copper Queen claim north of the Nugget Creek camp.

Nugget Creek received its name from the large mass of native copper found in the creek bed a short distance above the camp. This nugget is estimated to weigh between 2 and 3 tons and is too heavy to be removed economically by means of transportation now available. It is 7 feet in its greatest dimension, 3 feet 2 inches wide in the middle, and has a maximum thickness of 12 inches, but the average thickness is probably less than 6 inches. Many smaller nuggets ranging in size from shot to pieces of several ounces or pounds are found in the gravels of the creek, but their bed-rock source has never been discovered.

STRELNA CREEK.

The copper prospects of Strelna Creek are of interest chiefly as showing the close relation between copper deposition and the limestone-greenstone contact. The Chitistone limestone forms numerous cliffs in the upper part of the creek, particularly on the branch leading to the Elliott Creek pass.

About a mile southeast of the Elliott Creek pass a small area of Chitistone limestone caps the greenstone of the ridge south of Strelna Creek. The north contact of the two formations is here a fault contact. From 6 to 8 feet of the decomposed greenstone along the fault is heavily mineralized with pyrite, weathering to brown iron oxide. Along with the pyrite is a little copper, as is shown by the green stain of malachite. In the heavy overlying limestone, but not over 10 to 20 feet above the contact, thin veins of copper-bearing pyrite were seen in the limestone. Stringers and small bunches of ore are not uncommon in the underlying greenstone at various places on the creek.

LAKINA RIVER.

Lakina River rises in an area of glacial drainage of minor importance lying between the much more extensive basins of the Kuskulana Glacier on the west and the Kennicott Glacier on the east. The Lakina is not as large nor as turbulent a glacier stream as the Kuskulana or the Kennicott.

The trail regularly traveled through this region reaches Lakina River about 6 or 7 miles below the lower ends of the two glaciers from which the river emerges. This portion of the valley of the Lakina differs somewhat from those of Kuskulana and Kennicott rivers where they flow from their glacial sources, in that it has a more basin-like expansion in its lower half. This basin-like expanse, which is about 2 miles wide along the trail and gradually narrows into a mountain gorge valley one-half mile wide toward the head of the river, as the glaciers are approached, is floored with deposits of gravel, sand, and mud.

In an ascent of Lakina River from the main trail, the first bed rock to present itself along the margins of the flat gravel floor of the valley is the Nikolai greenstone. This rock appears on both sides of the valley where it begins to become more restricted, about 3 miles below the glaciers, and rises in steep mountain slopes on both sides. Above the greenstone the Chitistone limestone presents its characteristic cliff-like faces, and above the Chitistone limestone a series of shales and thin-bedded limestones form on the east side of the valley bare slopes that are also present, though not so evident, on the heights west of the river.

The camps of two prospecting parties are located within a few hundred yards of each other on the west side of the Lakina, about a mile below the glaciers from which the river flows. The copper prospects occur at comparatively low elevations above the river, in the greenstones that form the steep western side of the valley at this place.

The prospect farthest up the river is about 250 feet up the mountain side from the upper cabin. A short open cut, about 6 feet deep, has been made on a shear or minor fault plane that strikes N. 30° W. and dips 70° SW., into the country rock of amygdaloidal greenstone, which, at this place, is weathered to a reddish-brown color. The walls of this plane are separated at this opening for about 2 feet, and the space thus formed contains a filling of crushed and slickensided slabs and fragmental pieces of the country rock, the whole being cemented together by the deposition of quartz in the interstices. The quartz in one place is somewhat continuous along one of the walls for a few feet and has a thickness of 1 to 2 inches. Most of the filling, however, is crushed country rock. A small amount of native copper in the form of specks and scales occurs within this filling. The amygdaloidal greenstone country rock just north of this filled space is checked with thin veinlets of quartz and contains some scattered chalcopyrite in specks and films. The small size of the opening makes it impossible to give any idea of the extent or amount of mineralization at this place.

The second prospect of this vicinity is similarly located on the lower slopes of the mountain side only a few hundred yards south of the one just described. At this locality the natural exposure of the rocks is good enough to exhibit the so-called pseudobedding that the Nikolai greenstone shows in many localities. Here this bedlike structure of the greenstones strikes N. 70° E. and dips 45° SE. Apparently there has been some shearing or movement along a major plane of pseudobedding or faulting, as well as movements along joint or other pseudobedding planes parallel to the principal one. This is shown by clean block or slab spalling for a distance, on the strike and dip above recorded, of 500 to 600 feet. This well-exposed face extends up the mountain side to the west and above the camp in a diagonal direction. The surface of the exposure is a natural dip slope along the major pseudobedding plane, offset somewhat by parallel bedding or joint planes. Slickensided surfaces may be observed along the joints or planes, and a tendency toward plication, indicative of shearing movements, is present. A small stream flows down over the surface of this rock incline. Along the major pseudobedding plane at this locality there is a somewhat continuous sheetlike filling of rock that does not look very different from some phases of the country rock at this locality and elsewhere. This sheetlike filling ranges from 1 to 6 or 8 inches in thickness and, as the surface of the rock incline is now exposed, this material lies in patches as a veneer over the surface of the country rock. It does not appear to be so markedly siliceous as the filling in the prospect several hundred yards to the north. It is this filling that contains the native copper in specks, flakes, slugs, and nugget-like lumps. No pieces of native copper of large size were observed, the largest pieces seen being about 2 inches by half an inch in area, and the size of these, as they are exposed on the surface, is due to the flattening and spreading to which they have been subjected by the impact of material carried down over this steeply inclined rock surface by the stream. The surface exposure of this sheet of native copper-bearing material, which lies bare over an area of about 400 by 20 to 30 feet, has been well picked over for specimens, and most of the larger pieces of copper originally present have been removed. For this reason it is impossible to give an estimate of the quantity of native copper that a given volume of the sheetlike filling along this sheared pseudobedding plane may have originally contained. No work has been done in opening up the locality to show how extensive or persistent the deposit may be in any direction, and there appears to be no evidence to justify an assumption that there is a mass of native copper-bearing rock 20 to 40 feet wide extending into the mountain in a direction perpendicular to the strike of the pseudobedded structure.

High up on the mountain side, 2,400 feet above and three-fourths of a mile west of the camps on the river, some surface stripping has been done that exposes a fault in shattered amygdaloidal greenstones. This fault strikes N. 15° E. and dips 75° W. The walls are 18 inches apart and the space is occupied by what appears to be a gouge of crushed country rock, the 6 inches of material adjacent to the hanging wall being essentially earthy and the remaining 12 inches on the foot wall being cemented by a quartz filling. Apparently just enough copper-bearing mineral matter is associated with this cemented gouge to stain the surface of the 18 inches exposed with green carbonate films. Apparently no other copper minerals were present, although there may be such finely disseminated through the cementing material. A very little bornite in specks and stringers not over one-eighth inch thick was observed in a piece of loose material at this place.

KENNICOTT RIVER BASIN.

ROUTE.

The summer trail that leads through the mountains east of Lakina River to the Kennicott Glacier follows the banks of the Lakina to Fohlin Creek, a tributary flowing from the north. The trail then ascends Fohlin Creek about 2 miles to its first large tributary from the east, locally known as Bear Creek, and continues up the valley of Bear Creek to Kennicott or Fourth of July Pass. From this mountain gap the trail descends Fourth of July Creek to the western margin of the Kennicott Glacier, along which it continues to Kennicott River.

HIDDEN CREEK.

Hidden Creek is a tributary to Kennicott Glacier on its west side, about 4 miles northeast of the mouth of Fourth of July Creek. It presents a feature of lateral valley drainage that is unique in a way, yet also characteristic of many glacial valleys that are tributary to larger glacial valleys where the main ice stream still flows past and completely dams the mouth of the smaller valley. Considered by itself, the valley of Hidden Creek presents all the features of larger glacial valleys. The head of the valley comprises ample cirque basins for the accumulation of snow and its transformation into the ice of the comparatively small glaciers that now exist at its head. These glaciers flow from their basins and terminate well down toward the valley level, but do not extend into its flatter main portion. From them issue small streams that within a short distance join to form a good-sized creek that flows down over the gravel-floored part of the valley. At its lower end the valley of Hidden Creek is completely dammed by the Kennicott Glacier, which ponds back the waters of the stream so as to form a lake which occupies the entire lower valley. This body of water is known as Icy Lake. It is one-half mile across and extends 1½ miles up the valley to a point where the gradually ascending gravel floor rises above its surface. This gravel floor continues as bare flats to the foot of the slopes of the cirque basins, from which the small steep glaciers occupying the head of the valley descend. The stream flowing over it from the glaciers at its head to the lake at its foot is about 2 miles long and has been well named Hidden Creek, as its existence is not to be suspected and it can not be seen until the valley is actually entered. About half a mile above Icy Lake, on the south side of the valley, a small stream that heads near Fourth of July Pass flows out of a steep mountain gorge. This stream is locally known as Glacier Creek.

The steep walls of both the north and south sides of the valley of Hidden Creek expose on the lower halves of their slopes the Nikolai greenstone, above which rise practically inacessible cliffs of the massive Chitistone limestone. A number of lode claims have been located along the contact of the greenstone and overlying limestone, where in places a little evidence of copper mineralization is to be seen. Most of these locations were made in 1906, and during the summer of 1907 assessment work was performed on them with a view to prospecting the ground.

The Great Northern Development Company had in this neighborhood for part of the season a crew of men who expended most of their labor in making a trail to the valley by following the steep mountain that bounds the western side of the Kennicott Glacier for a couple of miles south of Hidden Creek. This trail was not completed.

The only actual work on claims located in the Hidden Creek valley was done by the Valdez Exploration Company. This company packed its supplies with horses up a trail over the western lateral moraine of Kennicott Glacier to the Hidden Creek valley, thence, by a hazardous route across the ice that dams that valley, to the north side, and thence up the northern shore of Icy Lake to its head. The camp was located 500 feet above the bed of Hidden Creek, on a small area of bench ground, about 4,100 feet above sea level, that still remains in the fork formed by the junction of Hidden and Glacier creeks. During the summer season of 1907 five or six men were employed by the company in prospecting a group of twenty-five lode claims, more or less, some of which are located on the greenstone-limestone contact that extends along the south side of the Hidden Creek valley above Glacier Creek. About half a dozen claims extend from this group along the contact to the west and across the course of Glacier Creek into an area of greenstones. Another chain of claims has been located up the valley of Glacier Creek and across the divide at its head into the headwater drainage area of Fourth of July Creek.

Most of the work on Hidden Creek is on its south side about a mile above the camp, and consists of open cuts in the greenstones about 300 to 400 feet below their contact with the overlying limestones. All the work done during 1907 was necessarily in the form of open cuts because of the difficulty of getting supplies into the place, especially timber for tunnel work, necessitated by the condition of the rock. No timber of any kind grows near Hidden Creek. Five open cuts were seen on claim No. 3 at this locality, at an elevation of 4,800 to 4,900 feet above sea level, in much-sheared greenstones, the shattered blocks and fragments of which are tightly keyed into one another. The displacements that the greenstones have undergone at this place have been severe enough to obscure their pseudobedded structure to a large extent. The mineralization through and between these keyed shatter blocks consists of irregular and disconnected stringers of bornite, with lumps of the same mineral, some of which may weigh as much as 20 to 30 pounds. There is no continuity to the mineral deposits. They appear to be scattered erratically through the greenstones in an irregular zone for a width of 25 to 75 feet, and by far the greatest amount of this material is only shattered country rock.

GLACIER AND FOURTH OF JULY CREEKS.

Nebraska claim.—About three-fourths of a mile up Glacier Creek, at an elevation of approximately 4,800 feet above sea level, an open pit 8 feet square and 8 feet deep has been sunk, on what is called the Nebraska claim, in a shattered mass of the greenstone that forms a low knoll in the valley. This knoll appears to be a slide mass from the mountain side on the east. Green copper-carbonate stains, specks of bornite, and one speck of chalcopyrite were observed in some of the pieces of rock that came from this pit, but nothing more was revealed. There is said to be a surface showing of chalcocite, on which no work has been done, in the greenstones about 400 feet below the limestones on the southeast side of Glacier Creek opposite the camp.

Bekka and Eli claims.—Above the Nebraska claim the Chitistone limestone dips southward under thin-bedded limestones and shales. But the stratigraphic continuity of the rocks that occupy the headwater areas of Glacier and Fourth of July creeks is disturbed by a line of major faulting that passes in an east-west direction through the head of Fourth of July Creek. This fault throws the heavy-bedded Chitistone limestone to the surface again on the divide between Glacier and Fourth of July creeks, where it is exposed for a thickness of about 600 feet. There is probably a minor fault that passes across Glacier Creek north of and parallel to the major displacement on Fourth of July Creek. Over this faulted area the Bekka and Eli claims extend, crossing the divide to the head of Fourth of July Creek, where the major fault brings the thin-bedded limestones and shales against the greenstones. In the greenstones at the head of the creek, about 200 feet below the massive Chitistone limestone, is a bed of crystalline rock about 30 feet thick that has the attitude of a sill. Above the sill-like rock at this place is typical amygdaloidal greenstone that does not appear to be altered from its usual texture in any way. Along the contact between this crystalline rock and the overlying amygdaloidal greenstone are a few thin seams of chalcopyrite, and there are also specks of this mineral within the amygdaloid a few inches from the contact. Bornite occurs associated with this chalcopyrite in very small quantities, and the presence of a small amount of chalcocite is suspected by its presence in a piece of rock float picked up below.

Realgar.—About one-third of a mile farther down Fourth of July Creek there is an occurrence of realgar (sulphide of arsenic). The mineral fills small spaces in a crushed zone in thin-bedded limestones. Some of the spaces are filled for a width of 1 to 2 inches with well-formed crystals, but other seams contain the realgar in a more impure earthy form. The rest of the shatter spaces of the limestone are largely filled by thin seams of calcite. No considerable amount of realgar appears to be present at this place.

Coal.—On the divide between Fourth of July and Bear Creeks to the north of the pass crossed by the trail, at elevations of 5,800 to 6,000 feet, is a small patch of coal-bearing shales and flaggy arkosic sandstones covering an oval-shaped area of about 20 acres. The thickness of these beds is probably not over 50 feet. They are partly covered by more recent andesite lava that occupies a smaller area and stands at its highest point as a pinnacle about 50 feet thick. These rocks, which may be provisionally assigned to the Tertiary, appear not to have been involved in the major fault that is well exposed on the head of Fourth of July Creek, which brings the Nikolai greenstone and Chitistone limestone, to the north, against the thin-bedded limestones and shales, to the south. The Tertiary coal-bearing beds seem to lie in a nearly horizontal position on top of the inclined beds of the older series. The coal was not seen in place, its presence being indicated only by small weathered fragments mixed with the disintegrated shales. It is probably not of workable thickness, and even though it were, the small amount and its inaccessibility would prevent it from becoming of commercial importance.

BONANZA CREEK.

The Bonanza, the most valuable known copper deposit of the Chitina Valley, is situated at the head of Bonanza Creek about 1½ miles east of Kennicott Glacier and 7 miles north of the glacier's southern extremity. It is the property of the Kennicott Mines Company and is the only property visited during the season that gives promise of shipping ore in a commercial way in the near future. Two other groups of claims, known as the Jumbo and Independence groups, are situated in the near vicinity and are owned by the same company.

Bonanza Creek is about 3 miles long and heads on the west side of the high mountain ridge running north and south between Kennicott Glacier and McCarthy Creek. Its general course is to the southwest. The company's main camp and office, however, are located at the mouth of National Creek, almost 4 miles by trail from the mine. A new trail, sufficiently wide for a wagon road, is nearly completed and leads from the lower camp to the upper one, and a second trail of easy grade and good width leads down the east side of the glacier to the Kennicott River crossing.

South of National Creek the high north-south ridge between the glacier and McCarthy Creek is made up of Triassic shales and limestones intruded by large masses of a light-gray quartz porphyry. These Triassic rocks and the intrusive are separated by a great fault from the greenstone and overlying Chitistone limestone on the north. The strike of the limestone is northwest and southeast, and its dip averages between 25° and 35° NE. It therefore cuts diagonally across the main ridge and appears at the glacier's eastern edge nearly 9 miles north of the head of Kennicott River. The limestone here has a thickness of more than 1,000 feet. Still farther northeast the Triassic shales conformably overlying the heavy limestone reappear, but they do not occur within the area of the copper-bearing rocks. Bonanza Creek and the other creeks where copper claims have been located lie wholly within the greenstone-limestone area.

The Bonanza mine is situated on the west side of Bonanza Creek on a spur running down to the southwest from the main ridge. This spur divides Bonanza Creek from a small southwestward flowing tributary heading just west of the mine and is crossed by the greenstone-limestone boundary about one-half mile southwest of the main ridge. On the axis of the ridge this boundary has an elevation of approximately 6,000 feet above sea level, or 3,800 feet above the mouth of National Creek, where the ore bins are to be built. To the southwest the spur is greenstone; to the northeast it is limestone, rising to an elevation more than 1,000 feet greater than that of the contact.

The base of the limestone consists of not less than 40 feet of coarse gray limestone rock filled with cylindrical bodies which look like worm borings or seaweed. Over this is a few feet of impure shaly limestone, which in turn is overlain by dark and light-gray massive beds which carry the ore bodies. The ore is chalcocite, with which is associated, as an alteration product, in some places at least, considerable quantities of azurite. The limestone is broken by numerous faults and fracture planes, the most prominent of which are nearly perpendicular and range in direction from N. 40° E. to N. 70° E. Another set of faults runs in a northwesterly direction, and in several places striations on the slickensided surfaces or the clay seams show that the movement was horizontal. Horizontal fault surfaces are also present. None of the faults observed give evidence of any very great displacements, but, together with the numerous joints, they gave opportunity for ore-bearing solutions to enter the limestone. The principal fault planes—those running from northeast to southwest—form what may be described as a sheeted zone in the limestone. In this sheeted zone are the principal ore bodies. In places numerous closely spaced parallel fractures which contain thin veins of copper ore may be seen, especially near the north end of the deposit. This sheeted zone is not very conspicuous in the limestone beds and greenstone southwest of the main ore body, nor does it extend in a well-developed form for any considerable distance northeast of it.

The copper ores are chalcocite and azurite. The chalcocite is in veins of solid ore up to 5 or 6 feet in thickness and in large, irregularly shaped masses. On the surface two principal veins are seen. They stand almost perpendicularly, 12 to 15 feet apart, and strike N. 41° E., forming the comb of the sharp ridge, but crossing it at a slight angle, as the ridge at this place has a more nearly north-south direction than the veins. In places the precipitous west face of the ridge is a mass of solid chalcocite for a distance of 50 or 60 feet vertically below the top. Azurite appears on the surface of the glance and also as a lining of small vugs in the glance, but it is present chiefly as thin veins that form a network in the limestone and probably are due to the alteration of original chalcocite veins, for much of the azurite has an inner core of chalcocite. Azurite is more conspicuous than chalcocite in the northern 150 feet of the ore body, but chalcocite forms the great mass of the remainder. The ore bodies formed along the northeast-southwest faults of the northern part of the deposit are not the direct continuation of the large chalcocite veins at the south, but lie in nearly parallel veins which cut the ridge at a greater angle, their strike being about N. 60° to 70° E. The very rich ore can be traced on the surface for a distance of about 250 feet. It ends abruptly on the south in a nearly vertical limestone wall, but on the north gives place to the lower-grade ores, consisting of small veins of azurite and chalcocite, with scattered masses of chalcocite, some of them weighing several tons. This lower-grade ore shows on the surface for a distance of at least 150 feet northeast from the high-grade ores, and small scattered azurite veins extend still farther in that direction. The ore, as it shows on the surface, therefore, extends northeast and southwest along the strike for a distance of 400 feet. The thickness, however, is more indefinite, but the very rich ore, with its included limestone, as seen at the surface, has a width of approximately 25 feet, although the thickness of ore sufficiently rich to be mined may be greater.

Two crosscuts have been driven in the ore body in a direction N. 33° W. They are therefore not exactly perpendicular to the ore body. The longer of these crosscuts starts on the east side of the ridge, 75 feet below its top. It is 180 feet in length and extends through to the west side of the ridge. The richest ore, consisting of large masses of chalcocite with some included limestone, is encountered at a distance of 90 feet from the tunnel's mouth and continues for a distance of 21½ feet, as measured in the roof. There are smaller bodies of chalcocite, however, for a distance of 10 or 15 feet on either side of the main ore body. About 115 feet from the entrance to the tunnel a winze 30 feet deep was sunk in the ore, and from the bottom a drift, which cuts some rich ore and also some of the lower-grade azurite-chalcocite limestone body, zigzags to the northward.

About 120 feet southwest of this tunnel is a parallel tunnel driven from the west side of the ridge and 50 feet lower than the little saddle above it. This tunnel starts in a face of solid chalcocite and extends S. 33° E. for 50 feet. The ore, which is chalcocite with a small amount of azurite, extends for 34 feet along the tunnel, but is interrupted by horses of limestone. The remainder of the tunnel shows limestone cut by small azurite veins and in places containing a small amount of chalcocite.

From the description that has been given, it will be seen that there is little on the surface or in the tunnels by which to determine whether the ore body has a greater extension from southwest to northeast than about 400 feet or, at most, 450 feet, or whether it extends down into the basal beds of the Chitistone limestone. It is evident, however, that the Bonanza is an exceedingly rich and unusual body of copper ore.

JUMBO CREEK.

From the Bonanza mine the Chitistone limestone continues northwestward in a succession of lofty cliffs as far as Kennicott Glacier. The base of these cliffs is at the greenstone contact and in many places contains veinlets and stringers of azurite or chalcocite. In at least two places the quantity of these two minerals, especially of the chalcocite, is such as to make the deposits of commercial importance.

The ore body of the Jumbo claim is 4,600 feet northwest of the Bonanza, at the head of Jumbo Creek, and is located in limestone just above the greenstone-limestone contact on a small southwestward-projecting spur or angle of the limestone cliff. South of it and nearly 200 feet below is the glacier in which Jumbo Creek heads and which must be crossed to reach the ore body. The Jumbo and Bonanza ore bodies are at practically the same elevation above sea level, approximately 6,000 feet.

The limestone at the Jumbo is made up near the base of slightly cherty beds, ranging in thickness from 8 to 12 inches. The strike is

N. 65° W.; the dip 35° N. A tunnel 12 feet long was started on the south face of the ridge, 10 feet above the greenstone. The limestone is jointed or cut by minor faults parallel to the bedding and is crossed by veins of calcite from 1 to 2 inches thick. Thin veins of chalcocite and azurite accompany them and fill some of the fractures. Seven feet above the tunnel mouth is the east end of a large chalcocite mass which is well exposed on the axis of the ridge. As indicated on the surface, this body of ore is a mass of solid chalcocite, 30 feet long, 6 feet by 4 feet 6 inches at the west end, and tapering to a diameter of 1 foot at the east end. It is a rudely conical body, but has irregularly shaped protuberances, as may be seen at the west end, where the steep west face or slope of the spur gives a cross section of the ore body.

A little way east of the Jumbo tunnel is a second tunnel in limestone a short distance above the greenstone. The tunnel runs nearly north or slightly to the northeast, in limestone that strikes N. 65° W. and dips 25° N. In the tunnel, which is 12 feet long, the limestone is crushed and jointed. Small veins of calcite and azurite up to 2½ inches in thickness fill joint cracks, especially a set of perpendicular minor faults or slip planes running N. 70° W. No chalcocite is exposed in the tunnel, but it is believed that the azurite indicates its former presence. Fifty feet below the tunnel a lenticular vein of chalcocite, 3 inches thick at its widest part and 3 feet long, was found in the limestone.

OTHER CLAIMS.

Northwest of the Jumbo claim and nearer Kennicott Glacier is another chalcocite body of similar character that is said to be larger than the Jumbo. This property was not visited by the Survey party, nor was the Independence group of claims, which lies just below the top of the ridge between Bonanza and McCarthy creeks, on the McCarthy Creek side. The vein of the Independence is in greenstone and is described by Mendenhall[a] as being a fairly persistent fissure vein from 6 to 8 inches wide and trending obliquely to the limestone-greenstone contact. The ore is essentially bornite, but is associated with a small amount of chalcopyrite. The gangue is calcite and crystalline quartz, but a considerable part of the ore is without gangue and is relatively pure. The walls of the vein are fairly well defined, but the ore is observed to gradually fade away into the country rock on the eastern side of the gulch in which the vein is exposed.

The Nikolai mine on Nikolai Creek, a tributary of McCarthy Creek emptying into Kennicott River a short distance below the glacier,

[a] Mendenhall, W. C., Geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41, 1906, p. 104.

was not visited by the Survey party, as no work has been done there since the claim was patented, and the shaft was reported to be filled with snow and ice.

CHITISTONE RIVER BASIN.

MAIN STREAM.

Chitistone River is a southwestward-flowing tributary of the Nizina and joins that stream approximately 30 miles above its mouth. It heads in the glaciers which cover the divide between Copper and White rivers, and its valley is one of the routes by which prospectors reach Skolai Pass and the White River Glacier. Between the lower end of the Chitistone Glacier and Nizina River the stream has a length of 18 miles, but the copper properties on which most work has been done are situated within the lower 10 miles of the valley. Within this lower 10 miles of its valley Chitistone River flows over a broad gravel-covered flat, ranging in width from one-half mile to 1 mile. The largest tributaries are Glacier and Toby creeks, both flowing in a northwesterly direction and joining the main stream within 2 miles of each other. The mouth of Glacier Creek, the more westerly of the two tributaries, is 7 miles from Nizina River. The larger tributaries, including two or three besides the two named, have broad gravel-covered valley floors similar to that of the Chitistone itself, but much narrower and with higher gradients. The smaller tributaries tumble down steep rock-walled gulches.

For more than half its length the valley of Chitistone River is cut in Nikolai greenstone and the overlying heavy Chitistone limestone. In this vicinity the limestone reaches the maximum thickness observed, at least 2,000 feet. South of the river it dips gently northward, forming a conspicuous cap on the greenstone that may be seen for many miles to the southwest and everywhere lies at least 1,000 feet above the valley floor. On the north side of the river, between the Nizina and Glacier Creek, the whole mountain mass, with the exception of 200 or 300 feet at the base, is Chitistone limestone extending to an elevation of more than 4,000 feet above the valley. On the west side of Nizina River the limestone dips to the north at about 30°, so that the great thickness on the east side represents the central low-lying portion of a large syncline. Farther up the valley Triassic and other younger rocks with granular intrusions and included coal beds appear.

Copper is found on Chitistone River in both the greenstone and the limestone, but in 1907 development had not revealed any considerable ore bodies. On the Chitistone itself most of the work had been done by the Houghton Alaska Exploration Company and by the Alaska United Copper Exploration Company, the first-named company directing its efforts to prospecting claims north of the mouth of Glacier Creek on the north side of the river and claims on the south side of the river about 4 miles below Glacier Creek, and the second to prospecting ground on Contact Gulch opposite the mouth of Toby Creek. A large number of claims have been staked, including practically all of the limestone-greenstone contact, but some of them show nothing but the green carbonate stain.

Glacier Creek, among the tributaries of Chitistone River, is at present the area of greatest promise. Native copper is the ore chiefly found.

The property of the Houghton Alaska Exploration Company west of Glacier Creek on Chitistone River on which most work has been done lies at the limestone-greenstone contact 1,225 feet above the river valley. A tunnel 20 feet deep follows a fault in the limestone, running S. 30° E. and dipping 70° to 80° E. This tunnel lies just above the greenstone contact, at the top of a large limestone talus slope. Fifteen feet higher and 20 feet farther east is a slope about 25 feet long driven on the dip of a fault parallel to the bedding, which strikes N. 60° E. and dips 35° S. There is a fault zone of crushed country rock which has a thickness of 4 feet on the west side of the slope but diminishes to 2 feet on the east side and practically dies out at a short distance from the mouth. It can be followed for 15 feet westward and is then cut off by a cross fault, giving it a lenticular cross section with a maximum thickness of 4 feet and a length of about 25 feet. The limestone is further cut by many small calcite veins. The fault zone is heavily impregnated with blue and green copper carbonate, accompanied by epidote. Iron oxide also is abundant in the crushed zone. The copper minerals penetrate the country rock, coating the joint planes with green carbonate, but azurite is almost restricted to the crushed zone.

The central camp of the Alaska United Copper Exploration Company is at the mouth of Contact Gulch, opposite Toby Creek, and most of the summer's work was done in that vicinity, although the company owns many other claims. A large part of the season was consumed in the construction of a cabin and trails by which the prospects, situated over 2,000 feet above the mouth of Contact Gulch, may be reached. Bornite in greenstone is the principal ore, but not enough development has yet been done to reveal any large body of it.

GLACIER CREEK.

Native copper is found on Glacier Creek in a small gulch about 1 mile above the lower end of the glacier, or 6 miles above the mouth of the creek. This copper was known to the Indians, who broke out fragments from the bed rock. The outcrop is on the northwest side of a steep gulch 625 feet above the glacier and less than half a mile from it. The gulch is reached by a trail over a high rock cliff, by going along the north side of the glacier between the ice and the bank or by crossing diagonally from the south side of the glacier. Traveling along the glacier's side is dangerous because of almost continuous rock slides and is not possible at all in some seasons.

The country rock is a series of bedded amygdaloidal greenstone flows, and the copper is seemingly restricted to a particular one of these beds. Nearly 75 feet above the creek, on the claim known as the Chiti, the greenstone is cut by a fault running N. 10° E. and dipping 40° W., almost parallel to a bed of greenstone filled with black amygdules and cut by small veins of the same material. Above and below this bed, whose maximum thickness is 8 feet, is greenstone with quartz amygdules and only a small amount of the black mineral. In the main open cut the fault appears at first glance to form the hanging wall, but there is a small thickness, not over 2 feet, of the black amygdaloidal greenstone just above it. Thirty feet farther north along the strike the fault is at the foot wall, and here the black amygdule rock has its greatest thickness, 8 feet. The main fault changes its direction here and strikes more nearly east and west. It is cut by minor faults and slightly displaced. The black amygdule rock is covered by slide rock 50 feet south of the largest cut, but continues with decreasing thickness northeastward for about 200 feet. The large fault, however, is easily traced for not less than 300 feet.

Copper is present as malachite, native copper, chalcocite, and cuprite. Masses of native copper weighing several pounds are found, but it is present chiefly as small specks in the greenstone and the black amygdules and as thin sheets or leaves of about the thickness of paper and small stringers in the greenstone. The larger masses occur in sponge or net-like form inclosing country rock. The largest one seen in place was not over 8 inches in diameter, but a quartz vein 300 feet north of the main cut yielded a mass weighing about 60 pounds. The fault with traces of the black amygdaloidal rock and some copper are reported to be found still farther northeast, but were not followed.

DAN CREEK.

Dan Creek is the first tributary to Nizina River below the Chitistone, from which it is separated by a mountain mass made up of Nikolai greenstone capped by gently northward-dipping Chitistone limestone. On the northern side of this mountain mass the limestone-greenstone contact at its lowest point is only a few hundred feet above Chitistone River. On the southern or Dan Creek side, however, it ranges from 2,000 to 4,000 feet above the stream. A further description of the geography and geology of Dan Creek is given in the account of its gold placers, a few pages beyond.

Just below the contact, north of Dan Creek, the greenstone in many places is stained with copper green and contains small stringers and bunches of copper minerals, chiefly bornite. This is said to be particularly true of a zone of greenstone extending for a long distance along the contact and situated about 30 feet below it.

At the head of Boulder Creek, which joins Dan Creek below the canyon, is a claim called the Westover, belonging to the Alaska United Copper Exploration Company. The exposed ore is a mass of bornite at or just above the limestone-greenstone contact. This ore body is entirely in the limestone and is unusual in that the other known similarly situated copper deposits of the eastern portion of the Chitina copper region are chalcocite rather than bornite. The surface exposure has a length, in a horizontal direction, of 30 feet and a maximum width of 8 feet. At one end the ore consists of nearly pure bornite whose boundaries with the inclosing limestone are rather sharply defined. At the other end it gradually fades into the country rock. No development work has been done other than to clear away the face of the exposure.

THE NIZINA GOLD PLACERS.

LOCATION AND HISTORY.

The Nizina placer district, as now known, embraces in a general sense the drainage areas of Dan, Chititu, and Young creeks, which flow into Nizina River from the east and south. Young Creek empties into the Nizina about 20 miles above its mouth, Chititu Creek comes in about 1 mile above Young Creek, and Dan Creek flows into the main river about 4 miles farther upstream.

The discovery and location of these placers in 1902 has been described by Mendenhall and Schrader.[a] After passing through the stampede stage of exploration, the Nizina district relapsed into a period during which great many of the claims as originally located were worked only on small scale in an unprofitable manner. From one cause or another ..uch of the better ground was soon involved in lawsuits that have taken until last year to settle in a way to justify systematic work necessitating an investment of capital.

GEOLOGIC SKETCH.

The bed-rock floor of this area is, so far as known, made up of a series of shales with a few thin limestones that are rather commonly intruded by dikes and sheets of light-colored porphyry. This bed rock on Chititu and Dan creeks is for the most part a dark, fine-

[a] Mineral resources of the Mount Wrangell district, Alaska: Prof. Paper, U. S. Geol. Survey No. 15, 1903, pp. 59-61.

grained homogeneous shale in which there is very little limestone. These shales are hard and closely jointed and have been intricately folded and contorted. They have also been subjected to faulting, some of which is very recent, as it has occurred since the unconsolidated Pleistocene bench gravels that lie unconformably upon the shales were deposited. It is probable that this shale bed rock is the floor upon which rests the thick sheet of bench-gravel deposits that, so far as known, appear to extend from the northern slopes of the valley of Dan Creek along the gently sloping mountain sides that form the eastern side of the Nizina Valley to and probably beyond Young Creek. Schrader and Spencer represent the higher mountains to the east to be made up of this series of shales and thin-bedded limestones.

The unconsolidated deposits of the region that concern this paper include bench and stream gravels. Of these two the bench gravels are of less present commercial importance, although in amount they greatly exceed the stream deposits. The general distribution of this thick gravel terrane appears to correspond to the benchlike surface feature that extends along the eastern side of the Nizina Valley from Dan Creek to Young Creek and beyond in a southwesterly direction. The gravels apparently have their upper eastward limits about the middle altitudes of the mountain sides. They gradually slope down toward the west to an elevation of about 3,000 feet above sea level, where the surface descends more abruptly for several hundred feet and thence continues on to the west for 2 to 6 miles as a gradually sloping valley floor to Nizina River, where the elevation is about 1,400 feet.

It is not known to what extent the configuration of the surface of the rock floor buried by this thick mantle of gravels may influence their distribution, but there are undoubtedly considerable irregularities both in slope of surface and in surface forms, as ridges, valleys, and hills such as would be presented by a rolling topography of moderate relief, that have been controlling factors in the original distribution of the gravels. This consideration of the older rock-floor topography is especially important in studying the Nizina placers for the reason that at the present time all the evidence points toward the bench gravels on this older land surface as being the source from which the supply of gold in the present stream or creek gravels is chiefly derived.

The view that the easily worked creek gravels of the present streams have received their gold from a source in the higher bench gravels is amply substantiated by the fact that the presence of gold in the bench gravels has been established. On Chititu Creek the bench gravels have been prospected rather carefully and systematically at several localities by digging tunnels into their lower part along their contact with the underlying shale bed rock, and it has been found that gold is present in no inconsiderable amount and that although the values are naturally highest on or near bed rock, yet there is a considerable amount of gold distributed in the gravels for some distance above bed rock. Under present conditions, however, it does not seem that the bench gravels can be worked profitably for their gold content. When supplies and labor can be obtained at lower cost, it may prove profitable to mine these bench gravels by tunnel and drift methods along the bed-rock surface or possibly by hydraulicking on a large scale. These bench gravels are not frozen, as are similar deposits in some parts of Alaska; consequently in working them by tunnels and drifts it is necessary to timber the workings thoroughly, an item of expense that increases the cost of such operations. It is by no means improbable that there may be old channels in the rock floor underlying these gravels, where placer gold has been concentrated in amounts large enough to pay for mining by timbered tunnels and drifts. It may also be found that over some areas the bench gravels are not too thick to be profitably worked by hydraulic methods, even if a considerable thickness of barren overburden should have to be removed to reach the pay ground. It is possible that a systematic and thorough sampling of large areas by drilling test holes is the best manner by which this problem of the bench gravels may be approached.

The present stream gravels of Dan, Chititu, and Young creeks are the deposits in which gold was first discovered and on which active operations are now being conducted. They are in part derived from the bench gravels and in part by the cutting of the streams in their own bed-rock channels. These deposits are more fully described in connection with the individual creeks.

The suggestion that the present auriferous creek deposits were evidently derived from the thick mantle of bench gravels leads to the question as to the source of the bench gravels and the placer metals they contain. Greenstone bowlders, cobbles, and pebbles form a characteristic percentage of the material of the bench gravels. Another characteristic feature is the presence of considerable native copper in the form of nuggets. A few of these copper nuggets weigh more than 100 pounds, but most of them run about 1 or 2 ounces. The nearest known source for the greenstone and native copper of these gravels is on the north side of the valley of Dan Creek and thence northward in the area of Chitistone River. Here there are areas of greenstones in which some small amounts of native copper are known to occur, but no gold has been reported from these rocks. The following statements are quoted from the report by Mendenhall and Schrader:[a]

[a] Mendenhall, W. C., and Schrader, F. C., Prof. Paper U. S. Geol. Survey No. 15, 1903, p. 61.

The rocks throughout the greater part of the district are reported by Schrader and Spencer to be the black shales and thin limestones of the Triassic, but in the northern part of the basin of Dan Creek the Nikolai greenstone and the overlying heavy-bedded Chitistone limestone outcrop. There is a doubtful region about the head of Young Creek where these older rocks may also be found.

The black Triassic shales are reported to be intruded in this region, as they are known to be in other localities, by abundant porphyritic dikes, and the gold may be found to be genetically connected with these intrusives.

So far no facts have been brought to light to show whether the porphyry dikes in the Triassic shales may be a possible source of gold or not. On the other hand, it has been reported by a prospector that placer gold occurs in the conglomerates of the Kennicott formation in this region. This formation has been assigned to the Upper Jurassic or Lower Cretaceous, and at present the only rocks of this age known to occur in the Nizina placer area lie south of Young Creek. There is also an area on the west side of Nizina River, opposite the mouth of Chitistone River. The Kennicott formation as now known occurs in isolated areas, of no very great extent, distributed from Kotsina River to the mountains south of Young Creek. It lies unconformably upon the Triassic shales and limestones and older greenstones. This series of conglomerates was no doubt formerly very much more widely distributed than it is at present. Extensive deposits of it have probably been entirely carried away by erosion, and if they were gold bearing in part or as a whole it can easily be seen how such a source might have supplied the present bench gravels in the Nizina district.

CHITITU CREEK.

The stream gravels of Chititu Creek and its tributaries are the deposits that have received the most attention in this district. The upper half of Chititu Creek occupies a comparatively narrow valley that is excavated to a depth of 200 to 400 feet through the thick deposits of bench gravels to the shale rock floor beneath. In this shale bed rock the stream has carved a trough that conforms in slope to that of the surface of the rock floor. In width this trough ranges from 200 to 700 feet and its depth is from 10 to 50 feet. It is well filled to a depth of 8 to 16 feet throughout its length and width by recent stream gravels. These gravels have been mostly derived and concentrated from the bench gravels in which the creek valley has been excavated. In brief, the whole process has been that of a natural ground sluicing of the bench gravels down to the grade of the shale rock floor, in which a natural bed-rock flume has been cut. This bed-rock flume has been paved with the bowlders and larger cobbles of the bench material and has thus afforded a natural set of riffle blocks that have served to catch and hold the gold and copper which make up the metal values.

Only one of the original locators of claims on Chititu Creek has developed his holdings along conservative and consistent lines from the time of their discovery. On claim No. 11 above Discovery open-cut work was begun with pick and shovel. This was facilitated the next season by the use of canvas hose, and finally a small hydraulic plant with giants was installed. This plant has been improved from year to year and the results obtained have been increasingly satisfactory to the owner.

In 1907 active development work was begun on a group of claims that includes the major portion of the placer ground on Chititu Creek. A complete hydraulic plant, supplemented by a well-equipped sawmill run by water power and an electric-lighting plant to aid in night work during the latter part of the open season, was during the winter taken over the snow and ice to Chititu Creek from Valdez, a distance of 200 miles, by means of horses and sleds. This winter method of transportation is the only way by which any considerable quantity of materials can be conveyed into the Copper River region at the present time. Even when economically conducted, on a large scale involving quantities of 100 tons or more, such transportation from Valdez to the Nizina district has never cost less than $130 per ton. On small amounts of supplies the cost may be as much as $400 per ton.

The greater part of the open season of 1907 was spent in installing this plant on the lower eight claims on Chititu Creek. The sawmill was erected on claim No. 4 above Discovery to supply lumber for flumes, buildings, and other purposes. A large amount of hydraulic pipe was riveted together from the separate sheets, and as the season progressed the whole plant with dam and head-gates on claim No. 8 above, the flume and pipe lines, lighting plant, etc., was assembled in working order so that by the close of the season all arrangements were completed for beginning active mining on claim No. 1 with the opening of the season of 1908.

DAN CREEK.

Dan Creek in point of size is the first important tributary to Nizina River above Chititu Creek and, as has been previously stated, is also the first one below Chitistone River. Its general course is west-northwest and it joins the Nizina at the point where that stream, flowing southward from the Skolai Mountains, abruptly changes its course to the west. The drainage area of Dan Creek covers approximately 45 square miles and is nearly as broad as it is long.

The stream for a distance of nearly a mile below the place where it emerges from the mountains flows across the gravel floor of the Nizina River valley, but is raised slightly above it by the broad, low, fan-shaped deposit of gravels it has brought down from above. The valley above this portion of the stream presents three different topographic features. For nearly 2 miles Dan Creek has cut its way through the deep bench gravels bordering the Nizina Valley and has excavated a shallow trough in the country rock. In this narrow trough the stream gravel is laid down. Above this portion the channel is in a narrow box canyon, which finally expands into the more open, basin-like upper valley. Two principal branches unite above the canyon to form the main stream. The northern branch retains the name Dan Creek; the other is known as Copper Creek.

The bed rock as naturally exposed or as uncovered by mining operators along the lower part of Dan Creek is made up of Triassic shales intruded by light-gray porphyritic and greenstone dikes. These shales, so far as is now known, occupy most of the area south of Dan Creek to Chitina River. North of Dan Creek is the Nikolai greenstone, overlain by a heavy capping of Chitistone limestone that forms the top of the mountain mass between Dan Creek and Chitistone River. The unnatural position of the Triassic shales south of the stream with reference to the greenstone north of it is believed to have been brought about by a great fault extending through the valley from southeast to northwest and removing from view the Chitistone limestone, which normally should be present between the greenstone and shales. This fault continues northwestward at least as far as Lakina River.

Placer mining is at present restricted to the regions above and below the canyon. Above the canyon the most work has been done on Copper Creek. This part of the stream is difficult to reach with supplies and only a few men were at work there in 1907. Most of them were doing nothing but assessment work, and yet a few thousand dollars in gold have been produced during the several years since work began. The creek claims below the canyon are under one control, and though the gold production has not been large, owing to the difficulty of working the ground, prospecting has shown that gold is present.

Placer gold is associated with two classes of deposits—the present stream gravels and the older and much more extensive bench gravels. Mining or prospecting has been carried on in both of these. Undoubtedly a great part of the gold in the present stream is a concentration from the benches through which the creek has cut its channel. Whether any part of it has been brought by the present stream directly from its original source or a source other than the higher unconsolidated bench gravels to the place it now occupies is a question whose answer was not determined.

The first claim below the canyon is No. 7 and the numbers decrease down stream. Near the camp a cut approximately 400 feet long and as wide as the shovelers could work at one setting of the boxes was made in the creek gravels of claim No. 5. Directly above is a larger cut, nearly as long and averaging about 75 feet in width. The bed rock is hard, close-jointed shale cut by dikes of light yellowish-gray porphyry and of greenstone. The gravel and its slight soil covering range in thickness from 8 to 12 feet. The gravel consists in part of shale fragments and contains a large percentage of greenstone and porphyry. Some of the bowlders in the large cut have diameters as great as 4 feet, and many of them average 10 or 12 inches in maximum diameter. All of this material has been more or less rounded by stream action. It is poorly bedded and spruce logs and fragments of wood are buried in it. The large cut was made by piling up a wall of bowlders along the gravel face, thus forcing the creek water to undercut the bank and causing it to cave. Bed rock was then cleaned by hand. Such work is expensive, as it requires several handlings of all the larger material. A third cut, 300 feet long and one box wide, on claim No. 6, showed gravel and bed rock of the same character.

The width of the stream gravels is not great, in places not over 100 or 200 feet, but increases as the creek is descended. On either side benches of gravel close to the stream rise to a height of several hundred feet. Tunnels in these benches have demonstrated that they carry gold. One of these tunnels on the upper end of No. 6 or the lower end of No. 7 had a length of 72 feet. It was driven along the rock floor upon which the gravel rests and is 10 feet higher than the present stream. In other words, the creek here has cut 10 feet into the bed rock since the present drainage was established. The tunnel was driven in winter as a prospect and yielded good values in gold.

The Dan Creek gold from the gravels below the canyon is coarse and smooth. Most of it is flat, and the heaviest of it is found either on bed rock or within 2 feet of it. It is accompanied by placer silver and placer copper. Nuggets of silver and copper, such as are called "half breeds" in the Lake Superior region, are frequently found here, and on Chititu Creek also. Copper is associated with both the creek and the bench gravel, in pieces ranging from the size of shot to masses of 100 pounds or more. It is only recently that any effort has been made to secure the copper, as it is of no value with the present means of transportation. Most of the operators are now saving it, however, and when railroad transportation is available the returns from the copper may be found to reduce considerably the cost of mining.

The gold from Dan Creek above the canyon differs from most of that below in that it is generally rough and not flattened, indicating that it has not been hammered out and worn so much by moving bowlders.

Surveys for a hydraulic plant on the lower end of Dan Creek have been made, and it is expected that the plant will be installed during the summer of 1908.

NOTES ON COPPER PROSPECTS OF PRINCE WILLIAM SOUND.

By Fred H. Moffit.

The copper prospects of Prince William Sound were examined by U. S. Grant and Sidney Paige in 1905 and a short account describing the general geology of the region and the occurrence of the copper ores was published.[a] Since that time the region has not been visited by members of the United States Geological Survey, but the statements here made concerning later developments have been procured from sources that are believed to be reliable. A small map of the region (fig. 2) is here reproduced without change from Grant's preliminary report.

During the two years since 1905 two mines have made regular shipments of ore to the smelter, several promising prospects have been partly developed, and further prospecting has been carried on in all parts of the sound. The search for copper has been active on Knight Island, Latouche Island, and in the vicinity of Copper Mountain and of Orca. Attention has been directed most strongly toward Knight Island and considerable money has been expended in the endeavor to prove the presence of ore bodies of commercial value, but it can not be said that a copper mine has yet been developed there. Shipments of ore have been made from prospects in various parts of the sound, but most of them must be regarded merely as smelter tests and give no indication of the ability of the prospects to produce ore regularly and in quantity. This statement is made because one or two companies are said to have purposely endeavored to misrepresent the state of their development work or the value of their ore deposits by reports of this kind.

As described by Grant, the geology of the region may be briefly summarized. The rocks of Prince William Sound are in part sedimentary, in part igneous. The sedimentary rocks consist essentially of graywackes and slates, the graywackes in places approaching arkoses and sandstones or even quartzites. The color of both gray-

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

wackes and slates is dark gray or black, the slates being the darker. Limestones are few and inconspicuous.

Granite, aplite dikes, basic dikes, and basic lava flows constitute the igneous rocks. Only the basic lava flows are of special importance in connection with the copper deposits. These flows are more or less altered and in places are schistose. They are usually referred to as greenstones.

Sedimentaries and interbedded lava flows are much folded so that

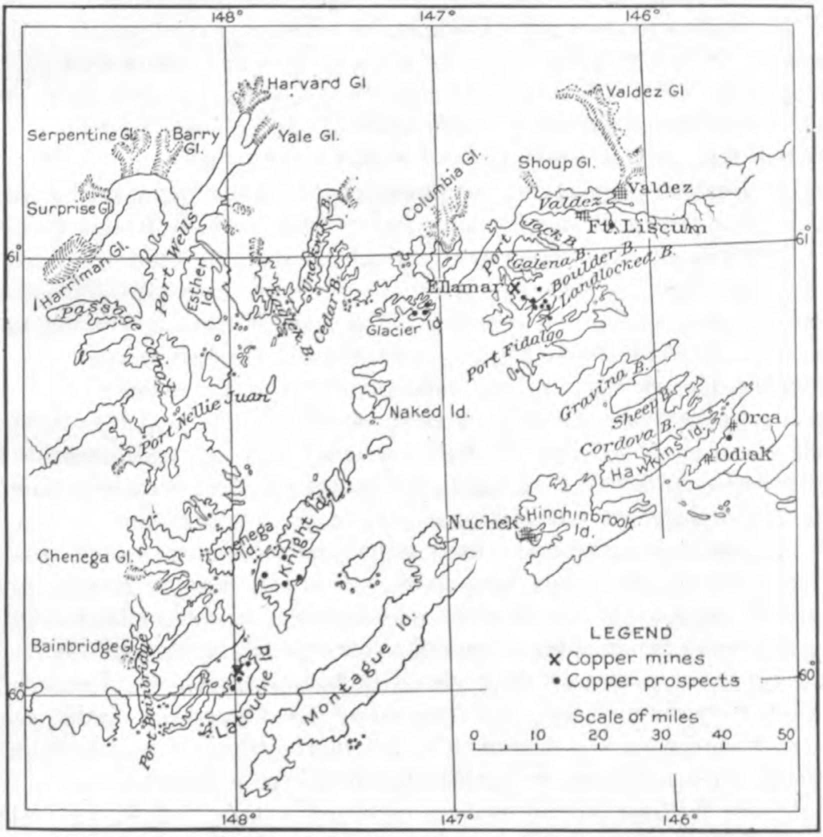


FIG. 2.—Sketch map of Prince William Sound. By U. S. Grant, 1905.

bedding and cleavage are in most places parallel. The sedimentary rocks of Prince William Sound consist of two series of nearly similar beds that have been given the names Valdez and Orca. Of these the Orca is more widespread and differs from the Valdez in being a little less metamorphosed and in containing much black slate, conglomerates, and many interbedded lava flows.

The copper ores are chiefly chalcopyrite, generally associated with pyrrhotite and less commonly with pyrite and marcasite. It occurs in many places in shear zones in greenstone, and this association of copper ore with greenstone is so pronounced that the copper is believed to be derived from the greenstone. Native copper and chalcocite have been found in the vicinity of Orca in sufficient amount to indicate a possibility of their commercial importance.

Among the older and better-known properties that at Ellamar was partly idle during the summer, it is said because of labor troubles. The shaft was sunk to the 600-foot level and 650 feet of drift was made. At Galena Bay an aerial tram 5,000 feet long, from the mine to the beach, was begun and ore bunkers were being constructed at the beach. Only a small amount of work was done at Boulder Bay, most of it by the Reynolds-Alaska Development Company, which extended its main tunnel. Some small shipments of ore were made from Landlocked Bay and a tramway and wharf were built.

The Beatson property at Latouche, known as the Bonanza, but not to be confused with the Bonanza mine on Kennicott River, in the Chitina region, was the only property of western Prince William Sound to make regular shipments. A crosscut tunnel 900 feet long was driven, cutting the ore body at a level 90 feet below the old tunnel. The Reynolds-Alaska Development Company has erected a wharf, electric-light plant, trading store, and a number of houses on its property at Horseshoe Bay, on the west side of Latouche Island. A shaft was sunk on one of the claims and a small amount of ore was shipped. East of the Bonanza mine, on the Barrack claims, active development work was in progress. A wharf, ore bunkers, and a tramway were under construction and a little ore was shipped.

A great many claims have been staked on Knight Island, but most of the locations were made within a year or two so that development work is not as far advanced as on some of the older properties. Among those most actively engaged in prospecting is the Hubbard-Elliott Company, whose property is located at Drier Bay, on the west side of the island. A tramway with other equipment was installed during the summer and a small shipment of ore is reported.

Prince William Sound properties enjoy a great advantage over those of the interior in that nearly all of them are within comparatively easy reach of tide water and their development is not dependent on expensive railroad construction or hindered in the same degree by the severity of the winter.

OCCURRENCE OF GOLD IN THE YUKON-TANANA REGION.

By L. M. Prindle.

INTRODUCTORY STATEMENT.

The placer-gold production of the Yukon-Tanana region up to 1907, inclusive, has been approximately $33,500,000, or nearly one-third the total gold production of Alaska; of this amount over two-thirds has been contributed by the Fairbanks district. The importance of this region has led to comprehensive work by the Geological Survey. The mapping of the region, commenced in 1898 by the mapping of the Fortymile district, has been carried on continuously since 1903, until at the present time the greatest part of it has been mapped on a scale of 1:250,000, or about 4 miles to the inch. Geologic work of a reconnaissance nature, commenced by Spurr, Goodrich, and Schrader in 1896,[a] has also been carried on continuously since 1903, and a body of material has been collected that has not yet been thoroughly studied. The following statements, therefore, being based on a very superficial study of the data, have only provisional value. A map (Pl. IV) has been prepared to show the distribution of known gold placers, of the main rock groups of sedimentary origin, of intrusive rocks so far as they have been approximately delimited, and of recent volcanics.

BED ROCK.

The rocks of sedimentary origin in this region include essentially two groups—one of metamorphic, complexly folded schists provisionally assigned to the pre-Ordovician, and another, supposedly in unconformable relation to the schists, of phyllites, greenstones, quartzites, and limestone belonging to the Silurian, Devonian, and Carboniferous. Besides these two groups there are areas of Lower Cretaceous slates along the Yukon, Upper Cretaceous sandstones and shales in the Rampart region, and several areas of Tertiary clays, lignites, sandstones, and conglomerates.

[a] Spurr, J. E., and Goodrich, H. B., Geology of Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 87–392.

Igneous rocks are present as intrusives and extrusives. There are many large areas of intrusive rocks in the eastern part of the region, and the portions of them that have been traversed are indicated on the map (Pl. IV). Isolated areas are scattered throughout the region and there are probably many more than are shown on the map. These rocks range in composition from acidic granite to peridotite. Granitic rocks and those of intermediate composition are most common. Some of the granites have been metamorphosed to granitic gneisses and have been intruded by later granites. The only age of intrusion that has been definitely established is that of rocks of intermediate composition in the vicinity of Rampart, where Paleozoic rocks and Upper Cretaceous sandstones have been intruded. The greenstones of Paleozoic age are largely altered diabasic and basaltic flows.

Areas of fresh volcanic rocks are indicated in the eastern part of the region, where they occur generally as masses capping the hills of schist or as plugs with a surrounding mass of volcanic material. In one place they occur as a small volcanic cone. The composition of the volcanic rocks parallels that of the intrusives to a certain extent; there are rhyolitic, andesitic, and basaltic types. The latest volcanic rocks are believed to be at least post-Tertiary and are possibly of Quaternary age.

ALLUVIAL DEPOSITS.

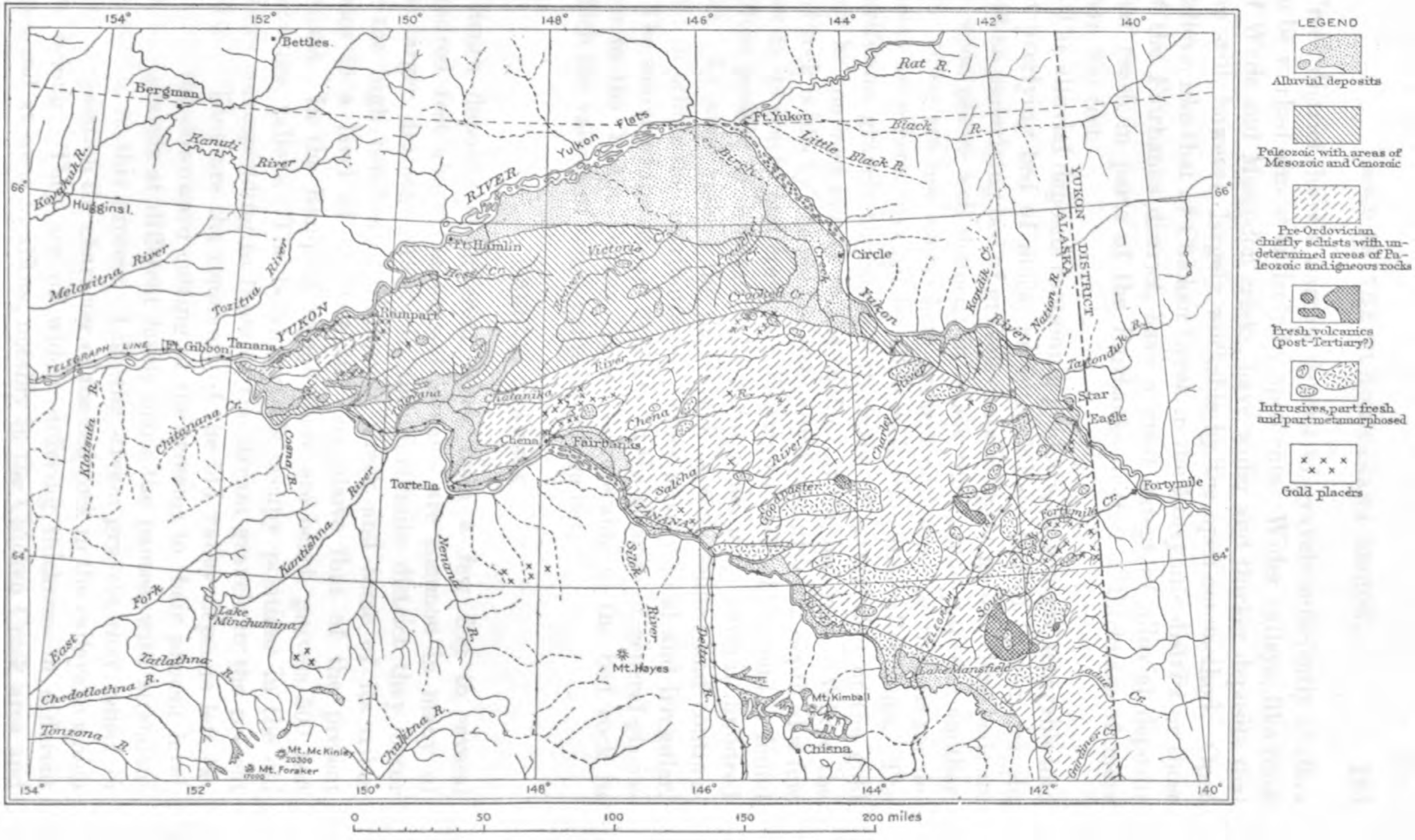
GENERAL CHARACTER.

The alluvial deposits comprise silts, sands, and gravels of Pleistocene and Recent age, and these are partly auriferous. The Fortymile, Birch Creek, Fairbanks, and Rampart districts have up to the present time produced most of the placer gold, but intervening areas have also proved somewhat productive and the causes of mineralization have evidently been in operation over a large part of the region. Though the alluvial deposits have furnished practically all the gold that has been produced, a few localities have been found where gold occurs in the bed rock.

The alluvial deposits containing gold include chiefly the present stream gravels and the bench gravels related to the valleys of these streams. Most of these deposits are frozen throughout the year. It is possible, also, that some of the Tertiary conglomerates have contributed a small part of the alluvial gold.

STREAM GRAVELS.

The extent and thickness of the stream deposits vary greatly in different valleys. Narrow valleys, like that of Franklin Creek in the Fortymile district or the upper part of Deadwood Creek in the Birch



GEOLOGIC SKETCH MAP OF YUKON-TANANA REGION.

Creek district, have a narrow deposit of gravels sufficiently shallow to be worked almost entirely by open cuts. Wider valleys, like those of Wade and Mastodon creeks, have wider and thicker deposits that are still, however, largely workable by the open-cut method. Open valleys, like that of Chicken Creek in the Fortymile district or those of the Fairbanks district, have a great extent of alluvial deposits that reach in parts of the Fairbanks district a thickness of more than 300 feet.

The alluvial deposits containing gold are, in general, separable into an overlying bed of muck, an intermediate bed of barren gravels, and an underlying bed of gravels containing the gold. These beds are in some places well defined; in others they grade into one another. The three are not everywhere present and some of the stream deposits have been invaded by slide rock from the valley sides. The auriferous gravels may have a thickness of several feet or the gold may be confined mostly to the surface of the bed rock. Where the bed rock is blocky, the gold is generally found also to a depth of a few feet in its cracks and crevices. The width over which gold is found differs greatly in different valleys; in some it is several hundred feet. In some valleys the pay streak is well defined and continuous; in others the distribution of values is very local and irregular.

The source of the stream deposits, in the absence of general glaciation in the Yukon-Tanana region, is referable to the bed rock in which the valleys of the streams have been cut.

BENCH GRAVELS.

Bench deposits at different levels from a few feet to several hundred feet above the present streams are common in many of the larger drainage areas. In the Fortymile district they occur on the high benches of Fortymile Creek and some of its tributaries to a level of at least 300 feet above that of the present streams. In the Rampart region there are bench gravels 500 feet above the valleys. The bench gravels occupy positions in the old valleys corresponding to those of the stream gravels in the present valleys. They are the remnants of the old valley deposits left behind in the downward cutting of the streams to their present level, and the gravels at different levels mark the pauses, with attendant deposition, in this process. Like the stream gravels, they reflect in their composition the character of the bed rock in the valleys to which they belong. They are of widely differing thickness in different areas, and at some localities, notably in the Chicken Creek area and in the Rampart district, they have been found rich in gold.

AURIFEROUS CONGLOMERATES.

Conglomerates regarded as Tertiary occurring in the Yukon-Tanana region are so much older than the stream and bench gravels that the conditions of their formation are obscure. The gravels forming them, however, were probably deposited under fluviatile conditions associated with or subsequent to lacustrine conditions, and since their deposition have been consolidated and folded. These rocks form a well-defined belt in the area between the Seventymile and the Yukon and westward toward Circle. The gravels of several creeks draining this area contain gold and have been mined for several years. Their gold content is regarded by Brooks [a] as evidence of the presence of alluvial gold in the conglomerates.

ORIGIN OF GOLD.

All the available evidence regarding the origin of the placer gold in the Yukon-Tanana region indicates that it has not been deposited in the placers from solution, but has been derived with the other constituents of the gravels by mechanical separation from the bed rock. Inasmuch as the material forming stream and bench gravels is definitely referable to the bed rock of the respective valleys, those auriferous valleys where there is the least variety of bed rock should throw some light indirectly on the origin of the gold. Furthermore, the immediate associates of the gold, or, better still, adherent pieces of other mineral or rock, bear definitely on this problem. If in addition to these indirect sources of information, localities can be cited where gold occurs in place in the bed rock, a considerable body of material will have been assembled that should prove illuminative of at least some phases of the origin of the placer gold.

There are few creeks in the Yukon-Tanana region where the geologic conditions are relatively simple. The variety of bed rock of sedimentary origin is further complicated by the intrusive rocks that are locally present in all the important placer-mining areas. Under what are apparently some of the simplest conditions, however—those on Wolf Creek in the Fairbanks districts, where the bed rock observed in the amphitheatral area at the head of the creek is quartzitic schist and quartz-mica schist with small quartz veins and where the gravels so far as observed are of the same material—the rough, gritty gold, some of it with quartz attached, must have been derived from the schist and most likely from quartz stringers cutting it. The conditions of origin are apparently the same in Fairbanks Creek, heading on the opposite side of the same ridge. On Harrison Creek, in the Birch Creek region, where the same bed rock prevails, a slab of similar schist was found in the gravels containing a gold-bearing

[a] Brooks, A. H., Report on progress of investigations of mineral resources of Alaska in 1906: Bull. U. S. Geol. Survey No. 314, 1907, pp. 198–200.

quartz seam. This occurrence was described by Spurr.[a] A similar association has been observed on Davis Creek, in the Fortymile region. The fact seems definitely established that in some of the most productive regions a part of the gold, at least, has been derived from the quartz veins in the schists, and as these schists are the most common rocks in the Fortymile, Birch Creek, and Fairbanks districts, it is probable that a large proportion of the gold has had this origin. That the mineralization of the schists has not been confined to the deposition of gold is shown by the facts that in the Fairbanks district stibnite (sulphide of antimony), cassiterite (oxide of tin), and bismuth have been found in association with the gold in the placer deposits and that veins of stibnite have been found in the schists.

Rocks regarded as Paleozoic are present in the Fortymile district and some of the gold occurrences are referable to these rocks. The same is probably true of the Rampart district, where the rocks are predominantly Paleozoic but where there are also pre-Ordovician schists and a few Mesozoic rocks of Upper Cretaceous age. In the Rampart region native silver is a common associate of the gold on some of the creeks, and native copper is also found.

The metals and minerals associated with gold in the placers of the Yukon-Tanana region include lead, silver, copper, bismuth, argentite (silver sulphide), stibnite (antimony sulphide), galena (lead sulphide), cinnabar (mercury sulphide), iron pyrites, copper pyrites, barite, cassiterite (tin oxide), rutile, garnet, magnetite, hematite, and limonite.

On creeks tributary to the Yukon a close relation has been observed by Brooks between the alluvial gold and Lower Cretaceous slates, and the following is quoted from his report:[b]

> The rocks exposed along the Yukon between Eagle and Circle do not anywhere include any of the older schists, such as are associated with the Birch Creek placers. In fact, over much of this belt the formations are slightly altered limestones, shales, slates, and conglomerates, which do not bear evidence of mineralization and will not attract the placer miner. Locally, however, some of these rocks are mineralized and contain more or less gold. Thus on Nugget Gulch, a tributary of Washington Creek, slates of Cretaceous age are found which are permeated with quartz veins, some of which must yield gold, as the associated alluvium is auriferous. The writer was not able to study this locality, but it appears that the coarse gold occurs in small patches on the bed rock. This occurrence, though probably of small commercial import, has a far-reaching significance, as it indicates that there has been an intrusion of mineralized veins since these younger rocks were deposited. The writer is, however, of the opinion that this mineralization is not general enough to encourage the search for placers where these Cretaceous slates form the country rock.

[a] Spurr, J. E., and Goodrich, H. B., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 353–354.

[b] Brooks, A. H., Report on progress of investigations of mineral resources of Alaska in 1906: Bull. U. S. Geol. Survey No. 314, 1907, pp. 198–199.

Gold has been found in place at several localities within the Fortymile district, and these are described briefly in the succeeding paper. At the locality on Mosquito Fork about 2½ miles from Chicken Creek the gold occurs in a brecciated mineralized zone in a quartz diorite. There has been considerable silicification and an abundant introduction of iron pyrites. At the locality near the head of Chicken Creek the gold occurs in thin calcite veins that are associated with pyritiferous quartz veins in black phyllites regarded as Paleozoic. These are in contact with quartz diorite porphyry, the marginal facies of a rock like that on Mosquito Fork. The placer gold of Chicken Creek is derived in part, at least, from a deposit of this form. At Canyon Creek there is a brecciated mass of vein quartz and quartzitic schist. The rock here is very ferruginous and locally fragments have been found containing specks of gold visible to the eye. In the Flume Creek occurrence there are numerous small auriferous quartz veins penetrating a serpentinous igneous rock that is intruded by basic dikes. Other occurrences of gold in bed rock are reported, but have not been studied by the writer.

So far as definitely known, then, at the present time, the placer gold of the Yukon-Tanana region is traceable to quartz veins in the pre-Ordovician schists, apparently also to those in the Paleozoic phyllites, and possibly to those in the Cretaceous slates; to calcite veins in rocks regarded as Paleozoic in close contact with igneous rocks; and to quartz veins and silicified areas of secondary origin in igneous rocks.

A consideration of the map shows that igneous intrusives have a wide distribution over the entire region and are present in all the chief placer-mining districts. They are also of widely differing age. The Upper Cretaceous rocks in the vicinity of Rampart have been intruded by them and mark, so far as known, the last period of intrusion of plutonic rocks in the Yukon-Tanana region. Mesozoic rocks have not been found in other areas of intrusion and it is not known how many of the areas of fresh igneous rocks of granitic and intermediate composition are referable to this period. It is probable, however, that a large proportion of them were intruded at this time. Some of the granitic rocks and schists are cut by fresh basaltic dikes and the areas of fresh volcanic rocks attest the continuation of igneous activity. The question whether these volcanic rocks have taken part in the mineralization of the region has not been answered.

There are several hot springs in the region, and at least two of them are near the contact of granitic rocks with schists and with carbonaceous phyllites. The temperature of these waters is probably due to the residual heat of the igneous masses and indicates the long-continued operation of one of the factors influential in mineralization.

This region is regarded as one of large batholithic masses of intrusive rocks, now mantled by a comparatively thin shell of sedimentary rocks. Intrusions have taken place at different periods. Some of them have been accompanied or followed by numerous dikes and sills of an acidic character, and it is probable that at such times the depth of intrusion was so great as to favor, through increased pressure and temperature, a wide dissemination of the final products of the crystallizing magma through the surrounding rocks as acidic dikes and sills, as intrusive quartz veins, and finally as the ordinary quartz veins so common in the schists. Where the intrusives have penetrated to higher levels, as in the Upper Cretaceous rocks of the Rampart region, there was no opportunity for long-continued differentiation and distribution of the magma in such attenuated form and the action under such conditions has been confined to contact metamorphism and the release of the waters of intrusion to act as solvents, to mingle ultimately with meteoric waters, and to leave behind them the quartz or calcite or other substances carried in solution.

The acidic dikes and sills are very common in the Fortymile district. They have in places been crumpled and reduced to augen and exhibit generally cataclastic action. They are apparently most characteristic of the older intrusions. The occurrence of gold in the Fortymile district has not been traced directly to them, and they are not common in the Birch Creek, Fairbanks, and Rampart regions.

The intrusives of the Birch Creek, Fairbanks, and Rampart districts are comparatively fresh, and similar fresh intrusives are common in the Fortymile district. Many of these masses are surrounded by shatter zones of rock containing numerous dikes of the same material as the main mass, or a more basic marginal phase. The period of intrusion was one of great disturbance. The gold in the Chicken Creek area is in close relation with such intrusives and it is believed that in this locality at least they mark a period of mineralization accompanied by the deposition of gold derived primarily from the igneous rocks. The age of this period of mineralization is not known. The quartz veins in the Lower Cretaceous slates of Washington Creek regarded as auriferous by Brooks and ferruginous quartz veins in Upper Cretaceous rocks of the Rampart region that have been intruded by granitic rocks indicate a period of mineralization that is probably to be referred to such intrusions, and those of Chicken Creek may belong to the same period. There is as yet no direct evidence bearing on this point. The influence of igneous intrusion is far-reaching, especially in areas of such permeable rocks as siliceous schists, and in view of the widespread distribution of igneous rocks in the Yukon-Tanana region, both in space and time, and their relation to the facts at our disposal, it seems justifiable to ascribe to them the widespread mineralization of the region and to refer a part, at least, of this mineralization to the close of the Mesozoic. In this connection it is important to note the relation of mineralization to Mesozoic intrusion traced by Wright in southeastern Alaska.[a] It might be inferred, perhaps, that if the igneous intrusives have been responsible for the gold, the most productive areas should be found in the vicinity of the most abundant intrusives. Little, however, is known regarding the laws governing the occurrence of the gold in the bed rock. The composition of the intruding rock, the conditions of intrusion, and the character and physical structure of the intruded rock are among the factors in the problem. It is probable that extensive deformation at the time of intrusion, by rendering the surrounding rocks more permeable, facilitates the transportation of material from the igneous magma. It is perhaps true that in the vicinity of a cooling intrusive mass conditions favorable for solution may be maintained so long that gold derived from this source is carried in solution far into the surrounding rocks before reaching areas where conditions favorable for deposition prevail.

Some of the most productive placer areas lie within the pre-Ordovician schists and some within the Paleozoic rocks. Even in the Rampart region, where the Paleozoic rocks are abundantly developed, the older rocks are present, and the Birch Creek, Fairbanks, and Fortymile areas are not far removed from the present contact of the two groups. It seems probable, therefore, that these areas of gold deposition were adjacent to what before erosion was the contact plane of the two groups, and this plane may have afforded a favorable zone for circulating waters at the time mineralization was in progress.

SUMMARY.

So far as can be judged by present knowledge of the region, intrusion has been very general, especially in the schists, and continued to the close of the Mesozoic. Gold is very widely distributed in small quartz veins in the schists, and locally has been so abundant as to have proved richly remunerative in the associated placers. Gold is also present here and there in the Paleozoic rocks, and possibly also in later rocks, presumably in areas of intense deformation accompanied by intrusion. It has been found also in igneous rocks, where it has been introduced subsequent to the intrusion. It may be stated in conclusion that up to the present time no large body of bed rock carrying commercial values has been recognized, and that the areas of greatest and most extensive concentration in placers are in well-developed drainage systems, where there has been a long opportunity for the slow concentration of gold in the alluvial deposits.

[a] Wright, C. W., Bull. U. S. Geol. Survey No. 314, 1907, pp. 49-51.

THE FORTYMILE GOLD-PLACER DISTRICT.

By L. M. Prindle.

INTRODUCTORY STATEMENT.

The Fortymile quadrangle includes the area between the 141st meridian, which is the international boundary, and the 142d meridian, and the 65th and 64th parallels. The area is about 70 miles long from north to south, and 30 miles wide. It produced during 1907 approximately $150,000 in placer gold. The present brief paper gives some of its salient features. A more detailed description of the district is in preparation.

Fortymile Creek crosses the southern part of the district and in this region was located the first center of gold production in the Yukon basin. The knowledge of conditions acquired there was applied effectively in other regions that were afterward developed, and these in turn are having a reactive influence. The stage of mining in which the productive unit is a mining claim is giving place to that in which the productive unit is a group of claims worked by a process correspondingly efficient. Such methods are becoming increasingly necessary to meet the conditions that now prevail. To evaluate these conditions and to determine in a particular locality the sufficiency of a mining method to meet them successfully is the problem of the mining engineer. To state very briefly the main geographic and geologic facts and the mining developments of 1907 is the scope of the following description.

Considerable work has been done in this region by the Geological Survey. It was investigated by Spurr, Goodrich, and Schrader in 1896;[a] the quadrangle was mapped by Barnard in 1898 on a scale of about 4 miles to the inch; it was traversed by Brooks in 1899; and since 1903 parties from the Survey have been mapping adjoining areas and investigating conditions in the gold-placer regions. During the summer of 1907 the writer continued his work in the region by traversing the southern portion of the area covered by the map.

[a] Spurr, J. E., and Goodrich, H. B., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 87–392.

GEOGRAPHIC SKETCH.

RELIEF.

The country is one of undulating, rather even topped ridges separated by deep, relatively narrow valleys. Isolated domes rise above the general level of the ridges, which are locally of considerable prominence. Glacier Mountain attains 6,000 feet above sea level. The level of the Yukon at Eagle is about 800 feet. In general, the ridges are from 1,500 to 2,000 feet above the streams.

DRAINAGE.

The drainage of the northern part of the quadrangle is directly to the Yukon; that of the southern part to Fortymile Creek. Yukon River, crossing the northeast corner of the area, receives from the west Seventymile, Mission, and Boundary creeks. Fortymile Creek is a powerful stream and receives many important tributaries that have their sources far outside of the area covered by the map. There is considerable difference in valley development, but in general the valleys of the smaller streams are similar. Most of the larger streams have formed valley floors a few hundred feet in width. Benching is prominently developed in the larger valleys throughout the region at different levels, from a few feet to over 300 feet above the present streams. The Fortymile Valley is an example of the canyon type. The stream is deeply sunk and is still cutting downward, and the lower valleys of most of its tributaries are also narrow canyons. The streams in general head at about the same level and are cut to about the same depth. Any undertaking, therefore, involving water supply requires most careful preliminary measurements of available water and grades.

CLIMATE AND VEGETATION.

There are a few aspects of the climate that have an important economic bearing. The Yukon closes to navigation at dates ranging in different seasons from about October 10 to November 20 and does not open till dates ranging from about May 10 to May 20. Much of the ground is permanently frozen to bed rock and requires special treatment. Notwithstanding the extreme cold, there is much free water in the ground during the winter, and in many streams the water breaks through the ice already formed, causing overflows, which, although quickly frozen, are often a source of trouble and delay in travel. Constant repetition of this process throughout the winter results in the formation of thick deposits of ice in some of the smaller valleys, and these may linger till late in summer, thus further shortening the working season. Dams and other improvements are sometimes buried beneath such accumulations of ice and damaged beyond repair. This glaciering of streams is characteristic of the region, and must be taken into consideration in planning work.

The timber resources are moderate. Spruce grows abundantly in the valleys of the larger streams and is sparsely distributed over the hillsides throughout the area. It has been used generally for sluice boxes and to some extent for dredge building, the largest timber available for this purpose furnishing logs 12 to 15 feet long and a foot in diameter. Birch is common in some of the valleys, but is of minor importance. Timber for fuel is still abundant.

TRANSPORTATION.

Transportation to the creeks of the Fortymile region has always been difficult, and the situation has been rendered more complex by the presence of the international boundary with its attendant customs regulations. Most of the supplies are purchased in Dawson, Yukon Territory, and freighted up Fortymile Creek on the ice by horse sleighs during the winter months. The freighting was delayed to some extent during the winter of 1906-7 by the occurrence of glanders among the horses and by overflows to which the creek is subject. About 400 tons were shipped by this method for the dredge on Walker Fork and 100 tons for the dredge below Franklin Creek. The freight rate from Fortymile Post to the latter locality was $70 per ton in 1907. Summer freighting on Fortymile Creek is done by poling boats. It is a difficult stream to navigate, and boat loads of material are frequently lost or long delayed by low water. The rates from Fortymile to the farthest locality, Chicken Creek, are about 25 cents per pound. Cattle are frequently driven overland on the wagon road from Dawson to Glacier, a distance of 60 miles, and thence to the various creeks on the Alaska side, where they are sold.

The road commission has surveyed a Government wagon road from Eagle to the Fortymile country and has already practically completed about 9 miles of it, from Eagle to American Creek. Work is also being done on a road to make the Seventymile country more accessible from Eagle. During the fall of 1907 a road was constructed by private means from the head of Canyon Creek to Walker Fork, in order to save the long haul up the Fortymile in the winter.

Work was commenced in 1907 on the survey of the international boundary southward from the Yukon. This work includes also the topographic mapping of a strip of country 2 miles wide each side of the boundary. The work is carried on by representatives of both governments. The results will be final and will set at rest all doubt on the part of the miners as to the position of the boundary.

GEOLOGIC SKETCH.

The rocks of the Fortymile quadrangle are composed of highly metamorphosed schists with interbedded limestones, all assigned provisionally to the pre-Ordovician; of less-metamorphosed rocks including Devonian phyllites, greenstones and limestones, and Carboniferous slates and limestones; of Tertiary clays, lignite, sandstone, and conglomerate; of bench and stream gravels probably of Pleistocene and Recent age; and of intrusive igneous rocks, some of which have been metamorphosed with the schists.

PRE-ORDOVICIAN ROCKS.

The schists include essentially thin-bedded, little-altered quartzites, quartzite schist, quartz-mica schist, garnetiferous mica schist, hornblende schist, and carbonaceous schist. All these may occur in close alternation with each other. Crystalline limestones are interbedded with them in layers from a few inches to a hundred feet or more in thickness. The structure is most complex. Dips and strikes present much variability. In places the rocks are nearly horizontal, but such horizontality is in some localities the result of complex folding. In general the rocks lie in a highly inclined attitude. Closely appressed folds are common, and these in places pitch at high angles, even becoming vertical. Furthermore, there has been motion that has resulted in shearing planes at angles with these highly pitching folds. Thinly bedded quartzite and mica schist have been thus transformed into rods of quartzite a foot or more in length, with lenticular cross sections an inch or more in diameter. In a weathered cross section of such beds the eyes of quartzite in a micaceous matrix present the appearance of a metamorphosed quartzite conglomerate. The structure is further complicated by the abundant occurrence of intrusives, some of which have become so closely incorporated with the schists that they are not easily recognizable as of different origin. In spite of the complexity of the structure, a general strike is discernible, and this is nearly east and west, with variations to the north and south of this direction.

These schists with their interbedded limestones form the bed rock throughout the southern half of the Fortymile quadrangle, with the exception of an area to the southwest occupied by the other formations referred to above and several considerable areas of the intrusives. These rocks are finely exposed in the valley of Fortymile Creek from a point a short distance above Franklin Creek to the international boundary and beyond into Canadian territory. In the northern part of the quadrangle they are present on Seventymile Creek at the falls and above to the limits of the quadrangle.

A narrow belt of them lies at the base of the ridge adjoining Mission Creek on the north. They form also Fortymile Dome. The approximate northern boundary, with the exception of the Mission Creek occurrence, which is probably isolated, extends from the north end of Glacier Mountain to the international boundary near the head of Liberty Fork. The age of these rocks is at present unknown. They are probably at least pre-Ordovician.

PALEOZOIC ROCKS.

Green and black phyllites, greenstones, and limestones, regarded as for the most part of Devonian age, are present in the northeastern part of the quadrangle in the drainage areas of American and Mission creeks. They form the bluff at Eagle and those above Eagle on the left bank of the Yukon, and are abundant along the river below Eagle, where they are associated with Carboniferous rocks. In the southwestern part of the quadrangle they occur on Fortymile Creek from the mouth of Denison Fork to a point about 2 miles above Franklin Creek. The drainage area of Chicken Creek is formed partly of these rocks. They occupy a belt in the area about the headwaters of King Solomon and Champion creeks. There is a small area also on Canyon Creek above the mouth of Mariner Creek. These rocks have in places been closely folded, but the degree of metamorphism is much less than that of the schists, fossil fragments, chiefly crinoid stems, being of common occurrence in the limestones.

TERTIARY DEPOSITS.

Tertiary clays and sandstones with some interbedded lignitic coal and massive conglomerates with interbedded shales have a wide distribution in the northern part of the quadrangle, in the valleys of Seventymile and Mission creeks, and small patches are found at the southwest in the valleys of Napoleon and Chicken creeks. These rocks have in places, notably on Seventymile Creek, been tilted to a vertical position, but are otherwise little altered.

ALLUVIAL DEPOSITS.

The alluvial deposits consist of the bench gravels, partly auriferous, such as occur on the high benches of Fortymile Creek, on the Lost Chicken bench, and on benches of intermediate height, and the deposits of the present streams. The bench gravels have been found to a height of about 300 feet above the streams and have a thickness in places of about 50 feet. The stream gravels are in part auriferous and are in the main sufficiently shallow to be worked by open cuts. Chicken Creek is the only locality where the depth is considerable, reaching, in some of the ground that is being drifted, about 45 feet.

The alluvial deposits have been derived from the bed rock in the drainage areas in which they are found.

The material on the bars of Fortymile Creek has been derived from widely distant sources and a large variety of bed rock. The stream meanders in its course, leaving bars of this material deposited on the irregular planated surface of the schistose bed rock. Many of these deposits were rich in gold and the cleaned-out crevices of the bed rock on nearly every bar along the creek attest the thoroughness of the work done in the early days. On many of the bars the bed rock slopes very gradually upward until it is concealed by the overlying deposits; on other bars the slope is more abrupt, leaving but a narrow margin for work. All the most workable bars have inherited names, and at the present time many of those best known are being prospected with reference to dredges and values have been found in some of them averaging a cent to the pan. Some of the bars are backed by flats up to 1,000 feet or more in width, and the gravels of these flats are also being investigated.

IGNEOUS ROCKS.

The igneous rocks of the Fortymile quadrangle are predominantly intrusives, partly fresh and partly altered into gneisses. Altered diabasic and basaltic flows, with associated tuffs, are present in the areas occupied by the Devonian rocks.

The most common types of intrusives are granitic and dioritic rocks, but more basic rocks are also present. A large area in the northwestern part of the quadrangle, topographically emphasized by Glacier Mountain, is formed of quartz diorite. Numerous dikes and sills of the same rock and more basic varieties derived from the same magma penetrate the surrounding schists over a distance of several miles from the main mass. Another large area of similar rocks enters the southwest corner of the quadrangle, forming much of the bed rock in the Chicken Creek valley. Dikes and sills of biotite granite, hornblende granite, and diorite are abundant in the schists throughout the Fortymile country. A very common intrusive in this country is composed essentially of quartz and feldspar, and this rock with the disappearance of the feldspar forms quartz veins. A part of the quartz veins of the Fortymile region are thus of magmatic origin. This quartz-feldspar material has been intruded partly in the igneous rocks and partly as both dikes and sills in the surrounding schists. When the intrusions took place the intruded rocks were evidently at such a temperature as to allow the entrance and coarse crystallization of very thin sheets of the igneous material in both the crosscutting and concordant relation with the schists, and so extensively was this process in operation at some localities that a large proportion of the rock is composed of granitic material.

These magmatized schists have later been folded, and the acidic dikes have been crumpled and even torn apart into lenticular fragments. At a far subsequent period the granites and schists have been cut by a few dikes of basalt, the material of which is still practically unaltered.

ORIGIN OF GOLD.

At a few localities in the Fortymile region gold has been found in the bed rock. In the intrusive mass of quartz diorite that occurs in the southwestern part of the area, at a locality on Mosquito Fork about 2½ miles west of Chicken Creek, there is a zone about 6 feet wide that is partly brecciated and has been impregnated with quartz and pyrite. The weathered material pans fine flour gold and an average of two assays of surface material collected in 1903 gave a gold content of $9.70 per ton. Assays giving much higher value have been reported. Near the head of Chicken Creek black and greenish slates, with some limestone, occur in close relation with intrusive quartz diorite porphyry. These slates contain thin quartz and calcite veins. Iron pyrite is common in the quartz veins. In some of the thinner calcite veins there is a considerable proportion of gold, occurring as small lumpy masses and as thin plates along the cleavage planes of the calcite. The placers of Chicken Creek have probably derived at least a considerable part of their gold from such small stringers. Silver sulphide has been found associated with the gold in the placers below this locality. It is believed that in these two places the occurrence of gold is due to the after-effects of the igneous intrusives.

Gold has also been found in place in the ridge south of Kalamazoo Creek, a tributary of Canyon Creek. At this locality there is a conspicuous outcrop of brecciated quartzite and vein quartz that is in places very rusty from the large amount of iron content. Specimens have been obtained showing free gold in the rock. It is not known, however, whether gold is uniformly distributed through the rock or whether it is only of local occurrence. Placer gold is found in creeks draining this area and it is believed by the miners to have been derived from this locality.

In the Seventymile area gold has been found in place in a mineralized zone in serpentine. At this locality there are many intersecting small quartz veins containing considerable iron pyrites. Gold is reported in the weathered vein material, and the attempt has been made to save it by means of an arrastre.

The alluvial deposits of the streams, where mining is in progress, have been derived from the bed rock of the valleys in which they occur, and there has been in this area no interference by glaciation with the orderly deposition of material by stream action. The bed rock in some of these valleys is almost exclusively composed of schists of sedimentary origin containing many small quartz veins. Nuggets are frequently found with considerable quartz attached, and it is probable that they have been derived from such quartz veins. Small veins of barite also occur in the schists, and small rounded pebbles of this material accompany much of the gold, along with garnets, rutile, and black sand. Hematite and limonite pebbles are also common associates of the gold. Native lead has been found on Franklin Creek, and in the Seventymile area cinnabar pebbles are occasionally found.

MINING DEVELOPMENT.

Mining by the usual methods in the Fortymile quadrangle during the summer of 1907, partly on account of the prolonged dry weather, was not being carried on very extensively. Many of the bars of Fortymile Creek have been worked for years, and even during 1907 a few miners were found still making wages in the old way with the rocker. The prevailing low stage of water was especially favorable for this kind of work. Operations on Chicken Creek were practically at a standstill, but the field had been somewhat enlarged by the work on Ingle Creek and at the head of Chicken Creek. Sluicing was being done at the mouth of Napoleon Creek, and a few men were working intermittently on Franklin Creek. Ground was being tested at several localities along Fortymile Creek itself, and at Moose Creek a combined ditch and flume was being constructed to bring water about 3 miles to one of the Fortymile bars. Wade Creek was not visited, but the reports indicated more favorable conditions for work.

The greatest change of methods in the Fortymile region has been in the introduction of dredges. Four steam-power dredges were in process of installation or in operation during the season of 1907—one on Walker Fork, just above the mouth of Twelvemile Creek, and three on Fortymile Creek (about 2 miles below the mouth of Franklin Creek, at the international boundary, and about 4 miles above the mouth in Canadian territory). Plans were also under way for installing a dredge on the upper part of Walker Fork during the winter of 1907–8.

The ground to be worked by the dredge on Walker Fork near Twelvemile Creek was reported to range from 6 to 14 feet in thickness, with an average of about 9 feet. The muck was from 1½ to 4 feet thick. The bed rock is schist, with intrusive granite. The gold is said to be mostly on bed rock or within it to a depth of a few inches. The stream flat at this point is several hundred feet wide and the alluvial deposits are frozen. Steam points were in use to thaw ahead of the dredge. The dredge is a bucket open-connected dredge, with buckets having a capacity of 5 cubic feet. It was reported to be capable of working about 3 acres a month. The frozen character of the ground, however, made it impossible to use the dredge to advantage. It has been found necessary to prepare ground by stripping at least a year in advance in order to give it the best opportunity possible for thawing and thus save to a great extent the extra expense of thawing by steam points.

The dredge on Fortymile Creek at the international boundary is similar in character, with 2½-foot buckets and a capacity of about 1,500 cubic yards in twenty-four hours. The dredge was working on a bar where the average depth to bed rock is about 8 feet. While bowlders were somewhat troublesome, the ground was for the most part unfrozen.

The dredge on the Canadian side of the boundary has a capacity of 3,000 cubic yards in twenty-four hours. It has 5-foot buckets and can work ground to a depth of 35 feet. This dredge also was working on a bar of Fortymile Creek where the ground was not frozen and the bed rock soft.

The machine in process of installation on Pump Bar, below the mouth of Franklin Creek, is a dipper dredge. The machinery was being mounted on a scow 42 by 80 feet, built of native spruce lumber. The dipper has a capacity of 2½ cubic yards, and the machine was expected to handle about 1,000 cubic yards in ten hours. The ground to be worked was all unfrozen and averaged about 6 feet in thickness.

Some of the factors to be considered in the installation of dredges, aside from the great question of the values in the ground, which are sometimes barely investigated, are as follows: Remoteness of a region and absence of communication, entailing costly delays in installation, repairs, and procurement of supplies to keep a dredge in continuous operation; length of working season; water and fuel supplies; dimensions and character of alluvial deposits, with special reference to frost and bowlders; vertical and horizontal distribution of the gold in the deposits and the character of the gold; evenness or unevenness of the bed-rock surface, ridges of bed rock in some places interfering with the ability of the dredge to work all portions of the ground; hardness of bed rock; its receptivity for gold and adaptability for dredging; and, finally, the selection of a dredge best adapted to the conditions presented by the ground under consideration.

The Fortymile region comes well under the definition of remoteness. It is more unfortunate in this respect than the other mining regions in the Yukon-Tanana country. The length of the working season is limited to about four months. Most of the valleys are sufficiently timbered with spruce to have furnished up to the present time abundant fuel. The ground selected for dredging is in the valleys of the smaller tributaries of Fortymile Creek or along the bars of the creek itself. The deposits are such as have been worked by open cuts, and most of them are much under the maximum depths workable by the dredges already on the ground, 15 to 35 feet; some are even shallower than desirable. These deposits are of local origin, having been derived from the bed rock within the valleys, and are composed of gravels overlain by muck. They are, for the most part, frozen throughout the year. The gravels are composed of subangular or rounded fragments, up to a foot or more in diameter, and a large proportion of fine material, partly comminuted fragments of the same character as the coarser materials and partly products of decomposition. The proportion of bowlders is generally small, but at some localities it is so large as to become a troublesome factor. If it were not for the frozen character of the gravels, the conditions for dredging would be about as favorable as at some localities in the States. The overlying muck is removed by ground sluicing, and this process of stripping is one that requires a wide experience in the utilization of water to procure the best results. Although in some places the gold is found distributed through the lower part of the gravels, it is mostly on or within the bed rock. On some creeks there is a large proportion of nuggety gold. The greatest part of it, however, occurs as small flat pieces, and there is some very fine gold.

The bed rock in the Fortymile region is predominantly schist, with interbedded crystalline limestone and intrusive granitic rocks, either parallel to the structure or cutting it. Beds of more or less blocky material resistant to weathering are separated by softer material, and this characteristic gives rise in some places to an uneven bed-rock surface, the higher places of which may act as a hindrance to dredging. This emphasizes the need of a careful preliminary survey of the deposits and the underlying rock floor. Furthermore, the gold has a tendency to sink to a depth of several feet in the crevices and joint planes of the blocky bed rock.

Several plans have been under consideration for the utilization of the water supply in the Fortymile region, and during the summer of 1907 a dam was being constructed on Mosquito Fork near Kechumstuk for the purpose of bringing water by a ditch to the Chicken Creek area.

In the vicinity of Eagle mining operations were confined mainly to preparatory and assessment work. A dam with automatic gate was being constructed on American Creek. The new Government road is already proving of advantage to this locality. Work in the Seventymile area is also being helped by the construction of a road over the divide from Excelsior to Seventymile Creek.

PRODUCTION.

The largest part of the production of the Fortymile district is taken out of Alaska by way of Fortymile Creek. The following table has been prepared from records furnished to the Survey by the office of the United States customs service at the subport of Fortymile, Alaska. It shows the distribution and amount of production for the years 1904 to 1907, inclusive. Quantities are expressed in fine ounces, the value of the fine ounce being approximately $20.67, whereas that of the commercial dust of the Fortymile district averages about $17 to the ounce.

Production of gold in Fortymile region, 1904–1907.

Creek.	1904.		1905.		1906.		1907.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
	Fine ounces.		*Fine ounces.*		*Fine ounces.*		*Fine ounces.*	
Chicken, Lost Chicken, Myers Fork, Stonehouse, and Ingle	6,819.74	$140,964	5,368.11	$110,959	4,269.32	$88,247	2,377.74	$49,147
Franklin	494.29	10,217	581.47	12,019	783.79	16,201	100.34	2,074
Wade	5,233.24	108,171	4,521.00	93,449	3,094.87	63,971	3,381.90	69,904
Walker Fork, Poker, and Davis	1,222.11	25,262	1,124.28	23,239	1,184.32	24,480	484.42	10,013
Squaw, Camp, Woods, and Canyon	156.27	3,230	103.62	2,142	63.32	1,309	123.36	2,550
Napoleon, Montana, Buckstein, Dome, Eagle, and Twin	51.00	1,054	46.06	952	13.11	272	11.51	238
Fortymile bars and commercial dust	886.60	18,326	637.40	13,175	437.54	9,044	266.47	5,508
	14,863.25	307,224	12,381.94	255,935	9,846.27	203,524	6,745.74	139,434

These statistics, together with incomplete data of production for 1907 from creeks in the vicinity of Eagle—about 400 fine ounces, or $8,245—indicate a total production for the year 1907 in the Fortymile district of approximately $150,000.

WATER SUPPLY OF THE FAIRBANKS DISTRICT, 1907.

By C. C. Covert.

INTRODUCTION.

During the season of 1907 the United States Geological Survey extended to the Fairbanks district the stream-gaging work started in the Nome region in 1906. The investigations were for the purpose of determining both the total flow and the distribution of flow during the open season, and of collecting data regarding the general conditions affecting the water supply and its development.

The success of any project for water-supply development is measured largely by the completeness of the information on which the engineer designs his work in accordance with the maximum efficiency of the available flow, and this efficiency can be determined with greater accuracy by the aid of long and continued records. It is for the purpose of procuring such records that the Survey has undertaken the study of stream flow in this district.

The field work in the Fairbanks district was carried on from June 20 to September 15. Owing to the lack of adequate funds the work was largely that of reconnaissance. However, the keeping of systematic records on some of the more important streams was made possible through the hearty cooperation of people interested. 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 good roads commission; Mr. A. D. Gassaway, general manager of the Chatanika Ditch Company; Mr. Falcon Joslin, president of the Tanana Mines Railroad Company; Mr. Herman Wobber, Fairbanks Creek; Mr. C. D. Hutchinson, electrical engineer, Tanana Electric Company; and Mr. Martin Harris, Chena.

After making a careful study of the general topographic conditions of the mining district and its surrounding country, it was decided to establish a few regular stations at the most convenient points in the larger drainage areas, and to study the daily run-off, during the open season, from records thus obtained. This plan afforded greater opportunity for procuring comparative data than would that of covering a larger territory in a less definite way. In this country without storage daily records are an important factor, and such records could not have been obtained over an extended area. Outside of the producing creeks the country is practically a wilderness, and it is almost impossible to get observations, other than those made on the occasional visits of the engineer. No daily or even weekly records could have been assured, and the results obtained from the occasional measurements would have furnished no comprehensive idea as to what the daily run-off of the streams really was throughout the open season.

MEASUREMENTS.

Discharge measurements were made at 45 different stations as listed below. The detailed results are published in Water-Supply Paper No. 218, from which the accompanying summaries are taken.

Gaging stations in Fairbanks district.

1. Little Chena River about 2 miles above Elliott Creek.
2. Elliott Creek above mouth of Sorrels Creek.
3. Sorrels Creek above mouth.
4. Fish Creek above Fairbanks Creek.
5. Bear Creek near mouth of Tecumseh Creek.
6. Fairbanks Creek.
7. Miller Creek near mouth.
8. Miller Creek below Heim Creek.
9. Miller Creek above Heim Creek.
10. Charity Creek 1 mile above mouth of Hope Creek.
11. Hope Creek near mouth of Zephyr Creek.
12. Faith Creek at weir near mouth.
13. McManus Creek above Montana Creek.
14. McManus Creek below Montana Creek.
15. McManus Creek 1 mile below Idaho Creek.
16. McManus Creek 500 feet above mouth of Smith Creek.
17. McManus Creek below mouth of Smith Creek.
18. McManus Creek at mouth.
19. Smith Creek below mouth of Pool Creek.
20. Smith Creek above mouth of Pool Creek.
21. Pool Creek above mouth.
22. McManus Creek at weir near mouth.
23. Chatanika River below Faith and McManus creeks.
24. Boston Creek at elevation 800 feet.
25. McKay Creek at elevation 800 feet.
26. Belle Creek at elevation 800 feet.
27. Crooked Creek near mouth.
28. Kokomo Creek near mouth.
29. Poker Creek near mouth.
30. Poker Creek near elevation 800 feet.
31. Little Poker Creek above mouth.
32. Caribou Creek above mouth of Little Poker Creek.
33. Chatanika River below mouth of Poker Creek.
34. Cleary Creek near Cleary.
35. Little Eldorado Creek above trail to Dome Creek.
36. Dome Creek near Dome.

37. Goldstream Creek between claims 6 and 7 "B."
38. Fox Creek near elevation 900 feet.
39. Beaver Creek above mouth of East Branch.
40. East Branch of Beaver Creek above mouth.
41. Nome Creek 1 mile above mouth.
42. Bryan Creek at elevation 1,800 feet.
43. Trail Creek about 4 miles above mouth.
44. Brigham Creek 1 mile above mouth.
45. Fossil Creek near mouth.

Tables 1 and 2 show the monthly discharge of the streams where the daily flow could be computed. Table 3 gives the minimum daily flow of these streams. Table 4 gives the mean weekly supply. Table 5 is a list of miscellaneous discharge measurements made on different streams. All these results are given in second-feet, which can be reduced to miner's inches of 1.5 cubic feet by multiplying by 40.

TABLE 1.—*Monthly discharge of streams in Little Chena River basin, 1907.*

LITTLE CHENA RIVER ABOVE ELLIOTT CREEK.

[Drainage area, 79 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
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

ELLIOTT CREEK NEAR MOUTH OF SORRELS CREEK.

[Drainage area, 13.8 square miles.]

July 22-31	9	2.5	5.9	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

SORRELS CREEK NEAR MOUTH.

[Drainage area, 21 square miles.]

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

FISH CREEK ABOVE FAIRBANKS CREEK.

[Drainage area, 39 square miles.]

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

TABLE 2.—*Monthly discharge of streams in Chatanika River basin, 1907.*

FAITH CREEK NEAR MOUTH.

[Drainage area, 51 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
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.]

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.]

July 17-31	90	54	67	0.508	0.29
August	186	73	117	.887	1.02
September	1,770	110	297	2.18	2.43
76 days	1,770	54	178	1.31	3.74

KOKOMO CREEK NEAR MOUTH.

[Drainage area, 26 square miles.]

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

CHATANIKA RIVER BELOW POKER CREEK.

[Drainage area, 456 square miles.]

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

GOLDSTREAM CREEK NEAR CLAIM 6 BELOW.

[Drainage area, 28.6 square miles.]

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.—*Minimum daily flow of streams in Fairbanks district, 1907.*

	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum run-off per square mile.	Duration of record.
	Feet.		*Sec.-feet.*	*Sq. miles.*	*Sec.-foot.*	
Little Chena River above Elliott Creek.	800	July 22-25, 29-31.	42	79	0.53	July 22-Sept. 10.
Elliott Creek above Sorrels	890	July 31	2.5	13.8	.18	Do.
Sorrels Creek above mouth	800	do	6	21	.28	Do.
Fish Creek above Fairbanks Creek.	925	July 30-31	18	39	.46	Do.
Faith Creek at mouth	1,400	July 10	19.2	51	.38	June 20.
McManus Creek at mouth	1,400	July 10-12	15	80	.19	Do.
Chatanika River below Faith Creek.	1,350	July 31	54	132	.41	July 17-Sept. 30.
Kokomo Creek near mouth	750	July 23, 30-31	7.9	26	.30	July 9-Aug. 14.
Chatanika River below Poker Creek.	700	July 4-7, 10	167	456	.36	June 20-Oct. 14.

TABLE 4.—*Mean weekly water supply, in second-feet, from Little Chena and Chatanika River basins, 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 Elliott 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	70	224	52	7	12	24	95
July 29-August 4	80	540	80	12	18	55	165
August 5-11	128	516	110	12	24	42	188
August 12-18	82	313	73	10	16	26	125
August 19-25	104	260	56	6	10	24	96
August 26-September 1	169	413	90	11	18	26	145
September 2-8	120	324	82	9	15	26	132
September 9-15	513	1,360					
September 16-22	376	1,480					
September 23-29	216	737					
September 30-October 6		655					
October 7-13		415					
Mean	143	504	78	10	16	32	136
Maximum	513	1,480	110	12	24	55	188
Minimum	36	190	52	6	10	24	95

TABLE 5.—*Miscellaneous measurements in Fairbanks district, 1907.*

LITTLE CHENA RIVER DRAINAGE BASIN.

Date.	Stream.	Locality.	Discharge.
			Sec.-ft.
July 20	Bear Creek	Near Tecumseh	8.4
August 22	do	do	7.0
June 24	Fairbanks Creek	Elevation 1,300 feet	1.4
Do	do	Elevation 1,250 feet	2.2
July 5	do	Elevation 1,375 feet	.72
July 20	do	Elevation 1,400 feet	1.3
July 6	Miller Creek	Near mouth	7.00
July 24	do	do	7.6
August 20	do	do	8.0
August 6	do	Below mouth of Heim Creek	8.0
August 7	do	do	8.0
Do	do	Above mouth of Heim Creek	4.9

CHATANIKA RIVER DRAINAGE BASIN.

July 11	Hope Creek	Near mouth of Zephyr Creek	7.7
Do	Charity Creek	1 mile above mouth of Hope Creek	5.7
July 10	McManus Creek	At mouth	15.6
Do	do	do	16.4
July 12	do	Above Smith Creek	10.2
Do	Smith Creek	Near mouth	7.8
Do	McManus Creek	do	15.6
July 13	do	¾ mile above Montana Creek	1.8
Do	do	Below Montana Creek	3.8
Do	do	1½ miles below Idaho Creek	6.5
Do	do	½ mile above mouth	[a] 21.4
July 14	do	500 feet above Smith Creek	12.4
Do	Smith Creek	Near mouth	8.7
Do	do	Above Pool Creek	5.4
Do	Pool Creek	Above mouth	2.4
Do	McManus Creek	do	[a] 19.4
August 15	Boston Creek	Elevation 800 feet	3.9
Do	McKay Creek	do	3.7
Do	Belle Creek	do	10.0
Do	Crooked Creek	Near mouth	6.3
July 27	Poker Creek	½ mile above mouth	22.3
July 30	do	do	22.6
August 9	do	do	36.6
August 10	do	do	37.8
Do	Caribou Creek	Above Little Poker Creek	10.4
Do	Little Poker Creek	Near mouth	3.9
Do	Poker Creek	1 mile above Caribou Creek	21.1
July 4	Cleary Creek	Near Cleary	2.9
June 26	Little Eldorado Creek	Above trail to Dome Creek	.45
June 27	Dome Creek	Near Dome	.84
July 6	Fox Creek	Elevation 900 feet	2.0

BEAVER CREEK DRAINAGE BASIN.

August 27	Trail Creek	Approximate elevation, 1,700 feet	39.9
Do	Brigham Creek	Approximate elevation, 1,500 feet	16
August 28	Fossil Creek	Approximate elevation, 1,300 feet	19.2
August 29	Bryan Creek	Approximate elevation, 1,800 feet	75.3
August 30	Beaver Creek above East Branch.	do	267
Do	East Branch of Beaver Creek above mouth.	do	124
Do	Nome Creek near mouth.	Approximate elevation, 1,700 feet	135

[a] Measurement approximate.

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.

The results of the observations taken at these stations, together with records kept at Fairbanks in 1906 and 1907, are as follows:

Monthly precipitation in inches at stations in Fairbanks district, 1906–7.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1906.													
Fairbanks [a]	1.75	0.37	0.33	0.10	0.36	1.05	2.82	1.50	0.25	0.30	0.65	1.15	10.63
	17.5	3.7	3.3	1.0	------	------	------	------	------	1.6	6.5	11.5	45.1
1907.													
Fairbanks [a]	3.3	.86	2.42	.03	.35	1.47	1.51	1.81	3.58	2.44	------	------	------
	33.0	8.6	24.2	.30	------	------	------	------	------	24.4	------	------	------
Summit Road-house	------	------	------	------	------	------	2.71	3.27	------	------	------	------	------
Cleary	------	------	------	------	------	.84	2.55	2.88	3.82	------	------	------	------
Poker Creek [a]	------	------	------	------	------	------	------	1.40	3.70	1.70	.25	------	------
	------	------	------	------	------	------	------	------	------	24.0	3.3	------	------
Faith Creek	------	------	------	------	------	------	1.87	3.00	2.97	------	------	------	------

[a] Rainfall or melted snow is given in the first line; snowfall in the second line.

HYDRAULIC DEVELOPMENTS.

In the Fairbanks district little work has been done as yet toward constructing ditch lines from larger drainage areas for additional water supply. Mining has been carried on entirely by means of the meager supply from individual creeks. The camp is rapidly approaching a stage of development that demands a greater water supply than these creeks can furnish.

In general, the relation of the mining camps to the surrounding country is not favorable to an outside water supply by gravity. The topography of the country is such that ditch lines from the larger drainage areas are not altogether practical. The camp lies in three drainage basins, or valleys, separated by high dividing ridges, and in order to supply the producing creeks in one valley with the water by ditch line from another the ditch must have a high elevation, which throws its intake so far into the headwaters that there is only a small drainage area from which to draw the supply and consequently but little water. The records kept during the season of 1907 prove conclusively that had the high-line ditch which the Chatanika Ditch Company proposed to build from the upper Chatanika basin to the mining camp been built, instead of a daily supply of 125 second-feet, as was estimated, it would have had less than half that amount during the greater part of the open season.

However, investigations are under way which may overcome these difficulties. It is proposed to construct, from the mouth of Faith Creek to the mining camp, a ditch which will supply water to the producing creeks directly tributary to Chatanika River. A project is also under way to develop electric power for transmission to the mining camp by using the waters of Little Chena River. This project will also supply water to Smallwood, Nugget, and other creeks in the vicinity.

The development of water power for electric transmission in the Fairbanks district seems worthy of consideration. This method of utilizing the water supply would dispense with many miles of ditch construction and would not only furnish the camp 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 the dredge.

INVESTIGATIONS OF THE MINERAL DEPOSITS OF SEWARD PENINSULA.[a]

By Philip S. Smith.

INTRODUCTION.

It is intended in this paper to summarize the results of the geologic investigations which have been carried on in Seward Peninsula since the close of 1906. As an account of the earlier developments has been given in former progress reports,[b] a repetition of the facts there set forth is unnecessary and undesirable.

PRODUCTION.

In Seward Peninsula the past year has been marked by increased activity in prospecting for both placers and lodes, but so far no strikes of rich bonanzas such as characterized the winter of 1905–6 have been made. An estimate, compiled from various sources, of the amount of gold produced by the entire peninsula for the year 1907 shows the value of the output to be about $6,750,000. The production of gold in Seward Peninsula from 1897, the first year in which any notable amount of gold was won, down to the present time is shown in fig. 3. It will be noticed that in 1907 the production showed a decrease of about $750,000 over that of the preceding year. The high total in 1906 was due to the discovery and development of the phenomenally rich placers of the ancient beach about 3 miles north of Nome. Although extensions of this beach have been uncovered during the last year, nowhere else has the beach proved as

[a] In collecting data for many portions of this report the writer was assisted by G. I. Finlay and Frank J. Katz during the field season of 1907.

[b] 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; The Nome region: Bull. No. 314, 1907, pp. 126–144. Smith, P. S., Gold fields of Solomon and Niukluk River basins: Bull. No. 314, 1907, pp. 146–156; Geology and mineral resources of Iron Creek: Bull. No. 314, 1907, pp. 157–163. Brooks, A. H., The Kougarok region: Bull. No. 314, 1907, pp. 164–179.

rich as in the portion first discovered, between Snake and Nome rivers. But, as the mining of placers goes on with much rapidity, the explored ground on this portion of the beach has been more or less exhausted. As an instance of this may be cited the richest of all the third-beach mines, which early in the summer finished hoisting the last of its gravel. Just as the modern beach was soon exhausted, so this more ancient one has yielded up its treasure for nearly 3 or 4 miles of its length. With the exhaustion of the present beach new placer fields of even greater value were discovered, but no such good fortune has followed the yearly depletion of the store of gold in the ancient beach. It is the normal history of a placer camp to undergo great fluctuations in production, so that the falling off in 1907 does not, in all probability, mark the decline of the Seward Peninsula camps.

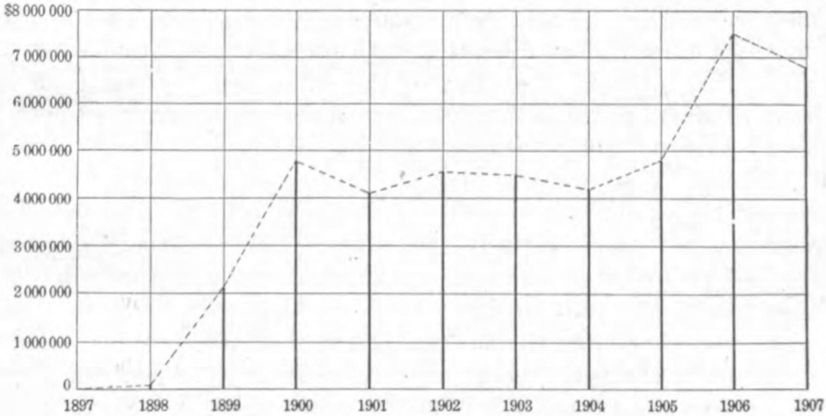


FIG. 3.—Gold production of Seward Peninsula, 1897–1907.

Although the decrease in gold is attributable mainly to the exhaustion of some of the rich bonanzas of the preceding year, there are several minor factors which may have also had some effect in reducing the output of the district. One of these minor causes was the labor trouble, which culminated in a strike during a portion of the winter of 1906–7. Previously it had been the custom to make winter wages one-half the summer rate, which is $5 a day and board. This scale was adopted because in the winter the country was oversupplied with labor. Such a condition is practically inevitable because in the winter all the shallow workings, which are active during the summer, of necessity are closed, only drift mines being operated. Thus the number of men who can be employed in the winter is only a small fraction of the number needed in summer. The surplus workmen must seek other regions, go prospecting on their own account, or accept the wages that are offered. The first two choices are not open to all, for they require a certain amount of capital and therefore many are compelled to accept the third. Under such conditions those needing labor can dictate the terms of employment.

During the winter of 1906–7, however, the men tried to force the adoption of a higher scale of wages, amounting to a raise of about 50 cents a day on the old winter rate, and, failing to have the demand recognized, quit work. This strike lasted in an acute stage for about a month. During this time the mine operators adopted one of two policies. The larger operators, anxious not to lose a day of valuable time from hoisting pay gravels, acceded to a raise in wages. Many of the smaller operators, who were either finishing up the last of their hoisting or whose lack of funds prevented their granting the higher scale, closed down. Personal communication with many of the smaller operators, however, led to the conclusion that the closing of their mines did not materially alter their production, but simply postponed their hoisting to a little later in the season and made them rush work a little more vigorously during the shorter time in which they had to operate. It is therefore the opinion of the writer that although the effect of the strike was depressing on the total production, the result was not so serious as many promoters would have the public believe.

Although it is conceded that the strike may have somewhat decreased the production of gold in 1907, it is believed that the effect may not have been entirely insalutary. This statement does not rest on the probable solution of the labor problem involved. The most beneficial result of the strike was that when several of the mines were closed and the laborers had to shift for themselves, many of the more energetic turned their attention to prospecting. Such prospecting must inevitably result in much good, for the future of Seward Peninsula depends not so much on the complete economical working out of the known deposits as on the systematic search for new fields and the extension of the known placer grounds.

Prospecting at the present time is much hampered in Seward Peninsula by the fact that nearly every available bit of ground has been staked. Even though the person desiring to locate knows that the annual assessment work has not been done, he is confident, from the bitter experience of many others, that successful location of pay gravel on the ground in question will inevitably lead to legal complications. For this reason prospecting by individuals is discouraged. The new law laying the burden of proof of assessment work on the holder if he does not record his work is variously viewed by different prospectors. There is, however, a feeling that a method of proving assessment work even more radical than by the word of witnesses is required to meet the best interests of prospectors.

CRITICISM OF POPULAR THEORIES.

Certain facts have been pointed out in previous reports which if heeded by prospectors would cause them to conduct their search with more promise of success than the hit-or-miss style so often adopted. Nevertheless there are numerous popular misconceptions which seem to have taken root in the minds of some inexperienced miners, and which are bound to have a retarding effect on the development of the district. The three most pronounced of these misconceptions are the theory that a second bed rock may be found below the first, the theory that the ledges are not wholly in place, and the theory that there is a uniformity of elevation of possible ancient beach lines in areas outside of the now partly explored Nome tundra.

ABSENCE OF MORE THAN ONE BED ROCK.

In regard to the first fallacy, it is necessary to understand clearly what is meant by the term bed rock. According to the loose usage prevalent among prospectors, bed rock is any layer of clay, sand, or other material on which gold is found. Such, however, is not the accepted scientific meaning of the term, by which bed rock is defined as the consolidated hard rock,[a] such, for instance, as the schist or limestone of Seward Peninsula. If used with this distinction it may be stated that there is no chance of finding a second bed rock below the first. It is evident, therefore, that drilling or exploration for placers beneath the hard schist bed rock is not advisable.

In making this statement the writer is well aware that certain peculiarities have been encountered which at first sight might suggest to the inexperienced that unconsolidated gravels do occur beneath the schist. One such peculiarity is afforded by the Golden Gate well at Nome, in which schist nearly 100 feet thick was encountered at a depth of 40 feet, and below it quicksand was struck. Various explanations have been suggested to account for this occurrence. Somewhat similar conditions were observed at the Daisy mine, near Nome. At this place a hole (A, fig. 4) was sunk 22 feet to what was supposed to be bed rock of schist, into which the hole penetrated for 8 feet. The hole was then abandoned and a new one started at B. In this hole pay was struck, and drifting on it traced the pay streak over in the direction of A. When the claim was carefully surveyed it was found that the drift from B was 67 feet below the bottom of hole A and directly under it. The explana-

[a] According to the Standard Dictionary, bed rock is "the solid rock underlying the looser material of the earth's surface."

tion of the section is suggested in fig. 4 by dotted lines. It is believed that the schist of hole A, which was thought to be bed rock, was merely a piece of slide and that the real bed rock was the schist encountered in hole B underlying the pay. The conclusion that the schist encountered in the first hole is not in place is unavoidable, for there is no known or conceivable process in nature which could produce a schist from gravels and not profoundly modify the underlying gravels as well. Schists are formed by one of two main processes, which may be summarized briefly as contact metamorphism and dynamic metamorphism. The first method of schist formation is due to contact with igneous rocks; but the blocks of schist found in the midst of gravels could not have been produced in this manner, for, as is well known to every miner, there are no igneous rocks cutting the gravels near the places where the schist blocks occur. In the production of schists by dynamic action the

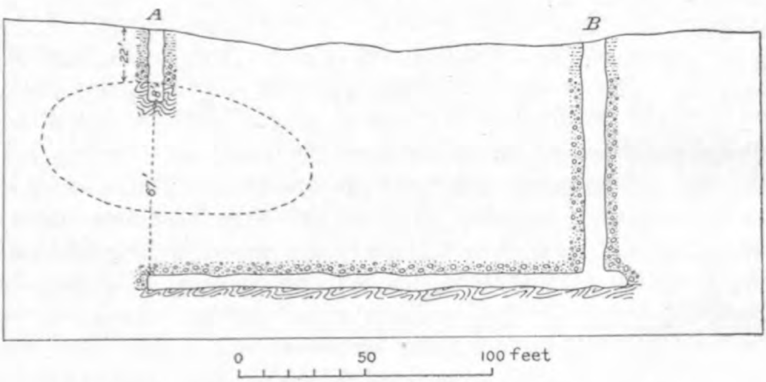


FIG. 4.—Diagrammatic cross section at the Daisy mine, near Nome.

mass of original material is moved and deformed. This process may take place deep under the surface as a result of the increased temperature produced by deep burial. But if such is the case the underlying gravels must have been subjected to just as much metamorphism as the layer which is supposed to have been changed into a schist. Another way in which schists may be formed by dynamic metamorphism is by the folding and deformation of rocks when subjected to mountain-building pressures. Such a process could not have affected this region after the underlying gravels were deposited, for the planes of original sedimentation, which are clearly visible in the gravels, have not been much disturbed.

It seems, therefore, that there is no reasonable way in which schist may be formed in the midst of a gravel deposit. It seems also evident that where the so-called "bed rock" is simply a stratum of clay or sand on which values may or may not be found, there is indisputably an underlying bed rock in place which may or may not have served as a surface on which placer gold has been concentrated. In this sense, therefore, pay horizons below the clay false bed rock, such as occur at the level of the old second beach, may be sought. There is absolutely no possibility of finding any gravel deposits beneath the bed rock, if this term is used in its technical sense, and exploration seeking to pierce this bed rock is inviting financial disaster.

LEDGES IN PLACE.

This brings us to the second popular fallacy already noted, that the ledges of the district are not in place. Without resorting to the verbal evasion possible, for the word ledge, according to all geologists, means "rock in place," it may be definitely stated that the rocks which outcrop here and there throughout the country are in place. Although the upper few feet of various outcrops are much riven by the frost, and although the normal downhill creep of material through gravitative action has caused a slight migration of material away from the actual outcrop, yet these processes have had so slight an effect on the region that their results are negligible.

The reason why the idea of the dislocated character of the ledges has taken root in the popular mind perhaps lies in the fact that apparently different kinds of rocks occur along the same line of strike. This condition is explained in two ways. In the first place, the most noticeable structure seen in the rocks—namely, cleavage—is not an original structure, but is secondary, and therefore does not indicate the true direction in which the rocks trend. It is consequently to be expected that on the strike of the cleavage different rocks should be encountered successively. The second explanation for the variety of rocks along the strike is that the region is very markedly deformed. This deformation consists both of folding and faulting. In papers now in preparation Moffit [a] describes some of the foldings observed in the Nome and Grand Central region, and the writer [b] notes instances of deformation in the Solomon and Casadepaga districts. In these papers it is shown that intense folding has taken place, coupled with faulting of both the normal and reversed types. The faulting seems to have occurred at two distinct periods, one probably coincident with the metamorphism of the district and another after the formation of the latest quartz veins. Because of these dislocations and crumplings of the crust the geology is very complex and the orderly sequence observed in less deformed regions is wanting.

It is impossible to evade the conclusion that the ledges are in reality in place. Although the geologic structure of Seward Peninsula is

[a] Moffit, F. H., Hess, F. L., and Smith, P. S., Geology of the Nome and Grand Central quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

[b] Smith, P. S., Geology of the Solomon and Casedepaga quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

much complicated by mountain-building deformation, there is nowhere in the district evidence that the blocks of this portion of the earth's crust have suffered any serious lateral movements since the beginning of the cycle of disintegration and decomposition which has resulted in the formation of the Seward Peninsula placers. Oscillations, it is true, have occurred and are occurring, but there has been no widespread landslide action since the recent gravels were accumulated. In fact, if the paleontologic evidence afforded by shells from the Nome tundra is accepted, there can be no reason for supposing any considerable movement to have taken place since Pliocene time.

In this connection it may be of importance to the prospectors for quartz to note that the region is considerably disturbed, so that in mining faults will be encountered which will add to the cost and difficulty of winning the ore. On the other hand, it is believed that the same kinds of rocks may be found in place beneath the cover of moss, slide, and vegetation as those from which the placer gold was derived. The discussion of quartz prospects and of the occurrence of veins from an economic standpoint, however, is given farther on in this paper.

ELEVATION OF ANCIENT BEACHES.

The third erroneous idea which has crept into popular fancy has reference to the places where prospecting for beach deposits may be carried on and especially to the elevation of these ancient beaches above sea level. The misconception has resulted from the fact that the known rich beach back of Nome has maintained a pretty constant elevation for a distance of 5 miles. It is therefore argued by many that the beach at Solomon or somewhere else ought to be sought for at this same elevation. Such a conclusion seems unjustifiable when the various incidents in the history of the beaches are considered. It is difficult to conceive how any process of uplift could have been absolutely uniform over any considerable distance, for the mechanical difficulties of lifting evenly a structure consisting of diverse units of different sizes and weights and balance would be practically insurmountable. Instead of supposing that every portion of the old beach must now be at precisely the same height above sea level, therefore, it is far more reasonable to imagine that only a few points would be at any given elevation and that the majority would be higher or lower. To pass to concrete examples of the present day, one has only to note the elevation shown at Cape York and Nome and the depressed character of the country near Port Clarence to see that all parts of the peninsula have not been affected in the same way at the same time.

To summarize, it is believed that when the third beach was formed at Nome there was a continuous beach around Seward Peninsula just as there is today; that in the intricate history which has taken place since the third beach at Nome was formed some portions of the peninsula have been uplifted higher than others; and, furthermore, that certain portions of the beach have been cut away entirely during the subsequent depression of the region, or that certain portions were preserved beneath the sea where the depression was rapid enough. In view of these facts, it is felt that only by the closest scrutiny of the surface features and of all the available physiographic evidence can the level of the third beach be predicted within reasonable limits.

Prospectors are fast learning that the mere presence of beach material is not sufficient ground for expecting pay, and that there are two essential conditions for forming rich beach deposits. These are (1) a large amount of land waste which has been sorted by wave and water action, so that concentration and reconcentration have been effective, and (2) proximity to mineralized areas from which the valuable metals of the placer may have been derived.

PLACER DEPOSITS.

INTRODUCTION.

The general tendency at the present time in placer work is to reduce the cost of operations by installing mechanical devices for handling the gravels. The miners of the Candle, Council, Kougarok, Nome, Solomon, and Bluff regions have taken advantage of the water resources to such an extent that but little additional water can be obtained, except at a prohibitive price. The conversion of water power into electric power is one of the possibilities of the future. Already on Solomon River a short ditch is in process of construction to furnish water power for generating electricity to run two dredges. A project for damming Salmon Lake and utilizing the head thus formed for the generation of electricity has been discussed for two years or more, but owing to legal complications nothing has been done on the actual construction.

NOME AND GRAND CENTRAL REGIONS.

BEACHES.

As a result of extensive prospecting, it has been found that there is considerable beach wash north of Cape Nome; but it has also been shown that pay gravels are practically wanting. If this is a fact, and there is every reason to believe that it is, the beaches of the more recent past must have looped from the seaward face of the cape; and probably the headland of Cape Nome was a portion of the mainland, at the time of the formation of the third beach, rather than an island. During the last year several paying properties have been located in the neighborhood of Cunningham Creek, and as the height of the pay above sea level is approximately that of the well-known third beach farther west, they are supposed to mark the eastern continuation of that beach. If this is the case, the beach makes a marked swing to the southeast from the point where it reaches the surface on McDonald Creek. This extension of the beach, although rich, is not nearly as rich as the portion earlier discovered between Nome and Snake rivers. Perhaps one reason for this decrease in gold content is that much of the waste of which the beach is formed is derived from the granitic mass of Cape Nome. It has previously been stated that in the Nome-Snake river portion the waste has been derived largely from a region contiguous to a limestone-schist contact. Such is not the case to the east. This relation may be only fortuitous, but it gives a suggestion which may be worth consideration.

The thickness of the overburden along the beach east of Nome River is variable, but is generally in the neighborhood of 100 to 120 feet. This requires a considerable plant, but the difficulties in the way of transportation are not very great. The gold from this portion of the beach seems to be of the same character and appearance as that obtained farther west. In some places it occurs on a false bed rock. The gravels are coarser than those from the third beach between Holyoke and Bourbon creeks, as would be expected if a large part of the waste had been derived from the Cape Nome headland. The larger amount of garnets in the gravels is due to the derivation of the material from the granites and from the large bodies of greenstone which predominate in the Osborn and St. Michael creek country. This beach is probably cut out by the valley of Hastings Creek and the rich placers of the lower portion of this stream may be due to partial reconcentration from the former beach.

West of Snake River the third beach is believed to have been located in the vicinity of Sunset Creek, and considerable gold has been won from this place during the last year. No new features were brought out in this locality beyond the continuation of the old beach to a region in which its presence has been for some time suspected. The western continuation shows that the beach must have extended at one time across Snake River and was subsequently cut through by that stream as it wore down its valley. The gold in this portion of the beach was scattered to some extent by the stream, as it re-sorted the older beach gravels. The rich spots, however, in the lower portion of Snake River, doubtless acquired their original concentration at the time when the Snake River valley was filled with gravels on which the sea was working.

There are some who believe that another beach has been located inland from the third beach, but it has not been possible for the

Survey party to go into the question in sufficient detail to make a statement. It is known, however, that beach material is found at a higher elevation than that of the third beach, so that it is not at all improbable that the sea has stood at a relatively higher level at a time geologically not very remote. This is demonstrated by the fact that marine gravels cover the pay gravels of the third beach.

Work on the third beach has gone on with as much vigor as formerly. Probably half of the entire production from the Nome district comes from this beach. A railroad runs nearly the entire length of the beach, from Sunset Creek to McDonald Creek, so that supplies may be easily transported. A few new pieces of ground have been opened up, but in the main it is evident that the earlier-discovered portion of the beach is nearing exhaustion.

On the second beach but little work has been done during the last year. Between the second and third beaches, however, another beach has been discovered, and this is locally known as the "intermediate" beach. Several large hoisting plants have been erected to handle the gravel. A peculiar thing about this beach, if statements made by presumably reliable men may be trusted, is that it occurs at an elevation of 22 feet above the sea. Such a height would make it lower than the second beach, which lies seaward of it. It would indicate, therefore, a depression of the land subsequent to the formation of the intermediate beach, whereby new deposits were laid down. A rapid uplift must then have occurred, so that the sea took a stand seaward of the second beach, and renewed its attack on the coast.

It was reported that in one of the mines on the intermediate beach a bar had been found which showed the layers of sand and gravel dipping off in both directions—toward and away from the sea. Although this property was examined with considerable care, no evidence to substantiate the report was observed. The facts indicated changeable conditions, but nothing which could be rightfully interpreted as an offshore bar. At this place the bed rock consists of black, graphitic, somewhat quartzitic schist breaking into small rectangular blocks. The pay gravel is made up of but poorly rounded black schist fragments mixed with a good deal of mud. The gravels are very dirty. Above, in the south end of the drift, there is a sand layer which rises very steeply toward the north. In the north end there is a thin layer of muck between the pay gravels and an overlying bed made up of large bowlders. The bowlders are well rounded and some of them are 2 feet in length.

The presence of layers of muck and vegetation in the midst of gravel and slide has been noted in many other places. Thus on the bench west of the middle portion of Dry Creek a drill hole showed the following section:

Section of drill hole west of Dry Creek.

	Feet.
Tundra vegetation and muck	4–5
Subangular fragmental material	30
Tundra vegetation and peat	4
Subangular fragmental material	50
Gravels and creek wash.	

The same thing is also seen on Otter Creek south of the rise in the bed rock.

On the intermediate beach near Center Creek a number of shells have been found. Some are intact, but many of them have been broken into small bits. From their resemblance to certain living forms, it has been suggested by Dall that they lived in water not colder than that on the southern side of the Aleutian Islands at the present day. This gives an interesting insight into the temperature conditions which prevailed while a portion of the coastal-plain gravels of this part of the Nome region were being formed, and serves as a valuable check on the imaginings of those who account for the gold of the tundra as the product of glaciation.

STREAM AND BENCH PLACERS.

The placers that occur in portions of the district outside the coastal-plain province have produced during the last year probably less than one-third of the gold that has been won from the Nome and Grand Central regions. Although forming such minor contributors, these placers, which do not owe their gold concentration to marine action, have yielded during 1907 considerably over a million dollars. The output from this source is obtained from a great number of streams, but the greater proportion comes from Dexter Hill and its environs. During the last year much gold has been recovered from Glacier Creek and its tributaries, from Anvil Creek, especially in its headwater portions, from the upper portions of Dexter Creek and its tributaries, and from the upper branches of Dry Creek.

A region which has sprung into some prominence during the last year, although it has been a producer for a long time, is the Buster Creek country. The completion of a ditch into Buster Creek has given water power under a sufficient head to permit profitable handling of the gravels. During the season of 1907 four outfits have been at work on this creek.

COUNCIL DISTRICT.

The Council district is second only to the Nome-Grand Central region in its gold production. Ophir Creek is the principal center of mining, and on the main stream thirteen different outfits have been at work during the past season. The methods used on the creek are varied. Four properties are being worked by means of hydraulic elevators; two by dredges; two by scrapers, one using both horse and steam scrapers and the other only horse scrapers; one by a steam shovel; one by a derrick and cars; and three by shoveling into boxes.

On the lower portion of Dutch Creek, a tributary of Ophir Creek, one group of claims is being worked by hand labor. None of the tributaries of Ophir Creek above Dutch Creek as far as Crooked Creek are being developed. On Crooked Creek, however, three outfits have been at work during the last season. The gravels are shoveled by hand into the boxes. On Albion Gulch, a tributary of Crooked Creek, two mining camps have been established. One of these is particularly interesting as it is the only hillside placer so far reported in Seward Peninsula. At this place there is a good head of water and the deposit is worked by hydraulicking. The other property is developed by ordinary hand methods.

Near the mouth of Melsing Creek a new steam scraping plant has been recently installed. At least a month was spent in getting the equipment into running order, so that an important part of the season was lost. It is hoped that another year will see the plant operating full time and yielding satisfactory returns. Between the scraper and the mouth of Basin Creek two outfits have been shoveling into boxes. Three or four men have been employed at each place, but no extensive work has been accomplished. At the mouth of Basin Creek a claim is being worked by horse scrapers. The pay gravels are practically at the level of the creek, so there is some trouble in handling the seepage water. Above Basin Creek no prospecting or mining has been done on Melsing Creek or any of its tributaries.

On the tributaries of the Niukluk below Council only a little desultory work has been done during 1907. Above Council two claims have been worked on the central portion of Warm Creek, the gold being won in both by shoveling into sluice boxes. Near Camp Creek some hydraulicking has been done, but the returns from the property are not available. At the mouth of Elkhorn Creek some work was in progress during the earlier part of the season, but later the party removed to Ophir Creek.

The most interesting exploration work that has been done in the vicinity of Council was the testing of the Niukluk flat gravels by drill holes. Near Council there are numerous exposures of bed rock along the river, and in many places ledges came so near the surface that it was originally believed that the gravels which formed the broad flats southwest of the river were only a thin veneer. During the last summer, however, explorations carried on between Fox and Bear creeks, 2 or 3 miles from the Niukluk have shown gravels 250 feet thick in places. Such a depth would carry the bottom of the hole 50 or 60 feet below sea level. It is not believed that this low area was formed by marine erosion, as the narrowness of the cut in bed rock suggests stream work rather than ocean work. As has been pointed out, bed rock outcrops above the level of the Niukluk at Council and also above the level of Fox River at the point where the road from Council to East Fork approaches that stream; yet between these two points the bed rock is at least 200 feet lower.

Local downwarp seems inadequate to explain this feature, for it would be expected that some indications of the depression would appear in the surface forms, if warping took place after the overlying gravels had been deposited. Such surface indications are wanting. It seems more probable, from the slight evidence at our command, that the region is a stream valley and that the low areas revealed by drilling probably mark an old channel. Subsequent to the formation of the channel depression took place, whereby filling of the more ancient valley was effected. At the close of this stage the land probably stood at a lower elevation than it does at present and the surface of the flat, southwest of Council, was the flood plain of the old Niukluk River. A later episode, marked by the physiography of the region, was a slight uplift whereby the rivers were allowed to incise their courses 20 to 40 feet below the old flood plain. The duration of the different stages is of importance, for if the channel which has been disclosed by the drill hole was made in a short time the distribution of the gold and the width of the profitable ground would be different from those features produced in a region which had been stable for a long time. The facts known are still too meager to permit final interpretation, but the occurrence of bed rock so near the surface in certain places in the flat suggests a canyon character for the old valley rather than a more mature form.

Further light on this question is afforded by the record of a shaft 102 feet deep which was sunk near Mystery Creek about halfway between its junction with the Niukluk and the point where it leaves the hills. A short distance above this shaft bed rock is practically at the surface in the creek, being covered only by a thin mantle of gravels, not more than 4 feet deep. The gravels cut by the shaft were but slightly waterworn, and yet small shells in a perfect state of preservation were found. Unfortunately the shells were not kept and it is not known whether they were fresh-water or marine forms.

It is evident that from the very fragmentary facts now known about this region it is unsafe and unwarranted to draw far-reaching conclusions, yet a setting forth of the known conditions and surmises may be of assistance in solving some of the problems. Residents in the district, knowing the fabulous riches of the beaches at Nome, are anxious to prove marine occupation of the Niukluk flats. The whole question, however, is one which depends not on salt water or fresh water, but on the work accomplished. No matter what the water was that occupied the area—river, estuary, lake, or bay—if no concentration of the gravels occurred, no gold placers could be formed.

From the topography of the country surrounding the flats it has seemed that the possible connection with the ocean would be so narrow that water sorting would be reduced to a minimum. To consider a concrete example, let us take the shaft near Mystery Creek. This shaft must have reached within 25 or 50 feet of sea level; in other words, if the popular idea that the flats near Council were occupied by the sea is correct, the region could not have been depressed more than 25 or 50 feet below its present position. Suppose all the unconsolidated superficial material which now forms the flats of the Niukluk Basin were removed and the region sunk 50 feet; it must be evident that the connection of this basin with the ocean south of Steamboat Creek would be so narrow that the conditions would be similar to those at Imuruk Basin. Anyone familiar with that basin knows that although it is an arm of the sea and its water is salt, no considerable beach concentration is taking place.

SOLOMON AND CASADEPAGA REGIONS.

BEACHES.

Prospectors aware of the similarity between the coastal plains at Nome and Solomon have begun to turn their attention to the latter district, and already scores of holes have been sunk to explore the tundra gravels. Up to the close of the summer of 1907, although beach material was encountered in many places, no pay had been located. The facts gleaned from the Nome tundra have been so driven into the minds of prospectors that they are inclined to give too wide application to the details. As has been mentioned in a previous paragraph, the hope of finding pay beaches at the same elevation throughout Seward Peninsula is fallacious.

The greatest amount of exploration has been carried on west of Spruce Creek, and during the last year over a dozen parties have been engaged in the search. A few sections may be of interest as showing the different kinds of material encountered in shafts 2 miles inland from the shore, just west of Spruce Creek. Of these shafts the second is 100 yards south of the first, the third 100 yards south of the second, and the fourth 75 yards southeast of the third.

Sections of shafts west of Spruce Creek.

1.

	Depth.	Thickness.
	Feet.	*Feet.*
Blue clay with large amount of ice	15	15
Slide rock consisting mainly of chlorite schist	30	15
Clean river sands, becoming coarser toward bottom	48	18
Yellow and red gravels	50	2
Fine dark sand	54	4
Black clay with some slide	58	4
Fine light-colored sand	62	4
Black peaty material containing some fragments of wood which look like spruce	64	2
Fine sand and black mud	67	3
Black clay containing well-rounded pebbles 1 inch in diameter	70	3
Fine iron-stained beach sand with schist and black quartz pebbles	73	3
Bed rock; black schist.		

2.

Blue clay with much ice	8	8
Reddish, fairly rounded gravels like the material between 30 and 48 feet, hole 1	20	12
Alternate layers of black mud and beach sand, not very gritty	40	20
Light-colored yellowish sand	41½	1½
Decomposed peaty material with some wood fragments	42	½
Black sand, mud, and quartz pebbles	50	8
Schist bed rock.		

3.

Blue clay with much ice	8	8
Slide with some water-made pebbles	20	12
Black, dirty, fine-grained sand	26	6
Clay with some reddish-yellow gravels	29	3
Light-colored beach sand	32	3
Black peaty material with some quartz pebbles	35	3
Gravels of black angular schist with some well-rounded quartz pebbles	43	8
Bed rock: black schist.		

4.

Blue clay with much ice	8	8
Black, somewhat angular fragments with some well-rounded pebbles	23½	15½
Yellowish sand with very fine small pebbles; looks like sea sand	27½	4
Decomposed peaty material with strong, offensive odor	30½	3
Black, dirty wash with some very well rounded beach pebbles. One of the pebbles was 8 inches in longest dimension	38½	8
Bed rock; black schist with some limy layers.		

The most interesting features brought out by a study of the foregoing sections are the thickness of the gravels and the presence of certain comparable beds. There is a marked seaward thinning of the deposits; thus in the first section the depth to bed rock is 73 feet, whereas in the last it is only 38½ feet. Not only is this true of the section as a whole, but also of some of the individual layers; for example, the blue clay and ice, which is 15 feet thick in the first section, is only 8 feet thick in the last. Certain members, however, show no constant variation in thickness.

One of the most marked beds, which seems to be rather constant throughout the area explored by the four shafts, is the layer of black peaty material. This bed occurs pretty constantly at an elevation of

10 feet above bed rock, and although there is some variation in thickness, the average is between 2 and 3 feet. It is uncertain what origin is to be assigned to this layer of vegetation. It may represent a land surface which has been submerged or it may be the accumulation of mud and marsh vegetation in a salt-water lagoon. The presence of spruce fragments is not conclusive, for logs may have been washed into ancient lagoons just as they are into those of the present day, or, on the other hand, the spruce may have grown on land near the point where the fragments are found. A careful study of the vegetable remains might shed much light on this point. Although no definite conclusion has been reached, it is tentatively suggested that the theory of tidal-marsh origin has many points in its favor.

CREEK AND BENCH PLACERS.

The Solomon and Casadepaga region produced a small percentage of the total placer output of Seward Peninsula for 1907. The greater part has been taken from Solomon River and its tributaries, only a small portion coming from the Casadepaga drainage. At the dredge near Oro Fino work has gone on even more actively than formerly, and even when almost all other work in the district had ceased owing to the cold, it was able to continue production. The lengthening of the season by even a day or two means a considerable increase in profit. The main new development at the dredge was a project for the generation of electricity by water power. This project was commenced only in the latter part of the season, but it is hoped that another year will see the entire plant run by electricity. The owners report that during the last year a large amount of a heavy iron mineral has been caught in the boxes which adds considerably to the work of cleaning up. This material on examination proved to be magnetic iron oxide, or magnetite. Much of it is in pieces an inch or so in length. No locality from which magnetite of such size could be derived is known in the area drained by Solomon River. The theoretical consideration of these fragments might have important practical value in giving an insight into the way in which the gravels were accumulated.

On Shovel Creek much work has been in progress during the season of 1907 as far as the mouth of Mystery Creek. In this area some technical problems have received a novel treatment, but no important scientific facts have been gleaned. Four or five parties have been at work on Mystery Creek below Problem Gulch. A new ditch line from Bonanza and California creeks which is nearing completion will soon reach this area, so that a more abundant water supply at a considerable elevation will be available. Above Mystery Creek no mining has been done on the main stream. On West Creek seven or eight parties have been mining the creek and low bench gravels. The most productive work, however, has been near the mouth of the creek. At this place a bucket dredge running on a track has been working double shift a large part of the summer. The section of the gravels shows a thickness of about 6 feet. The upper portion is rather fine creek wash consisting mainly of schist fragments. The lower part is as a rule coarser, and though many of the fragments are well rounded by water, numerous large, angular blocks 2 or 3 feet long are encountered. On Kasson Creek a continuation of earlier work has been in progress near the mouth of the stream. The limestone bed rock of this portion of the stream is much fissured, and this condition, added to the entire disappearance of the water, makes the winning of the gold a difficult problem.

Above Shovel Creek on Solomon River two outfits have been at work near the mouth of Penny Creek, but on Penny Creek itself little work has been done except at the junction with Minnesota Creek. One prospector has been located on the very summit of the saddle between Minnesota and Kasson creeks. Above Penny Creek the next group of mining operations have been on the Solomon River benches near the mouth of Quartz Creek. Between this place and Big Hurrah Creek some mining was in progress during the middle of the season, but work here began late and closed early. On Big Hurrah Creek mining was carried on most actively near the mouth, but work extended all the way up to Tributary Creek. Above that point, however, no productive work was accomplished. The elevators at the mouth of this creek did not commence work until late in July, and owing to the short season the production was relatively small.

Between Big Hurrah Creek and East Fork a little work has been done on some of the small side streams from the east and also just below East Fork. On East Fork and its tributaries no mining has been done during the last year. Above East Fork, near the mouth of Jones Creek, an elevator has been in successful operation. Near Winnebago Creek horse scrapers have been in use. On Butte Creek there has been a little mining, especially on South Fork. At this place the geology is very complex. A heavy white limestone which forms the divide between Winnebago Creek and South Fork is folded down so that for a considerable distance above the productive ground the stream runs practically on the contact between it and the underlying chloritic schist. Some quartz has been observed apparently filling nearly vertical gash veins near the contact, but these veins show no evidence of metallic mineralization.

Near the mouths of Johns and Coal creeks on the Solomon River flood plain some mining has been carried on recently, but on a small scale. On Coal Creek and its tributaries no mining has been done except on Fox Creek. Here, however, only one man has been at work, so the returns were small. The pay gravels were located upstream from the limestone which occupies the middle part of the creek's course. Between Coal Creek and the head of Solomon River work during the last year has been mainly of the assessment type, and the production is consequently negligible.

In the Casadepaga drainage area but little real mining work has been done recently. A mile or so above the mouth of Bonanza Creek, on the main river, one man has been mining gravels a few feet above the water. Most of the gold is coarse, but the returns are not adequate. On Dawson Creek, near the mouth, are some bench gravels which have been mined off and on during the summer. On Big Four Creek, about three-fourths of a mile above its mouth, one man has been doing a little work on the stream gravels. Difficulty has been experienced at this place on account of the depth of the gravels and the impossibility of taking care of the seepage water. No other work has been done on Big Four Creek, although in previous years several outfits have been located on the main stream and its tributaries. The region would appear favorable for further prospecting, as the complex deformation and dislocation that the rocks have undergone would undoubtedly allow easy passage for mineralizing solutions. Also, if there is truth in the idea that the contact between the heavy limestones and the schists is a zone of mineralization, there are, particularly in the Birch Creek country, many places where this contact can be followed for long distances. Not only does heavy limestone appear here, but also the continuation of the black, graphitic, quartzitic slate belt which has been described as present in the vicinity of the Big Hurrah mine.

Between Big Four and Penelope creeks three or four small outfits have been mining some of the low bench gravels of the main stream, but the production from this source is small. On Penelope Creek some active work has been in progress and the season has been satisfactory. Mining on this stream has centered on a group of claims about a mile above the mouth. At this place, to the west of the stream, a shaft has been sunk for 93 feet through creek wash and gravels. The low channel thus disclosed would seem to mark the deeper valley of Penelope Creek, which conformed with the previous deeper valley of the Casadepaga. The bed rock of this creek is almost exclusively schist.

Nearly opposite Penelope Creek Goose Creek joins the Casadepaga. An interesting experiment in the utilization of water power for scrapers is in progress on claims near the lower part of this creek. As this system undoubtedly furnishes power at a low cost its introduction may follow in other districts. The gradient of the stream is, however, so low that the tailings must be rehandled. The gold is mostly fine and much worn. At present the creek gravels only are being worked, but some of the lower benches which have been examined yield fair prospects. Work is going on at but one other camp on Goose Creek, located 4 or 5 miles above the mouth of the stream. Only a small crew has been employed. On Quartz Creek, the largest tributary of Goose Creek, a party has been at work about half a mile above the mouth. Here the bed rock is schist, but upstream a belt of limestone, rather flat lying, occupies the creek bed for nearly half a mile. Much of the gold is rather coarse, some pieces worth from $5 to $8 being found. The depth to bed rock changes rather abruptly; in some places it is only 3 feet below the surface, but in others it is 10 feet. At the place where bed rock lies nearest to the surface, no gravels intervene between it and the muck and vegetation, but where the bed rock is deeper there is a considerable body of gravel. It is stated, however, that the gold values are just as good on the higher bed rock as on the deeper. The gold has penetrated far into bed rock along the crannies and fissures, so that in many places it is necessary to take up 2 feet of the rock in order to win the pay. Some work has also been done on the first tributary of Quartz Creek from the east. The course of this creek has been largely determined by the contact between a heavy limestone and chloritic schist. There are many limestone caverns here which make the economical washing of the gravels a serious problem. The gold from the side stream is coarse and fairly sharp, and fragments of quartz are attached to many of the nuggets.

The next upstream tributary of the Casadepaga on which mining work has been done is Canyon Creek. The present stream flows in a comparatively recent valley incised 10 feet or so in older creek gravels. Practically no values are carried by the modern gravels. The best pay occurs in the benches, especially those north of the stream. These gravels are rusty and overlain directly by the muck and vegetation of the tundra. The bench gravels seem to be more thoroughly rounded than those of the present creek. The gold is bright and not much worn and on the whole medium coarse. The bulk of the gold is in flat pieces, from a fraction of a cent up to 50 cents in value. Nuggets worth up to $2 have been found, but they are rather uncommon. Some of the large pieces show quartz attached to the gold. The bed rock throughout the productive portion of the creek is almost exclusively chloritic schist. In the schist are numerous quartz veins, which probably belong to the earlier series. Work on the group of claims has been carried on by pick and shovel methods, but late in the season a hydraulic elevator was installed, and it is hoped that another season will record large returns from these properties.

On Banner Creek, a tributary of the Casadepaga from the east above Canyon Creek, some mining has been in progress about a mile above its mouth. This portion of the stream flows over the contact between a limestone and a schist. The placer is a creek placer. Only two men have been employed and they have worked but a portion of the season. On Lower Willow Creek several camps have been established, but not much production is to be credited to this creek. Besides two or three creek claims 3 to 4 miles above the mouth some work has also been done on the benches, which are most notably developed north of the stream. No work has been done on the upper portion of Lower Willow Creek.

At the junction of Ruby Creek and the Casadepaga a party of four have been hydraulicking the gravels with water brought by a ditch from the upper part of Ruby Creek. The gold at this place is almost entirely bright gold. This is the usual character of the Casadepaga gold because of the revival of dissection by uplift. The uplift has, as a rule, affected the smaller side streams less, and consequently much of the gold they carry is rusty. This is believed to be the real reason for the difference between the Ruby Creek and Casadepaga gold, instead of the one suggested by many prospectors, that they are two different "runs." Although remnants of previous mining may be noted throughout the length of Ruby Creek, the gold output for the last season has been derived entirely from the lower two claims. No mining has been done on the Casadepaga above Ruby Creek during 1907. A party, it is true, has been engaged in prospecting the higher benches on the northern slope of the valley, opposite Monument Creek, but the work was simply that of testing the ground.

Development in the entire Casadepaga region has been much hampered by the lack of adequate transportation facilities. It was believed that with the completion of the railroad to Penelope Creek in 1906 this difficulty would be removed. The season of 1907, however, has shown that such is not the case. Until late in the summer no trains were run across the Ruby divide, and then they were run only once or twice a week. Early in September train service beyond East Fork on Solomon River was discontinued. Even in this short season the charges ($50 a ton for freight and $5 apiece for passengers) for the 30-mile run to Penelope were so high and the protection given goods in transit and while waiting delivery was so inadequate that few miners could make use of the railroad. During the last year no additional track has been laid.

OTHER PORTIONS OF SEWARD PENINSULA.

It has been noted that no geologists of the Survey visited the Kotzebue Sound, Bluff, Kougarok, or Port Clarence districts during the last season. For this reason the report on these districts is wanting in details.

KOTZEBUE SOUND.

During the year 1906–7 about 9 per cent of the production of Seward Peninsula came from the region around Kotzebue Sound, known as the Fairhaven precinct. In this area there are three mining centers—one in the vicinity of Candle, one in the basins of the streams having their mouths near Deering, and the third on Bear Creek. Two large ditches and one smaller one have been completed this year, one for each of the mining centers, so that the problem of water supply has been more or less satisfactorily solved. An account of these and several smaller ditches may be found in a paper by F. F. Henshaw elsewhere in this volume.

At Candle there has been a continuation of the work of previous seasons, and prospecting has been carried on more extensively on some of the bench deposits. The gravels on the benches vary much in thickness and in elevation above the present stream. Some of the benches on which pay is reported are said to be about 50 feet above the river and to carry gravels from 15 to 30 feet thick. The opening up of these deeper gravels will undoubtedly have a beneficial effect on the district, for it will permit winter work. At the present time only a few men can be given permanent employment. The opening of the Candle ditch will also help the country, for in the past the lack of a water supply under sufficient head has been a serious detriment.

In the Inmachuk basin there has been a decided increase in the amount of winter mining. Where the summer season is as short as it is in the Kotzebue Sound region, it is of great importance for the miners to be able to work during the winter. In shallow creek diggings such work is impossible; but in many places the gravels are from 20 to 40 feet thick and lend themselves to advantageous development during the winter. No new mining developments, with the exception of ditch building, have occurred in the Inmachuk basin within the last year.

Bear Creek, the third mining center in the Kotzebue Sound region, is east of the range between Kiwalik and Buckland rivers. Bear Creek itself is a tributary to the West Fork of the Buckland. It lies about 40 miles from Candle. The productive ground is confined to a few claims and only a small force of men has been employed in the district. The production for this year has been rather small, because much of the season has been spent in ditch building. It is believed, however, that in another year the production of Seward Peninsula will receive an appreciable increase from this district. The isolation of this camp, however, makes the cost of supplies so high that it will not be able, for some time, to compete with more favorably situated fields.

BLUFF.

Considerable excitement has been awakened during the last year by the finding of an ancient beach deposit below sea level near Bluff. This strike has been looked on as a most unusual and inexplicable occurrence, not so much on account of the finding of pay, but because the deposit occurs below sea level. To one who has studied the Nome beaches, such a fact ought not to be surprising. The beaches already known bear witness to the oscillations that the region has undergone. Moreover, drill records which have been made at the mouth of Snake River show bed rock in places several scores of feet below the present sea level, with beach material above. The deep gravel-filled valleys of Nome and Snake rivers also show that the land once stood relatively higher with respect to the sea than it does at present. If such things are known to have taken place in the past in the Nome region, there is no reason why they should not also have occurred in other places.

To return to the Bluff region, there are certain facts that should be borne in mind by prospectors. The fact that, at Bluff, a certain beach occurs below sea level is by no means proof that it connects with a beach below sea level somewhere else. This point has been emphasized in other portions of this report (see pp. 212–213), but it is of such importance that it should be reiterated. At the present time there is no conclusive reason for connecting the newly discovered beach at Bluff with any of the beaches at Nome. Careful and systematic tracing by studying surface forms and by unraveling the details of the past history of Seward Peninsula is the only way in which the various beaches can be projected and correlated one with another.

The result of the uncovering of this new beach has been a notable increase in the production during the last year, so that probably almost as much gold has been taken from this small area as from the whole Fairhaven district.

Although more or less worn, the gold seems to be mainly of local origin. In this connection the presence of mineralized zones, as has been pointed out on page 239, is of importance.

KOUGAROK REGION.

The Kougarok was visited and described by Brooks[a] in 1906, and but few additional notes are available. Mining during the last year has been on practically the same scale as formerly. The completion of the Seward Peninsula Railway from Nome to Lanes Landing or

[a] Brooks, A. H., The Kougarok region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 164–181.

Shelton, in the late fall of 1906, has been of much benefit to the district, for it has provided quick and relatively low-priced transportation to a district which was practically inaccessible except by small boats in summer or by sleds during the winter.

Mr. F. F. Henshaw, who spent considerable time during the last year in the Kougarok district, has kindly furnished notes on the mining operations.[a] On Coffee Creek five or six men have been employed. On Dahl Creek some work was done before July 10 and after August 20, but probably not more than ten men have been mining during the season. The next productive stream is Windy Creek, where four men have been ground sluicing. Still farther upstream, in the vicinity of Left Fork, a small tributary of the Kougarok, three men have been doing a little prospecting. On North Fork there has been no productive work except below the mouth of Eureka Creek, where two men have been shoveling into boxes and ground sluicing. Still farther upstream three men have been at work on a bench of Kougarok River just below Arizona Creek. Practically only prospecting work has been done on Henry Creek during the last year, two men being employed. Just below Henry Creek, at the mouth of a small tributary from the east, two men have been mining. On Taylor Creek an outfit of two men has been shoveling into boxes at the mouth of Solomon Creek, about 6 miles east of the junction of Taylor Creek and the Kougarok. Two men have been mining on Macklin Creek. On the main river two outfits of four and six men each have been mining creek gravels near the mouth of Macklin Creek. Four others at the same locality have been shoveling in bench gravels that occur at a small elevation above the river. Probably six or seven men have been prospecting or washing gravels on a small scale above the mouth of Macklin Creek. In this portion of the river only two of the side streams have yielded pay. These tributaries are both small. On the lower, Trinity Creek, which enters 2 miles above Macklin Creek, two men have been working the creek gravels. On Mascot Gulch, which is about 2 miles above Trinity Creek, a party of two men has been working whenever water was available.

Although lying outside the Kougarok drainage basin, the tributaries of the Noxapaga heading in the Kougarok divide have generally been considered as belonging to this district. In 1907 the only two streams from which any production was reported were Garfield and Boulder creeks. On the former five men have been employed and the reports are encouraging. On the latter four men have been mining, but no returns are available.

From the foregoing statements it would appear that about seventy men have been mining in this region during the last year. None of

[a] The ditch-building operations are described in Mr. Henshaw's paper on the water supply of the Nome and Kougarok regions, elsewhere in this volume.

the operators have done any extensive work, the mining being generally carried on by pick and shovel methods, so it is doubtful whether more than 50,000 yards of dirt have been handled. In the above enumeration no account of the men engaged in ditch building has been taken. Over a hundred men have been employed in this work, but they have contributed nothing to the gold output.

PORT CLARENCE REGION.

The Port Clarence region has not been visited by members of the Geological Survey for a number of years and but few new notes about it have been collected from mining men. For several years the region received but scant attention from the outside. Now, however, it has shown increasing activity and mining promises to be pushed more energetically. To the north of Grantley Harbor and Port Clarence there are two areas in which most of the mining is being done. One of these is near Sunset Creek and the other is in the American Creek basin. On Sunset Creek a ditch line over 30 miles in length has just been completed, so that in August, 1907, the water was available for mining. Owing to the late turning on of the water, much of the season was lost for productive mining. The gravels at this place are between 6 and 8 feet deep, and it is planned to handle them with a hydraulic elevator. It is expected that the work will be vigorously pressed in the future.

In the American Creek district the most active mining work has been on Windy Creek at the mouth of Budd Creek, but only one crew of five or six men has been employed. The completion in the late fall of a large ditch will probably give a great impetus to mining in 1908 in this region. The ground to be worked with water from the ditch is about a mile downstream from the junction of Budd and Windy creeks.

South of Port Clarence the main productive area is in the Bluestone basin. Heretofore work has been greatly impeded by the lack of sufficient water, but this deficiency is being remedied by ditch construction. Gold Run is the most important tributary of the Bluestone, and it is from this creek that most of the gold obtained in 1907 has come. There have been about eight different outfits in the Bluestone country, ranging from camps of fifteen men down to individual prospectors.

LODE MINING.

During the year 1906–7 there has been increased activity in prospecting for lode mines, and on the whole the work has given a healthy stimulus to the district. Nowhere, however, except at the Big Hurrah mine, has the work progressed beyond the prospect stage, so that the output of the peninsula has not been materially affected.[a] The holders of many of the veins, however, have placed an unreasonably high value on their properties and this discourages investment by outside capital. A few thousand dollars is ample reward for the pluck and luck which locates a promising ledge, but several hundred thousand dollars should be the prize reserved for the man who makes a producing mine from the unproved project. A realization of this fact is important if outside capital is to be invested, for business men will not accede to the fabulous valuations set on the undeveloped properties scattered through Seward Peninsula.

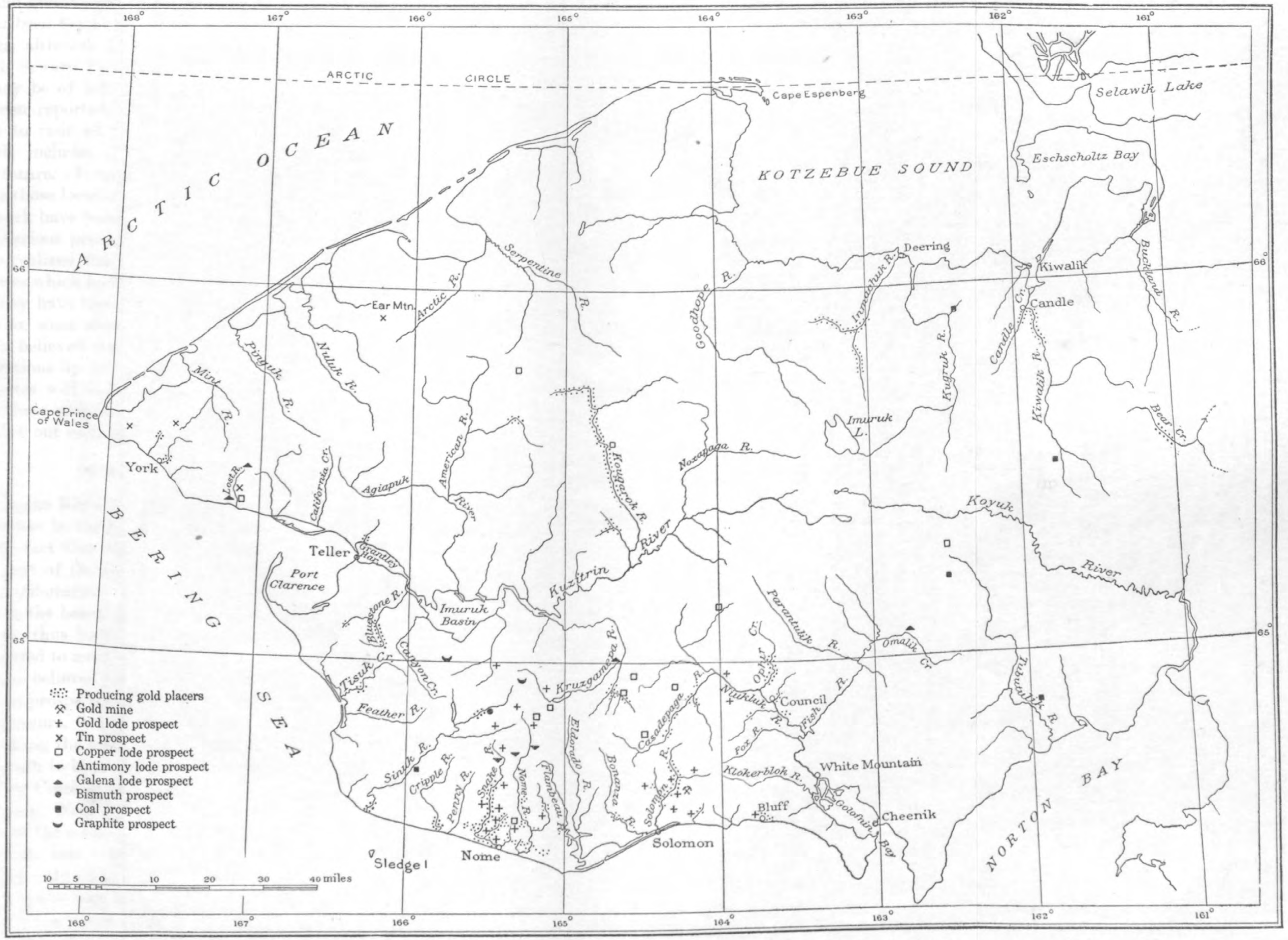
GOLD.

GENERAL CONDITIONS.

The fact that mineralization is widespread in this portion of Alaska is being more and more conclusively proved each succeeding year as prospectors turn their attention to the search for veins. The lode deposits that are attracting most attention at the present time in Seward Peninsula are those in which gold is the main or most important metallic mineral. This is necessarily true, for all the other metals require more elaborate plants and the products must be disposed of in a constantly fluctuating market. The other metals are sought, but only those which promise to return some values in gold are likely to be of immediate importance. Thus, although antimony is found in some of the lodes, copper in others, and bismuth in still others, the owners are counting on defraying some of the expense incident to mining by the returns from the accessory gold content.

There are two main types of veins. In one the filling is mainly quartz with the values carried as free gold; in the other the filling is mainly quartz, but the gold occurs chemically combined with sulphur or some other element. Although the question has not been thoroughly studied it is believed that the veins in which free gold is the principal valuable mineral have been formed later than the larger part of the metamorphism and are therefore not very badly sheared or altered. From a geologic standpoint the places where veins occur may be summarized as follows: In the black quartzose slates, near the contact between two different lithologic types, and in the chloritic schists. The importance of these geologic conditions in the production of mineralized veins, measured by the facts at present known, is indicated by the order in which the different kinds are named. The veins in the black slates are generally destitute of sulphide mineralization, but many of those of the other two classes carry sulphides. Some of the contact deposits occur near the contact of heavy limestone and chloritic schist and others near the contact of heavy lime-

[a] In this paper the tin developments are not considered, as they are treated in detail by Adolph Knopf in the succeeding paper in this volume.



MAP OF SEWARD PENINSULA, SHOWING DISTRIBUTION OF MINERAL RESOURCES.

stone and greenstone or feldspathic schist. No productive veins have thus far been found in the greenstones and attendant schists or in the granites, although these rocks are distributed more or less widely through Seward Peninsula.

It may be of interest to mention the various places where lodes have been reported. It has not been possible for members of the Survey to visit all the different properties enumerated, so the list probably includes veins which have not the possibility of an economic future. It has been the object, however, to exclude as far as possible those locations in which no serious prospecting and development work have been done. The map (Pl. V) indicates the location of the various prospects described on the following pages.

It is realized that overemphasis may have been placed on some properties which have been producing but little, and that not enough space may have been given to others which because of their remoteness or for some other reason have not come to the writer's attention, yet it is believed that the following notes may serve as a summary of operations up to the close of 1907. To those outside the district these notes will indicate the tendency and scope of present work, and to those within its limits they will record what has been done and point out certain needs for further systematic development.

NOME AND GRAND CENTRAL REGIONS.

The Snake River basin seems to be one of the more heavily mineralized areas in the Nome region. This is interesting in connection with the fact that the richest portion of the ancient beaches occurs in the part of the tundra nearest the former mouths of this stream and its tributaries. In many places, however, the bed rock itself on which the beach material is deposited shows evidences of mineralization; thus between Holyoke and Saturday creeks veins which are reported to assay well have been found intersecting the schists.

As it is believed that the mere statement of localities where veins have been prospected in the Snake River region may be of some value to prospectors, it is proposed to note briefly some of the reported lodes, taking the main river and each of its tributaries in succession from mouth to head.

On Dry Creek most of the exploration for lodes has been near the upper part. Near East Gulch there is a contact of the heavy limestones and the schists and at this place a shallow hole has been sunk on a calcite vein. The evidences of mineralization are very slight, consisting only of a small amount of iron decomposition products. A vein has also been encountered in sinking an 80-foot shaft in placer ground in the upper portion of Dry Creek, and another prospector near the same place reports ore carrying from $5 to $15 a ton in gold.

Veins are also reported on Bear Creek, a stream whose course is determined by the limestone-schist contact.

On the west side of Anvil Creek, at an elevation between 300 and 400 feet, there is a quartz lode on which a small amount of work has been done. The country rock is a black, somewhat quartzitic schist which is much wrinkled. The folding that has taken place seems to have formed open spaces in which the quartz has been deposited. The quartz is very lean and no metallic minerals are visible. Three-fourths of a mile to the north there is another quartz vein which has been opened by an adit about 15 feet long. The general trend of the vein is north and south, with a westerly dip, but it is so brecciated that its true structure could not be determined with precision. In places the quartz shows well-terminated crystals an inch or so in diameter, and the vein is believed to belong to the later series. Although the quartz is considerably stained with iron there is no other sign of mineralization, and as no work had been done on the property for some time it seems probable that the returns from the work already done were not sufficient to warrant further outlay. A short distance above Perkinsville on Anvil Creek there are numerous quartz stringers from an inch to 8 or 10 inches in width. These occur in a black, finely fissile chlorite schist and although some of them cut across the schistosity, in general they appear to lie parallel to it. The stringers are somewhat bent and folded with the schist, and like it they stand nearly vertical and are badly fractured and minutely dislocated. The veins carry some iron pyrite scattered throughout in small stringers and vugs. Assays show a small gold tenor. In form the quartz veins are generally lens shaped and most of them are not more than 100 feet in major dimension.

The Anvil-Glacier divide shows numerous veins, some of which have given promising assays. Near the point where the road crosses this divide a shaft has been sunk for almost 100 feet in a schist which is intersected by a network of quartz veins. Some selected fragments of the quartz show free gold. North of this shaft on the same divide are numerous calcite veins, but so far no ore body has been found in veins of this type. The quartz veins in this neighborhood, however, carry a small gold content. One such vein occurring near a schist-limestone contact, according to Moffit,[a] has a thickness of 1 to 2½ feet and can be traced for a distance of about 100 feet.

Near the mouth of Snow Gulch on Glacier Creek there are numerous quartz veins, picked specimens from which yielded, according to Moffit,[b] $9 a ton in gold. The schist in the immediate neighborhood of these veins is in places heavily impregnated with pyrite and probably carries gold also.

[a] Moffit, F. H., Geology of the Nome and Grand Central quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

[b] Op. cit.

This belt of mineralization extends over toward Rock Creek and shows the same features of heavy disseminated mineralization. Near the wagon road leading to Rock Creek there is a shaft said to be 70 feet deep which has been sunk on a series of intersecting quartz veins. At this place, in addition to the ordinary iron pyrite, some arsenical pyrites have been found and also an intimate mechanical mixture of copper and antimony sulphides.

Above Rock Creek on Snake River the next veins which have been prospected occur near the mouth of Boulder Creek. At this place there are a number of small veins, the largest of which, according to Moffit,[a] is not over 5 inches thick. These all carry some gold, although the assay returns indicate too low a tenor to be profitable under present conditions. Near Goodluck Gulch also there are numerous quartz stringers showing mineralization—mostly iron pyrite or its decomposition products. The quartz shows much crushing. On Pioneer Gulch there is some mineralization which has led to considerable prospecting during the last summer. The quartz at this place is reported to carry considerable free gold, but the stringers are very narrow and would be difficult to mine.

Above Boulder Creek three leads have been found, but the most important is the one near the head of Goldbottom Creek. The vein at this place has been known for some time, as the ground was staked four or five years ago, but only within the last two years have exploration and development been active. The vein is located near the contact of the heavy limestone which forms the larger part of Mount Distin with the underlying schist to the west. It is reported that the vein has been traced for a distance of a mile and that everywhere it is parallel to the limestone-schist contact. Such a character would suggest a gentle dip, which would make the cost of operating rather high. At the present time the ore is treated in a 3-stamp mill the power for which is afforded by water delivered by a ditch about a mile in length. It is understood, however, that a gasoline plant is to be installed so that work may be kept up continuously throughout the year. This prospect was not visited by any member of the Survey during 1907, but from apparently reliable information it is believed that this group of veins belong to the class of contact deposits which are so common throughout a large part of Seward Peninsula, but which so far have not yielded much return.

On Nome River and its tributaries but few veins carrying gold as the main metallic mineral have been uncovered. On Osborn Creek a quartz vein which occurs near the contact of a greenstone and mica schist has been slightly developed. Assays of this ore are reported to show a great variation in gold content, from $4 to over $40 a ton. Associated with the gold is a little copper sulphide, which on weath-

[a] Op. cit.

ering imparts the characteristic copper-carbonate stain to portions of the vein. On Banner Creek a vein, said to be 8 feet wide, with both walls well defined, is reported, but was not visited by any member of the Survey. Several small limestone bands cross Banner Creek and the lode may occur near the contact of the schists and limestones, but this fact could not be ascertained. The ore is reported to show a small amount of free gold in the quartz. Near Mormon station, on the Seward Peninsula Railway below Dorothy Creek, a vein has been found more or less impregnated with iron pyrites and a little copper pyrite.

In the Kigluaik Mountains and in the plateau region to the south there has been some prospecting for quartz lodes. On Stewart River a quartz lead which is said to be 4 feet wide has been located and a tunnel has been started, but as yet nothing is known definitely of the property. Some prospecting has been done on Buffalo Creek and on the upper portion of Hudson Creek, but no permanent force has been at work, so the returns presumably were not satisfactory. On Cobblestone River on the north side of the mountains some free-milling quartz has been discovered, but its value was not learned. On the first tributary from the east to Grand Central River above Nugget Creek two men have been at work uncovering a ledge of auriferous pyrite. This lead is reported to be a series of quartz stringers, some of them 3 feet in width, which conform more or less closely to the cleavage of the black graphitic schists that form the country rock at that place. The quartz contains a considerable sprinkling of pyrite and the outcrop is heavily iron stained.

SOLOMON AND CASADEPAGA REGIONS.

In the Solomon region is located the Big Hurrah quartz mine, which is the only producing lode mine in the entire peninsula. This mine has been described in some detail by Collier.[a] It has been in almost constant operation since its discovery in 1900, and although the ore is known to be of low grade, its total production is important. There are several veins at this place, but the middle one has been most extensively worked. At the present time the shaft is down more than 250 feet and several hundred feet of drift are turned off. The veins occur in a black, hard, somewhat graphitic, quartzitic rock which breaks into more or less rectangular fragments. This rock occurs in a rather narrow belt, a mile or so wide, extending from Uncle Sam Mountain to the head of Solomon River. The country rock is much fractured and is thoroughly intersected by quartz veins or stringers from a fraction of an inch up to several feet in width. The veins have all been more or less crushed and crumpled, but they

[a] Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., The gold placers of parts of Seward Peninsula: Bull. U. S. Geol. Survey No. 328, 1908, pp. 228–231.

have not been so greatly deformed as to lose their continuity. The amount of deformation which they have suffered suggests that they belong to the later series of quartz veins, which were formed either coincidently with or later than the second period of metamorphism that the region has undergone.

A striking feature of the quartz in the Big Hurrah mine is the absence of much sulphide mineralization. To one familiar with many of the gold lodes in the States, the almost entire lack of iron stains on the quartz and the absence of any undecomposed sulphides in the rocks is very noticeable. It seems, therefore, that the gold must occur in the quartz mainly in a native state rather than mechanically mixed with pyrite or other metallic compounds. If this is true it has an important bearing on the successful search for gold lodes in the district, for the prospector, instead of being able to approximate the value of a ledge by sight alone, must have recourse to competent assays to determine the gold content. It is known that much of the quartz which is said to run $10 to $14 a ton in gold looks like a hard, dense, unmineralized rock which would generally be passed by as "bull quartz." The lode prospector should be advised to sample carefully all strong quartz leads and have the samples accurately assayed, rather than simply to neglect the lead because it looks lean and unlike the auriferous quartz found in many known productive camps. By no means would he always be repaid for his trouble, for undoubtedly many of the leads are barren, but he might discover lodes that would be overlooked in the more crude prospecting. In a quartz lode of low tenor, where the gold is in finely disseminated particles, it would be practically impossible to gain reliable information from roughly crushing the ore and panning.

The main developments at the Big Hurrah mine have been by means of an incline shaft which has a general though not constant slope of about 60°. The strike of the veins is northwesterly and the dip is to the southwest. The upper portion of the vein has also been worked in part by adits run in from the outcropping of the vein on Little Hurrah Creek. North of the main lead there is another vein which occurs about 50 feet below in the foot wall. This vein, unlike the two farther south, has a northwesterly dip, although the strike is essentially the same as the others. It is the belief of the mine operators that this northern vein is a continuation of one of the others, the structure being therefore anticlinal. From the evidence of the structure as shown in the rocks of the neighborhood, as well as from the amount and character of deformation of the veins, it is suggested that such an interpretation is not the correct one, but further developments alone can definitely determine the true structure.

The ore as a rule is in bunches of quartz some of which show a considerable segregation of gold, but the best grade of ore is in what is called locally "ribbon rock." The ribbon character is due to bands of quartz separated from each other by small partings or horses of dark graphitic schist, of varying width but all relatively narrow. The ore breaks down rather readily, as both the hanging and foot walls are generally determined by fault planes which show slickensiding. The faults, however, do not continue uninterruptedly throughout the mine. The movement was along a number of fault planes which were essentially parallel. The time of mineralization seems to have been later than the main folding and deformation of the region but earlier than the slight faulting which is marked by the dislocations already noted. It may therefore be associated with the later stage of mountain building which gave rise to the east-west structural trend now visible in the Kigluaik and Bendeleben mountains.

The Big Hurrah mine is well equipped for carrying on all the necessary mining and concentration processes. The main hoisting plant has consisted of steam-power hoists but the use of oil or gasoline in the future is contemplated, as the efficiency in ratio to the expense is higher. There is a compressor capable of running a few drills, but most of the ore is stoped by hand work. After arriving at the collar of the shaft the ore is trammed by hand through a covered way somewhat over a hundred yards in length to the stamp mill, where it is stored until needed. The stamp mill consists of four batteries of five stamps each. The location is well chosen for economically conducting the various processes, as the level of the track from the shaft is well toward the top of the mill. The batteries are of the usual California type, with automatic feed. After crushing, the ore passes over plates and the major part of the gold is won in the upper few feet. The pulp passing over the plates is led to tables for concentration. Two of the tables are of the Frue type, but the other two are of local construction. The tailings from the tables are carried out to a settling pond formed by diking a flat below the stamp mill. After the plates have been cleaned the amalgam and heavy concentrates from the stamps are put into an amalgamating barrel and slowly rotated with steel balls for twelve hours and then retorted and sold to the bank. The concentrates from the tables are sacked and shipped to outside smelters for treatment. The force employed for both the mine and the mill is about forty men.

In the belt of black graphitic quartzitic schist already noted as occurring in the Solomon and Casadepaga regions there is widespread evidence of mineralization, though save in the immediate neighborhood of the Big Hurrah mine no considerable prospecting has been done. At the small, dry gulch leading from Uncle Sam Mountain there is a prospect pit which has been abandoned for some time. It is sunk on the black quartzitic schist, which is very much sheared and folded; in fact, many of the small quartz veins form a complete S. The quartz of the veins has a peculiar appearance, owing to the presence of a halo of milky crushed quartz around a central more glassy portion. Some of the quartz is heavily iron stained, but as a rule no sulphide minerals are evident. Even on top of Uncle Sam Mountain prospectors have been looking for veins, for there are two abandoned pits slightly to the west of the highest point. In these holes a somewhat mineralized black slaty schist intersected by numerous quartz veins is exposed.

In the lower portion of Linda Vista Creek, a tributary of Big Hurrah Creek, there is a vertical quartz vein which strikes toward the northwest. It is 7 or 8 feet wide and has been faulted twice. Much of the rock near it is considerably crushed. The main evidences of metallic mineralization consist in the large number of limonite stains which cover the quartz. Somewhat north of this vein there is another hole in which an 18-inch quartz vein is exposed. This vein strikes in the same direction as the other, but dips only about 60° SW.

About a mile north of the mouth of Little Hurrah Creek a good deal of prospecting has been done in the past, although work has now been entirely abandoned and the pits are filled with water. This property also occurs in the area of black quartzitic schists, which here strike northwest and dip at a low angle to the northeast. Two inclines with a slope of about 30° have been driven, but the character of the veins could not be determined, owing to the water. Near the inclines there has been about 300 feet of open cutting, but in the exposed area only narrow quartz veins which pinch out within a short distance are visible. The quartz, like so much of the quartz in the black quartzitic slate area, shows but sparing amounts of metallic minerals. Evidences of faulting are common.

On the first tributary to Solomon River from the west below East Fork an adit has been driven on a vein occurring in the black graphitic slates. This vein is located along a fault which has an indeterminate throw, and is distinctly later than the fault. The amount of mineralization is not very great, although in places the rocks are considerably iron stained. The adit is only 20 feet long and the mineralization becomes progressively less toward the breast, and the amount of drag indicated by the wall rocks also diminishes. No work has been done at this place for some time.

Mineralization is also commonly associated with the contact of the limestone and the schists. In many places this mineralization consists only of the introduction of quartz, but in some places sulphides have also been formed. The heavy limestones of the Solomon and Casadepaga regions form a belt along almost the entire western margin of the quadrangles;[a] thence, with some dislocation,

[a] As mapped by the Geological Survey.

swing eastward to form the group of hills of which Mount Dixon is the highest point; and thence, continuing still farther east, form the bare limestone ridges so prominent in the No Man Creek region. There are, however, many other places where limestones occur and in some of these more isolated limestone areas the contacts with the schist show mineralization. At Spruce Creek, near the contact of a much folded limestone and schist, some work has been done in the past on veins which are reported to carry values in free gold. No recent prospecting has been done at this place. On the north side of the divide at the head of Trilby Creek, a tributary of Big Hurrah Creek, there is a quartz stringer which seems to strike north and south, but has been only slightly developed.

At some other places the veins apparently occur near the contact of igneous and sedimentary rocks. Thus at the contact of chloritic schists and greenstones on the high hill at the head of Butte Creek the schists are somewhat impregnated with sulphides, most of which are altered to limonite in the surface exposures. Also at the junction of French Creek and East Fork there is a heavy float of vein quartz showing a small amount of metallic sulphides. Some of the quartz fragments are 3 feet in longer dimension and the float can be traced almost continuously for nearly a quarter of a mile. This locality is near the contact of a limestone and greenstone, where there has been some dislocation.

Still other veins occur in the chloritic schist areas away from any contacts with other rocks. Such a series of veins has been opened on West Creek 2 miles above the mouth. Some work is done here every year and there are 600 or 700 feet of underground workings, but the mine has not yet shipped any ore. The development has been on a north-south vein, which was opened by an adit that drifted along the vein for over 350 feet. In this drift both walls were decomposed chloritic schist which in places showed marked slickensiding. Another adit about 300 feet long has been driven on a vein farther west which shows the same general character as the first. A crosscut following a small cross stringer has been run from the eastern drift. The quartz from all the veins is practically the same in character. It is white and somewhat shattered, but is apparently not sheared nor folded and presumably belongs to the later set of veins. In addition to the quartz the veins carry abundant chlorite and a small amount of pyrite and marcasite. The later metallic minerals occur in small stringers and vugs. The wall rocks are also said to be gold bearing and the foot-wall schist is reported to carry from $8 to $10 a ton in gold, but no assays of the rock have been made by the Survey.

OTHER DISTRICTS.

Near Bluff there has been a more considerable development of a group of properties, with the aim of definitely determining the character and distribution of the ore, than at any other place in the southern and eastern parts of Seward Peninsula. Although this group of claims was not visited during the past year by any member of the Survey, the statements here made are regarded as reliable. In occurrence the ore seems to be closely associated with a limestone-schist contact, with the limestone lying definitely above the schist. In these veins quartz is the most important gangue mineral. The lodes are all located rather near the sea, so that the question of freightage is not serious and supplies can be obtained much more economically than in the camps farther inland. Although these leads have been known for five or six years, the last summer has been more productive of economic results than any previous year. At one claim a shaft about 50 feet deep has been sunk and a short drift about 15 feet in length has been turned off. On the adjoining claim the zone of the mineralization is so wide that two shafts, one on the hanging wall and one on the foot wall, have been sunk. One of these is reported to be 100 feet deep; the other is slightly less than half that length. On the next claim also two shafts have been sunk to a depth of approximately 50 feet. Two shorter shafts have been put down on the next claim, and one shaft about 75 feet deep has been sunk near the end line of the next claim beyond.

The ore from these properties is crushed in an arrastre which is operated by a horse, but it is intended to erect a stamp mill later. No just estimate of the production from this group could be obtained. The properties are particularly interesting as suggesting a possible origin of the gold which has made certain of the creek and beach gravels near Bluff so rich.

Farther east, in the neighborhood of Golofnin, a lode which is reported to give assay returns of $2 to $17 a ton in gold has been discovered, but details regarding the occurrence are wanting.

In the neighborhood of Council several veins were mentioned by the writer[a] in 1907 as having been located and as appearing promising for further exploration. No mining has been done during the last season on the lode southeast of Post Creek other than the annual assessment work. Nor has any development work been carried on near the head of Camp Creek, where another vein was reported last year. The lode near the head of Crooked Creek was prospected to some extent during the winter of 1906–7, but the excavations showed the vein to be constantly decreasing in size until it finally pinched

[a] Smith, P. S., Gold fields of the Solomon and Niukluk river basins: Bull. U. S. Geol. Survey No. 314, 1907, p. 155.

out. Fortunately, however, a hillside placer, formed undoubtedly from the disintegration of this vein, was found farther downhill, so that the owners have more than made up for the loss of the lode.

COPPER.

NOME AND GRAND CENTRAL REGIONS.

At the present time there are only two localities within the Nome and Grand Central regions where lodes carrying copper are being prospected. One of these lodes, on Dexter Creek, is valuable mainly for its gold content, although it is reported that assays showing as much as 4 per cent of copper have been obtained. The second prospect is the larger and is being more actively explored. This lead occurs near the head of Nome River on the high ridge between Copper and Dickens[a] creeks, at an elevation of about 1,250 feet. The deposit is developed by a vertical shaft 10 feet deep and an incline shaft on a low slope was driven on the ore. It was intended to keep three men working on the property continuously during the winter and in this way to systematically explore the ground.

The geologic structure of the area immediately adjacent to the mine is somewhat complex. A narrow belt of heavy white limestone occurs at this place and it is in this limestone that the shaft has been sunk and the veins have been found. Below the limestone on the west there are several shallow prospect pits that show schist fragments and outcrops. The schists exposed under the limestone are of two types; one is a silvery-gray schist with an abundance of small muscovite flakes and much chlorite, the bulk of the rock being quartz; the other is a dark-greenish schist with numerous crystals of feldspar and with some amphibole. It has not been possible as yet to examine these rocks microscopically; but from the evidence acquired by the study of many rocks of nearly identical appearance from near-by areas, it is believed that the silvery schist is of sedimentary origin and that the green schist is derived from an igneous rock. Such an igneous rock would probably be akin to the greenstones, which in Seward Peninsula are allied to the quartz diorites.

Above the limestone there is a strongly developed ledge of typical greenish feldspathic schist which is presumably of igneous origin. The direction of the cleavage, the most dominant structure in the feldspathic schist, is N. 30° W., which is the general trend of the ridge. The dip of all the rocks is northeasterly and as a rule is rather

[a] This creek has recently been given the name Dome Creek by the miners of the vicinity. This seems undesirable, for the creek was originally known as Dickens Creek, claims were staked in this name, and the name was published by the Geological Survey in 1900. It is also undesirable because there are at present five Dome Creeks in Seward Peninsula—one a tributary to Tisuk River, one to American River, one to Taylor Creek, one to Kiwalik River, and one forming part of Iron Creek.

flat. The presence of schists of supposed igneous origin, however, suggests that they may cut the sedimentary rocks and so cause complications in the development of the property. It has been determined in other portions of the Grand Central region that the greenstones are later than any of the sedimentary schists; if, therefore, the feldspathic schists have been derived from these greenstones, they must be the latest hard rocks in the district.

The character of the vein and the distribution of the metals in it are peculiar. All over the surface are numerous blocks of limestone stained with a little malachite, but in the upper portion the vein shows mainly galena. Specimens from this upper portion show numerous drusy cavities and the appearance is that of a replaced limestone. In every fragment several small quartz veins are visible. The ore is almost entirely galena with only a small amount of copper carbonate and practically no copper sulphide. An assay of picked specimens made by the owners is reported to have yielded 15 per cent of copper and 20 per cent of lead, with a rather high silver and low gold content.

In the breast there seems to be a nearly vertical fissure which shows for some distance in the inclined shaft. From this fissure a good deal of bornite, practically unmixed with any other minerals except galena, has been won. This vein seems to pinch out 2 feet or so below the roof and the bornite is absent from the rest of the underground workings. Near the floor of the incline there is a quartzitic rock which looks much like a replaced limestone. This quartzite contains a band about 8 inches thick of copper sulphides and carbonates mixed with quartz. The sulphides are mainly chalcopyrite, and both the carbonates, azurite and malachite, are present. In addition to the main stringers already described, some ore is scattered throughout the breast, but it is too disseminated to allow profitable extraction.

The sulphides in the lower part of the mineralized belt occur nearly parallel with the stratification of the limestone. Nowhere in the underground workings was schist seen, but from the evidence already cited it seeems probable that the contact of the schist would be found a short distance below the floor of the incline. If this is the case and if the underlying schist is igneous in origin, the variation in the ore away from the contact might be explained. It is difficult, however, to believe that the ore was brought in by the igneous action which was responsible for the formation of the feldspathic schists, for the latter, where seen, were not mineralized. Unless, therefore, the distribution of ore may be explained by assuming that the limestone acted as a precipitant for the ore-bearing solutions or gases, while the schist did not, the absence of mineralization in the feldspathic schists is a vital objection to the theory.

About a mile north of the shaft is an exposure of a granite intrusive. Although it is possible that this rock may have had some effect on the deposition of the ore, none of the granite is found near the mine and it is believed that it has no intimate connection with the ore. In the absence of extensive openings that would permit careful study of the details it is believed that the ore was introduced later than the igneous activity connected with the greenstone-feldspathic schist intrusion and was coincident with the replacement of the limestone by silica.

A third of a mile above the mouth of Copper Creek, near the limestone-schist contact, an adit has been run in for 20 or 25 feet on some stringers of copper ore. Work at this point has been abandoned. This property belongs to the same company that owns the prospect on the hill above, and it is believed by the owners that the veins in the two places are the same; but the ground has not been studied in sufficient detail to make such a correlation more than a surmise. Both these properties are favorably located for shipping ore and receiving supplies, as they are less than a mile from the railroad. Already 5 or 6 tons of roughly sorted ore have been shipped for mill tests, but the returns are not yet available.

IRON CREEK REGION.

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. From the scattered evidence collected in a hurried examination, it appears that the limestone is very considerably folded but that the major structure is nearly flat. The limestone would appear to be a continuation of the limestone already described as 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 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 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 north 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.

OTHER COPPER PROSPECTS.

In the Solomon and Casadepaga regions, as has already been pointed out (p. 237), there is generally some mineralization near the contact of the heavy limestone and the underlying schists. The greatest amount of copper-stained float is found near this contact on Mount Dixon and in the Moonlight Creek divide. At the latter place a shallow prospect pit has been sunk and the larger stringers staked, but on Mount Dixon no exploration has been done. Near the gold prospect west of Spruce Creek, described on page 238, there is also an interesting group of quartz veins showing some copper stains. These veins occur near the contact of limestone and schist at an elevation of about 700 feet. At the contact is found a siliceous rock looking like a replaced limestone. This is cut by nearly unmetamorphosed quartz veins which show finely terminated quartz crystals. These late veins show but slight traces of mineralization other than the quartz; the copper sulphide and carbonates occur in the lower quartzitic layer.

In the Kougarok region a few copper properties have been located. Moffit [a] describes one of these as follows:

It is located near the head of South Fork of Serpentine River, between Quartz and Bismarck creeks. The copper occurs as carbonates, chiefly malachite with some azurite, with quartz, at a contact of limestone overlying gray mica schist. A shaft 25 feet deep has been sunk above the vein, which dips to the northwest. * * * An incline 20 feet long was also driven in the vein, whose thickness is said to be from 6 to 21 inches, and 10 to 12 tons of ore were taken out.

This prospect has not been visited recently by any members of the Survey. It is not yet on a producing basis. Near the mouth of Taylor Creek, also in the Kougarok district, a copper lode has been reported. The information concerning it is meager, but from some hand specimens which were seen it appears to occur in a much metamorphosed limestone. The copper is disseminated through this rock and occurs mainly in the form of sulphides. The specimens do not indicate a vein of any continuity, but development work has uncovered only the surficial portions.

East of the Kougarok no copper lodes are reported between the river and the vicinity of Mount Bendeleben, where there is a lead concerning which any authentic information is wanting. Still farther east, on the upper branches of Koyuk River, a copper lode has been staked and a small amount of development work was done in the fall of 1906 and the spring of 1907. The hanging wall is reported to be a heavy white limestone and the foot wall a dark-greenish feldspathic schist and greenstone. Although the lode is reported to be very wide, the similarity to the leads that have been studied by members of the Survey in other parts of Seward Peninsula suggests that the zone of mineralization may be flat lying and thus give the appearance of greater width than it really has. Assays made on picked specimens show that there is a high percentage of silver in the ore; thus a return of 17.5 ounces of silver was obtained from ore running 3.4 per cent of copper. The gold content is very low. The location of the lode is unfavorable, for it is very difficult of access and this will undoubtedly hamper developments.

ANTIMONY PROSPECTS.

In 1905 a vein of stibnite was located by float on the divide west of Manila Creek, and some work was carried on in 1906. The condition at this place at the close of 1906 has been described by Moffit.[b] Since that time there has been a fairly steady development of the property. The main work accomplished has been the driving of a crosscut adit which successfully located the vein. This adit was 315 feet long and the vein where intersected was 3 feet wide. It is reported, however,

[a] Moffit F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 139.

[b] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, p. 139.

that the amount of antimony was materially less than in the surface exposures, but that the gold tenor had fortunately increased. The quartz is described as being white and compact, with but a small amount of metallic minerals visible. Now it is proposed to erect a stamp mill near the mine and to recover the gold values on the plates. The residue from the stamp will be concentrated on tables; but it is not intended to market the antimony ore at present. Transportation of concentrates from the mine to the smelter at Tacoma costs about $12.50 per ton, and this high rate has led the owners to hold the concentrates in reserve until they feel justified in erecting a plant of their own to treat the antimony. In the present depressed state of the antimony market such a charge for transportation would be a serious handicap to the successful operation of the property. If the decrease in the amount of antimony present in the ore is as marked in the next lower level as it has been from the surface to the adit level the value of the mine is likely to be determined by the gold content of the ore, with very subordinate values in antimony.

The Manila Creek property is the only one in the district that has shipped any antimony ore, but there are several places in the same general region where stibnite has been found. On the east side of Nome River, near the head of the Osborn Creek drainage basin, three prospectors at the close of the season found promising indications of an antimony lode. The lead is reported to be rather flat lying and is much contorted, the ore occurring in lenses and kidneys. A piece of ore 6 inches wide, 8 inches thick, and a foot long from this vein was examined and found to consist of almost pure stibnite. The ore, in addition to antimony, carries more or less gold. Near the gold lode on Goldbottom Creek also some auriferous antimony ore has been reported, but the prospect was not visited by members of the Survey. On Last Chance Creek a vein which is said to be 5 feet wide has been discovered, but exploration has not proceeded far enough to show the value of the property. Picked samples, however, are reported to yield high assays in both gold and antimony. Near the mouth of Goldbottom Creek on Snake River some stibnite has been found and it was proposed to ship some of the ore, but it is not known whether this was done or not.

GALENA PROSPECTS.

In Seward Peninsula the greatest deposits of galena so far reported are in the region north of Port Clarence and in the hills east of the Fish River basin. The Port Clarence region is described by Knopf on pages 268–271 of this volume. Not much additional information over that published by Mendenhall [a] in 1901 is at hand regarding the region

[a] Mendenhall, W. C., Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900, a special publication of the U. S. Geol. Survey, 1901, pp. 213–214.

east of Fish River. It is known, however, that during the past year mining and exploration were more actively pursued in the Omalik country than previously. The ore body at this place has been opened up by a shaft, and a crosscut adit has also been driven to connect with the shaft in depth. The ore occurs in a massive, coarsely crystalline limestone. The property is said to have an efficient equipment for development work, but is hampered by the high cost of labor and of transporting supplies.

A third locality for galena, near the mouth of Iron Creek on Kruzgamepa River, was brought to the attention of the Survey in the fall of 1907. 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 the 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 less than 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.

LODE DEPOSITS OF THE RARER METALS.

BISMUTH.

Near the fork of Charley Creek, a tributary of Sinuk River, bismuth-bearing quartz has been known for some time and was recently described by Moffit.[a] This lode occurs near a limestone-schist contact. During the last season work has been carried on to some extent and the property is being developed by a tunnel. Bismuth is also reported in the Kigluaik Mountains, but no details of the location or occurrence were obtainable.

MERCURY.

Although no well-authenticated find of mercury ores in place has been made in Seward Peninsula, the following quotation from Moffit[b] suggests that the presence of cinnabar is not improbable:

> An interesting fact in connection with the melting of Daniels Creek gold is its loss of weight due to the volatilization of cinnabar caught in the sluice boxes with the gold. The cinnabar occurs in the creek gravels.

MOLYBDENUM.

A small amount of molybdenum, unfortunately not in economic quantities, is reported by Moffit[c] as associated with gold in quartz veins on the divide between Anvil and Glacier creeks. These veins carrying molybdenum occur near the contact of limestones and schists.

TUNGSTEN.

Although no lodes of tungsten have been discovered in Seward Peninsula outside of the area described by Knopf (see p. 262), the presence of much placer scheelite, a lime tungstate, suggests that lodes may be searched for in other portions of the peninsula with some assurance of success. Placer-gold miners in the central part of the Snake River basin often find a considerable amount of scheelite in the concentrates from the sluice boxes. It is a whitish, nonmetallic-looking mineral particularly characterized by its very high specific gravity. It is found only in small quantities and is used in making filaments for certain kinds of electric lights and in the manufacture of very tough steel. The value fluctuates within wide limits

[a] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, p. 138.
[b] Moffit, F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 139.
[c] Moffit, F. H., Hess, F. L., and Smith, P. S., Geology of the Nome and Grand Central quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

owing to the varying conditions of the market, but it may be approximately placed between $400 and $800 a ton.

Float scheelite has also been reported in the Council district, but in amounts so small that the promise of locating the ledges from which it was derived is remote. In the Solomon region, especially near West Creek, a heavy nonmetallic-looking mineral was reported, but the material from this locality examined by the writer proved to be barite. This is also a heavy white mineral, but not of any considerable economic value.

HINTS TO MINERS.

In closing this portion of the report, a general word of advice concerning methods of work may not be unacceptable to those unfamiliar with lode mining. It has been noticed that in many places after an ore stringer has been located on a hillside, there has been a disposition to leave the vein and to start a crosscut adit at a lower level to intersect the ore body in depth. Such a scheme seems too hazardous and too expensive to be attempted in a region where the general character of the veins is no better known than it is in Seward Peninsula. If the vein is caught in the adit all is well and good and the crosscut undoubtedly gives an easy and economical method of handling the ore above that level. But the intersection of the vein in the crosscut is more or less problematical, especially in a region of disturbed rocks. To intersect a vertical vein by means of a crosscut 500 feet below the outcrop where the slope of the surface is 30° requires 850 feet of dead work which gives but meager information concerning the value of the property. On the other hand, if a system of sinking on the vein itself were adopted, an incline or shaft 100 feet in depth would not only block out considerable ore, but would afford much information concerning the character of the vein. Such a system of "gophering" might have to be entirely abandoned for the subsequent economical development of hoisting and breaking down the ore. It would have, however, the advantage of practically doing away with dead work, and would undoubtedly prove the true value of the mine better than a more elaborate scheme based on the assumption that the work done was of permanent character. If the ore body proves to be of value the miner can afford to neglect in large measure the early charges for prospecting, whereas if the surface showings do not continue or if the vein becomes impoverished in depth the sooner he realizes the fact the better.

For the present, therefore, it is believed advisable for the developments to follow the ore even though it may lead in tortuous courses. Such a plan should be pursued until the values of the prospects have been firmly established and the course and character of the veins accurately determined.

NONMETALLIFEROUS PRODUCTS.

Earlier in this paper it has been pointed out that the high cost of essentials has prevented the development of all save the richest deposits, or those which produce an easily converted commodity. For this reason the nonmetalliferous deposits have received but scanty attention. It is true that so important a resource as water has been well utilized. Not only is it developed for mechanical purposes, but even the springs which afford drinking water have been commercially controlled for local use.

FUELS.

Owing to the absence of all forests near many of the most productive camps, the question of fuel is of the highest importance. Lignitic coal has been reported in several places on Seward Peninsula, but in only one of these is it produced on a commercial basis. This mine, near the junction of Chicago Creek and the Kugruk, has been described by Moffit.[a] It is still producing coal and is undoubtedly a great boon to the prospectors in the Inmachuk-Kiwalik country. The coal, however, is not of so good a quality as that from Washington and British Columbia, but the greatly reduced transportation charges make it locally important. For shipments to regions more than a few score miles from the mine, however, the low heat-giving capacity and the high cost of transportation will not permit competition with the Wellington and other outside coals.

Coal is also known in the Sinuk Valley, but the area of the coal rocks can not be over a square mile[b] and the coal is of a poor quality. In the eastern part of the peninsula prospectors report considerable float of lignitic coal on the headwaters of the Tubutulik, but the ledge has not been opened up. Concerning this region Mendenhall[c] says: "No direct evidence of the presence of this mineral [coal] was secured on the Koyuk, but along the river bank, associated with the sandstone [Tertiary?] outcrops, on the Tubutulik, are numbers of small pieces of bright, compact coal, seemingly of good quality." All the coal so far found in Seward Peninsula is lignite, and there is slight probability that other kinds of higher grade will be discovered.

An attempt has been made near Nome to use for fuel the peat and vegetable material which forms the upper 6 to 12 inches of the tundra. The experiment as yet has not been sufficiently thorough to determine its value. It is probable, however, that the peat is too

[a] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula: Bull. U. S. Geol. Survey No. 247, 1905, p. 67.

[b] Collier, A. J., MS. notes.

[c] Mendenhall, W. C., Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900, a special publication of the U. S. Geol. Survey, 1901, p. 214.

full of rock material and ice to be valuable except in the more inaccessible regions. In special areas, where the peat has accumulated without the admixture of much foreign material, it may be of local importance to prospectors. The long period required to dry the peat and its low fuel value will always be drawbacks to its extensive use.

GRAPHITE.

On the southern face of the Kigluaik Mountains the presence of graphite has been known for some time. The occurrence is interesting, for, as has been pointed out by Moffit,[a] there are three distinctly different associations of this mineral. Aside from the scientific interest attaching to this locality, it is of no present importance. On the north side of the mountains, however, not far from Imuruk Basin (locally called Salt Lake), there is another occurrence of graphite which has been recently exploited. At this place a series of very graphitic layers is interlaminated with more quartzose schists. Much of the graphite is obtained in blocks 2 feet in length and a foot in thickness, practically unmixed with foreign material. It is claimed that with rough hand sorting a very high grade ore can be obtained from the group of claims. The owners have already transported several tons of the ore to tide water and expect to ship it for sale in the States. The price of graphite is usually about 4 cents a pound, although there is considerable fluctuation, as the market is small. It would be well, however, to sample the properties on a thoroughly commercial basis before calculating the value, for much of even the high-grade Ceylon graphite contains 10 to 15 per cent of impurities.

MICA.

Mica is another of the nonmetalliferous products that has invited some attention in this region. In the Kigluaik and Bendeleben mountains there are a series of granite and pegmatite dikes which cut the later basic intrusives of the Kigluaik group. As is characteristic of many pegmatites from other parts of the world, the crystals of the component minerals are extremely large. Under such conditions some of the micas are large enough to have commercial value. At the present time the only place in Seward Peninsula where mica has been exploited is in the Bendeleben Mountains. Specimens of the product from this place show that the mica is of light color and that from selected pieces plates 5 or 6 inches square could be obtained. The inability to utilize the by-products and the high cost of mining and transportation will prevent the development of the properties in the near future.

[a] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 139–140.

THE SEWARD PENINSULA TIN DEPOSITS.

By Adolph Knopf.

INTRODUCTION.

The known Alaskan tin deposits that are of a character sufficiently encouraging to warrant prospecting are limited to the extreme western part of Seward Peninsula, and are embraced in an area of about 400 square miles. Four localities are at present being prospected. These are Ear Mountain, Buck Creek, Cape Mountain, and Lost River, named in order from north to south. Ear Mountain is isolated from the other three localities, which are grouped together in what is known as the York region.

The York tin deposits were examined by Collier in 1903 [a] and 1904,[b] and by Hess in 1905.[c] No member of the Geological Survey visited the region in 1906. Numerous reports indicated that extensive development work was in progress. Owing to this fact and to the fact that the earlier examinations had been limited on account of lack of time, it was deemed advisable to make a more detailed investigation of the tin deposits in 1907. With this purpose in view the writer was instructed to examine all known occurrences of tin in Seward Peninsula and to give special attention to the origin of the ores and the commercial importance of the field. A summary of results is herewith presented, wherein it is shown that the mode of the origin of the ores has a direct bearing on the economic importance of certain types of tin deposit that are now being prospected. A more detailed report, embracing the scientific results of the investigation, is in course of preparation.

The various localities will be described in geographic order, as already enumerated.

[a] Collier, A. J., Tin deposits of the York region, Alaska: Bull. U. S. Geol. Survey No. 225, 1904.

[b] Collier A. J., Recent development of Alaskan tin deposits: Bull. U. S. Geol. Survey No. 259, 1905, pp. 120–127.

[c] Hess, F. L.,The York tin region: Bull. U. S. Geol. Survey No. 284, 1906, pp. 145–157.

EAR MOUNTAIN.

Ear Mountain is located in the northwestern part of Seward Peninsula, in latitude 66° north, longitude 166° west. It is 50 miles north of Teller and 15 miles south of Shishmaref Inlet. The mountain has long, smooth profiles on the northern and eastern sides, but on the southern and western sides rises abruptly from the tundra-covered plateau which lies at an elevation of 1,000 feet. It is flat topped and attains a maximum elevation of 2,308 feet.

The only cassiterite obtained by the writer from Ear Mountain was stream tin from Eldorado Creek on the northeastern side of the mountain. No tin ore in place could be seen. Attention has lately been directed to some occurrences of yellow copper pyrites and galena along the contact of the granite of Ear Mountain and the rocks that have been intruded by it.

GENERAL GEOLOGY.

The core of Ear Mountain consists of a large intrusive mass of coarse-grained granite. Radiating from this main body of granite are numerous tongues of fine-grained white granite which have been injected into the surrounding sedimentary rocks. These are prevailingly of a limy character, comprising crinkled limestone and lime-mica schists, gashed with numerous quartz stringers. On the south side of the mountain the rocks are more siliceous and include quartzites and black siliceous schists. The youngest rocks of the region are a system of quartz porphyry dikes cutting both the limestones and the granites. The two most prominent of these dikes have a thickness of 15 feet and can be traced for several thousand feet. They strike N. 30° E. and north and south, according to the compass.

The granite of Ear Mountain consists of well-formed feldspars and dark, smoky quartz crystals embedded in a finer matrix of feldspar, quartz, and black mica. The smoky quartz crystals are a characteristic feature of the granite, and have not infrequently been mistaken by the prospector for cassiterite, especially when the color is more intense. In addition to the minerals named, black tourmaline occurs very abundantly. It is, however, usually connected with narrow seams that traverse the granite. These seams consist of quartz and tourmaline and are adjoined by a band of altered granite 2 or 3 inches broad. This alteration has been produced by the introduction of numerous tourmaline needles which have grown at the expense of the earlier-formed feldspar. The quartz-tourmaline seams, on account of their resistance to atmospheric attack, weather out in relief. Several such seams can be seen running up and down the "Ears"—the granite monoliths responsible for the name of the mountain.

The offshoots from the main granite body are finer-grained and lighter-colored granites. They contain, besides quartz and feldspar, white mica and, in many places, numerous small three-sided prisms of tourmaline.

MINERAL OCCURRENCES.

The granite has exerted considerable influence on the sedimentary rocks that surround it, and the line of contact is marked by a belt of rocks of distinct character. Numerous minerals, such as garnet, vesuvianite, and tourmaline, make their appearance in this contact zone. They are due in part to a recrystallization of the material of the sedimentary rocks under the influence of the heat furnished by the granite and in part to an accession of new material by emanations from the granite during its period of cooling. In addition to the tourmaline, axinite, and other contact-metamorphic minerals, the contact rocks are flecked at certain localities with galena, chalcopyrite, and a lustrous coaly black mineral, an iron borate—a mineral new to science and as yet unnamed. It is this type of rock which has raised hopes that copper and lead deposits of economic value exist at Ear Mountain. Tin-bearing rock also is believed by the prospectors to occur along the contacts.

The practical importance of understanding how these deposits were formed arises from the fact that (1) the size and persistence of the deposits and (2) their probable value are dependent on the mode of origin.

Under the first heading attention may be drawn to certain structural features of the granite boss of Ear Mountain—features which occur also at Cape Mountain and at Brooks Mountain. It can be shown from various lines of evidence that any such granite mass as that of Ear Mountain must have cooled under a considerable blanket of protecting rocks. The surface of the granite against these overlying rocks is not necessarily smooth, but may be gently undulating, or may even contain sharp ridges, such as, for instance, have been revealed by the extensive mining operations in Cornwall. The troughs or depressions between these granite ridges will be occupied by the overlying rocks, which will thus appear immersed beneath the general surface of the granite. At Ear Mountain erosion has proceeded far enough to strip off much of the protective capping of sedimentary rocks which formerly arched over the granite, though on the highest peak—the south peak—the granite is still covered under a thickness of 100 feet of schists. (See fig. 5.) This erosion has revealed the fact that the former surface of the granite boss was slightly uneven. The limestones and schists resting in these inequalities now occur as isolated patches surrounded on all sides by granite. The section across Ear Mountain at Eunson's shaft (fig. 6) will illustrate this feature. These rocks may show local indications of ore, but the ore rock, being of contact-metamorphic origin, will have a small areal extent, will have no great depth, and will give out when the underlying surface of the granite is reached. The prospector, therefore, should use considerable caution before attempting any exploitation of ore bodies occurring in such patches of rock lying upon the surface of the granite.

Along the periphery of the granite the ore deposits of contact-metamorphic origin are more likely to have permanence in depth. What

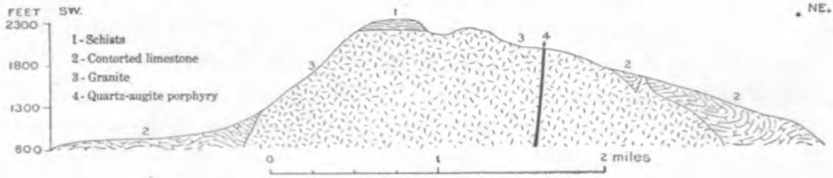


FIG. 5.—Section across Ear Mountain, Seward Peninsula.

is known of contact-metamorphic deposits in other parts of the world, however, is not of a character to encourage extravagant hopes for the similar occurrences found at Ear Mountain. They are usually of low grade and irregular in form. Such deposits are mined in southeastern Alaska for their copper contents, but conditions must be exceptionally favorable to make them of commercial value.

On the northeastern side of the mountain, near Vatney's cabin, the contact metamorphism has been more pronounced than usual. Some metamorphosed limestone in proximity to a granite dike was being

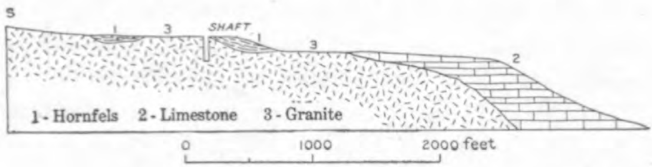


FIG. 6.—Sketch section at Eunson's shaft, Ear Mountain, showing patches of hornfels resting upon granite.

prospected for tin ore. It contains small bunches of a reddish-brown mineral showing crystal faces, which, when carefully examined, are seen to be diamond shaped. This is typical of garnet. When only the apex of the garnet crystal is visible it bears an exceedingly deceptive resemblance to the four-sided pyramid characteristic of cassiterite.

The quartz-tourmaline seams that cut the granite have already been described. At various places on Ear Mountain interlacing networks of such seams occur, and an extensive tourmalinization of the adjoining granite has taken place. Masses of quartz-tourmaline rock have been produced, little resembling the original granite. Such occurrences have been opened up by shallow prospect pits at a number of points. It is quite possible that some deposits of this character may carry low-grade values of tin, but those opened thus far lend small encouragement to this idea. The principal basis of faith, as it exists in the locality, is the presence of abundant tourmaline. It is rather generally held throughout this part of Seward Peninsula that tourmaline is an infallible indication of tin ore. It is true that cassiterite is usually accompanied by tourmaline, but it is emphatically not true that tourmaline is usually accompanied by cassiterite. Tourmaline is of world-wide distribution, and extensive occurrences are known which contain no traces of tin. It would, therefore, appear advisable to proceed cautiously on the tourmaline prospects of Ear Mountain.

The quartz porphyry dikes merit detailed description, inasmuch as they have been actively prospected for tin ore. They consist of dense-textured rock of dark-blue or green color in which are set numerous large crystals of white feldspar and smoky quartz. In addition to these, but occurring in lesser abundance, are augite of a peculiar brownish color and lustrous crystals of black mica. Many of the augites attain unusually large dimensions—as much as 2 inches or more—and are commonly regarded as "tin crystals" by the local prospectors.[a] The presence of these augite crystals, thus mistaken for cassiterite, has led to considerable prospecting of the quartz porphyry dikes. No cassiterite was visible in the specimens submitted to the writer, and he could detect only the minutest grains in the thin sections studied under the microscope. Moreover, chemical analysis of "ore" samples, made in the laboratory of the Survey, showed the presence of traces of tin only, amounting to a few hundredths of 1 per cent.

On the northeast side of Ear Mountain an augite-quartz porphyry dike has been opened by a shaft and explored by a drift 112 feet long. Nothing but hard barren rock was encountered. Work was suspended, and at the time of visit the shaft was flooded with water. Farther southwest, on the extension of the same dike, a number of open cuts have been made on account of the prevalence of numerous large augite crystals embedded in the dike rock.

A shaft known as Eunson's shaft was sunk near the point where a quartz porphyry dike striking north and south crosses the granite-limestone contact. The shaft was reported to be 30 feet deep, but at the time of visit was flooded with water and partly caved in. On the dump a variety of rock is represented. Contact-metamorphosed limestone, granite, granite porphyry, quartz porphyry, and various

[a] Augite is approximately half as heavy as cassiterite and is easily distinguished from that mineral by the fact that it is rather readily fusible before the blowpipe. Cassiterite is entirely infusible.

altered modifications of the quartz porphyry appear. The quartz porphyry is partly tourmalinized and contains small patches of purple fluorite. Arsenopyrite is rather abundant. The tin ore reported from this locality probably came from highly altered portions of the quartz porphyry dike.

BUCK CREEK.

GENERAL GEOLOGY.

The bed rock of the Buck Creek area consists of slates, many of which are poorly fissile and resemble shales. Some greenstones are associated with the slates, but can rarely be found in place. A prominent exposure of greenstone, however, forms a low ridge just north of Buck Creek. The slates dip prevailingly at low angles. The slaty cleavage is developed in an irregular and variable degree in different parts of the area. Much of the rock is shaly looking, but at other points, such as at the head of Sutter Creek, the slates are thinly fissile and the cleavage is at right angles to the sedimentary banding.

Two quartz porphyry dikes cut the slates at the head of Buck Creek. The characteristic feature of these dikes, especially of the one running northward from Potato Mountain, is the number of large, fine glassy quartz crystals set in a light-gray groundmass. The margins of the dikes have been strongly chilled and show a bluish-black rock containing small crystals of quartz and feldspar. Where the dikes are thin they consist entirely of this kind of rock. As is usual in this part of Seward Peninsula, these quartz porphyry dikes have been prospected for tin, and a number of cuts have been opened on them. One of these cuts shows a dike 10 feet wide, somewhat impregnated with pyrite, especially in the vicinity of seams. A small amount of tourmaline in radial groups and a little white mica also appear. Some specimens containing cassiterite have been obtained, but they appear to be of extremely rare occurrence.

The largest porphyry dike, which has a maximum thickness of 50 feet, trends N. 35° W. (magnetic) across the country. It has been faulted approximately 400 feet along the north-south line. The line of this fault is marked by a great quartz vein, 15 feet or more in thickness, which can be traced for considerably more than a mile. The vein contains a vast number of slate fragments, and each of them has acted as a nucleus around which quartz crystals commenced to grow. Failure of the crystals to coalesce in their outer extremities has produced a vuggy vein structure lined with innumerable hexagonal pyramids of quartz. No minerals, with the exception of some botryoidal limonite incrusting the quartz crystals, have been observed in the vein, so that it is without economic importance.

DEVELOPMENTS.

On the ridge of hills at the head of Buck Creek a prospect hole at an altitude of 1,140 feet discloses a fine showing of tin quartz. The claim, known as the "Eureka," is situated on the summit of the ridge. The hole is 10 feet deep, and exposes a face of 7 feet of quartz, carrying a considerable percentage of cassiterite. The quartz is milk white and of greasy luster, and the cassiterite occurs disseminated through it in crystalline aggregates, intimately intergrown with arsenopyrite and small needles of blue tourmaline. Developments on this property are at present inadequate to give either dip or strike of the ore body with any degree of certainty. The depth attained is not great enough to expose solid bed rock. The wall rock is still in a highly shattered condition, due to the heave of the frost. About 60 feet from the prospect hole croppings show that the country rock (slate) is lying nearly horizontal.

At numerous points on the same ridge of hills open cuts have been made exposing networks of quartz stringers in the slates. Some carry cassiterite and some merely show small rosettes of blue tourmaline. At the head of Peluk Creek a shaft 20 feet deep was sunk on stringers in the slate. The quartz on the dump shows abundant pyrite and here and there some cassiterite.

In the vicinity of this last-mentioned occurrence float tin ore has been picked up in which the cassiterite occurs in a totally different mineral association. It is found in a green rock, composed largely of radiating groups of actinolite. Under the microscope some finely granular calcite is found to be associated with the actinolite. Arsenopyrite, in amounts greatly exceeding the cassiterite, is very abundant. A number of open cuts have been made in the effort to locate the bed-rock source of this tin ore. At the time of visit the owner had just succeeded in uncovering the edge of the deposit in place, so that no facts are available as to its probable value. It is apparently lying flat and seems to represent a stratum of limestone interbedded between impervious slates and now highly altered by the action of tin-bearing solutions.

CAPE MOUNTAIN.

Cape Mountain forms the promontory fronting Bering Strait at the westernmost extremity of the American continent. On the eastern flank of the mountain are a few scattered houses, which form the settlement known as "Tin City." Tin City is 110 miles by steamer route from Nome, with which it is now connected by telephone.

GENERAL GEOLOGY.

Cape Mountain consists of a granite mass which has invaded a series of crystalline limestones of Carboniferous age. The limestones are lying nearly flat, but with a slight easterly dip. They extend eastward nearly to the mouth of Baituk Creek, where they are faulted against the York slate of undetermined age. At the cape the limestones dip in toward the granite. Some siliceous schists are associated with the limestones. Their main development is in the capping forming the summit of Cape Mountain, where they are 300 feet thick. Some narrow dikes of basalt cut the granite as exposed in mining operations.

The granite of Cape Mountain is a coarse-grained gray rock, strongly porphyritic, containing numerous large crystals of feldspar. The essential minerals making up the granite are, in addition to the feldspar, quartz and black mica. Along the contact with the limestone the feldspars are aligned with their longer axes parallel. More commonly, however, the granite becomes fine grained along its margin, and fluorite, tourmaline, and white mica appear. A number of dikes, standing nearly vertical, cut the rocks surrounding and overlying the granite. In addition, horizontal sheets of granite have been forced in between the limestone beds. These features tend to increase the irregular character of the contact surface between the limestones and the granite. Some limestone masses were broken off from the roof which covered the granite at the time of its intrusion and partly sank into the molten rock. An isolated limestone patch which had this origin rests in the granite near the head of Lagoon Creek. Attention is drawn to these foundered blocks of limestone, because, if any ore occurs along their contacts, it can have only a meager distribution. The principal effect of the intrusion of the granite on the surrounding limestone has been to coarsen its grain and to produce a coarse white marble, extending at a maximum 200 or 300 feet from the contact. Proximity to the granite contact is indicated in many places by the peculiar rough appearance of the limestone, due to the development of small patches of lime-silicate minerals, ordinarily invisible to the eye. These weather out in relief and give the limestone a characteristic "shaggy" appearance near the granite. Contact metamorphism is relatively rare, and is confined mainly to the limestone adjoining the dikes.

ORE DEPOSITS.

Tin ore occurs in three ways at Cape Mountain—(1) in tourmalinized granite dikes and peripheral portions of the main granite mass; (2) in contact-metamorphic rock; (3) in veins in granite and as an impregnation of the adjoining wall rocks. The miner makes no distinction between the first and second modes of occurrence. In general it may be said that the ore of the first type is apt to be of low grade, and that the second is an unlikely source of tin ore. The third is the normal type of lode tin the world over.

Some of the dikes cutting the limestone show margins which are strongly tourmalinized. Large masses of bluish tourmaline occur, and some of these carry rich bunches or pockets of tin ore. The limestone adjoining the dikes has here and there been converted into coarse white spar in which numerous prisms and columns of tourmaline are embedded. In places it is difficult to discriminate between tourmalinized limestone and tourmalinized dike rock. The tourmalinization, however, appears to be purely local and erratic in occurrence. Furthermore, the tourmaline, though, as already stated, in some places rich in cassiterite, is in general quite barren.

The contact rocks adjoining the main granite mass and some of the granite sills have been prospected at a number of places. A heavy green rock, here and there showing pyrrhotite, has been regarded as tin ore, but microscopic and chemical analysis fail to reveal

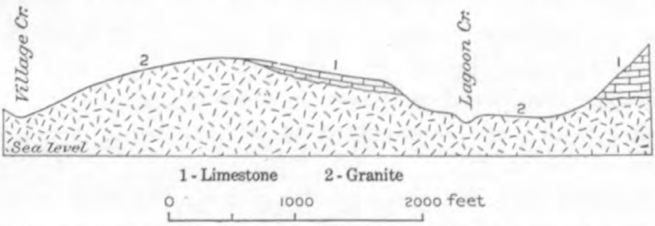


FIG. 7.—Section across Lagoon Creek, Cape Mountain, one-half mile below Canoe claim, showing thin capping of limestone resting in granite.

any tin. The green rock is locally known both as " greenstone " and as " tinstone." It is a finely granular rock consisting of augite and fluorite in equal proportions. This rock is well exposed in a cut on the Canoe claim, where a few feet of it directly overlie a granite sill 8 feet thick. At other points on Cape Mountain, notably half a mile north of the Lucky Queen, the augite is embedded in calcite. The augite, which is unusually well developed for a contact-metamorphic rock, is of brown color and does not look unlike cassiterite. Where tin is suspected in such rocks, assays can give the only reliable information.

The statements regarding deposits of contact-metamorphic origin made for the Ear Mountain region are equally applicable to Cape Mountain. (See fig. 7.) In addition, the highly irregular nature of the granite contact makes prospecting for such deposits difficult, and would entail heavy and probably unwarrantable expenses in mining them.

Up to the present time a single narrow quartz vein has been found in place, cutting the granite on the north side of Cape Mountain at an altitude of 1,850 feet. The vein is accompanied by some alteration to greisen and by partial tourmalinization of the adjoining granite—changes characteristic of tin-bearing veins. At other points on Cape Mountain cassiterite accompanied by tourmaline is found as an impregnation of the granite adjoining slips or fault planes. This type of occurrence, in the opinion of the writer, holds out greater possibilities for the future of the district as a tin producer than do the other two. Unfortunately exploratory work has been confined mainly to the contact deposits.

DEVELOPMENTS.

At the time of visit two properties only were being actively worked—those of the United States Alaska Tin Mining Company and the Bartels Tin Mining Company. The former property is situated near the summit on the north side of Cape Mountain. Developments up to the end of July, 1907, consisted of a shaft reported to be 22 feet deep, now filled with water, and a 7-foot tunnel 270 feet long. The company has also erected a 10-stamp mill near the beach at Tin City. Four men were employed at the time of visit. The shaft is sunk upon a quartz ledge 1 foot thick, striking N. 45° W. (magnetic) and dipping 80° E. The tunnel, whose altitude is 1,600 feet according to aneroid, is driven in a direction S. 40° W. through hard, firm granite and is expected to tap the ledge 250 feet below the collar of the shaft.

The main development work by the Bartels Tin Mining Company has been done on the North Star property. Eight men were employed during the summer of 1907. The main tunnel with its drifts and winzes aggregated 750 feet in length. This tunnel is being driven to catch the granite-limestone contact at a depth of 100 feet below the workings of the Lucky Queen tunnel. About 400 feet from the mouth of the tunnel a band of granite was encountered carrying numerous visible crystals of cassiterite, associated with some tourmaline. The width of this band is about 18 inches. The granite is soft and iron stained. The succeeding 3 feet consists of gray hard granite carrying pyrite disseminated through it. This is followed by 15 feet of iron-stained granite. At the time of visit the 18-inch belt of rich tin ore had not been drifted on to prove its persistence. The drifts branching off from the main adit follow the contact of a large limestone block which was evidently torn off from the main limestone mass during the intrusion of the granite. In following this contact, which proved to be of a highly irregular nature, several winzes were necessary.

A new tunnel, 67 feet below the North Star tunnel, is being run from the surface to connect with the lowest drifts reached by these winzes. The granite along the limestone contact is charged with numerous radiating groups of tourmaline prisms, with iron oxide, and locally with pyrite and tin ore. Some crushing has taken place along the contact, and heavily iron-stained gouge matter, a foot in thickness, has been produced. At points where the red clayey material is absent the granite is fresh and the progressive increase of fineness of grain as the contact is approached can be noted.

A considerable portion of the energies of the company has been expended on assessment work on the numerous claims which it holds on Cape Mountain.

LOST RIVER.

Lost River is a small stream rising near Brooks Mountain in the northwestern part of Seward Peninsula and flowing southward into Bering Sea. The tin prospects of this region are located 6 miles from the coast on Cassiterite Creek, a branch of the river.

GENERAL GEOLOGY.

The bed rock of the Lost River region is prevailingly limestone, known as the Port Clarence limestone, which has been determined on fossil evidence to be of Silurian age. The Port Clarence limestone dips to the north at an angle of about 20°, and in this region has a thickness of not less than 2,000 feet. Two types of rock can readily be distinguished. One consists of a dark leaden-gray limestone forming massive beds. It breaks into large blocks and on fracture appears somewhat crystalline. The other is ashy gray in color and is of dense texture, like lithographic stone. It breaks readily into large thin slabs and many of these are covered with fragments of fossil seaweeds. Some shale is locally associated with the limestone. Near the head of Cassiterite Creek the limestone is intimately banded with shale and intensely crumpled.

On Tin Creek, another tributary of Lost River, a small granite boss a third of a mile in diameter is intruded into the limestone. Its principal effect has been to convert the surrounding limestone into a white marble, though locally some large masses of contact-metamorphic minerals have been formed, consisting chiefly of brown garnet and vesuvianite. A considerable number of quartz porphyry dikes pierce the limestone. They are fairly persistent and can be traced for several miles across the country. The quartz porphyries are light-colored rocks containing small glassy quartz crystals embedded in a matrix irresolvable by the naked eye. The main tin prospects of the region occur in highly altered dikes of this character. The various other dikes have all received separate names and have been more or less prospected, on what encouragement, however, the writer is unable to understand. They are usually unmineralized, except for sporadic cubes of pyrite, and there is no known reason why they should become tin bearing with depth.

CASSITERITE PROSPECTS.

At Tin Creek some thin quartz-cassiterite stringers have been found in the granite. Collier has shown that some pyritiferous granite from the same locality contains 0.3 per cent of tin. A cut has been opened on this occurrence and shows a number of narrow bands of altered granite carrying finely divided pyrite and arsenopyrite.

The principal tin prospects are located on Cassiterite Creek and occur in the quartz porphyry dike known as the Cassiterite lode. This dike is 6 to 10 feet thick and can be traced from the head of Tin Creek in a northwesterly direction over to Lost River, a distance of 9,000 feet. The conspicuous features of the dike rock are its white color and the numerous fine crystals of quartz embedded in it. The quartz porphyry dike has broken through an older dike, a feldspar porphyry, along a portion of its course.

The tin-bearing portion of the dike has a maximum length of 3,000 feet. This portion is marked by a large amount of alteration, a highly varied mineralization, and an intense seaming of the adjacent limestone with innumerable veinlets. The tin ore contains cassiterite and wolframite, associated with iron oxide, pyrite and arsenopyrite, some molybdenite, and rarely a little galena and sphalerite. The gangue material consists of kaolin, quartz, fluorite, zinnwaldite, topaz, and calcite, though all are not present together. The richest tin ore is associated with quartz and lithia mica seams an inch or so in thickness, cutting the quartz porphyry. Considerable alteration has taken place in the rock adjoining the seams, and cassiterite occurs as an impregnation in belts parallel to the stringers. Wolframite is constantly associated with the cassiterite, and though no actual tests have been made, it is probable that the tungsten content of the lode is as valuable as the tin. Where no such seams occur the quartz porphyry is hard and barren and contains no cassiterite. The dike is intensely and irregularly slickensided. Clay gouge is common and the whole mass of rock is stained red with iron oxide. The limestone wall rock, however, is firm and hard. It is considerably impregnated with fluorite, which glows with a greenish light when struck with the pick. No cassiterite appears in the wall rock.

A few hundred feet north of the Cassiterite lode is another quartz porphyry dike, known as the Ida Bell lode. It is about 35 feet thick on the summit of the hill between Lost River and Cassiterite Creek. The rock is dense and fine grained. In the vicinity of Cassiterite Creek stringers of quartz and cassiterite with some wolframite, an inch or so in thickness, cut the porphyry dike. The alteration that is so characteristic a feature of the Cassiterite lode is conspicuously absent from the Ida Bell quartz porphyry dike.

At the time of visit five tunnels had been driven on the Cassiterite lode, three of which were open and could be examined. Tunnel B, 260 feet above Cassiterite Creek, was 180 feet long. The tunnel follows the southern margin of the dike and is partly in limestone. At 45 feet from the mouth a drift has been run 10 feet to the north, crosscutting the lode. Tunnel A 1, 170 feet above the creek, was 80 feet long. The dike rock is soft and can be augered, so that an advance of 4 feet per day (single shift) is easily made. Both these tunnels are on the east side of Cassiterite Creek. On the west side is Tunnel E, 100 feet long. A 9-foot crosscut has been driven 50 feet from the mouth of this tunnel. From the foregoing statements it is apparent that developments are substantially the same as recorded by Hess [a] for 1905.

One mile north of the Cassiterite lode is another tin-bearing quartz porphyry dike which has been named the Dolcoath lode. It is from 2½ to 3 feet thick, strikes N. 50° E. (magnetic), and dips 65° NW. This dike differs considerably from the two previously described, both in its mineralogy and in the mode of occurrence of the tin ore. It is so highly altered that its original quartz porphyry character is not readily apparent. Some movement has taken place along the walls of the dike, especially on the hanging wall, forming a crush zone 1 to 6 inches thick. The dike rock is heavily charged with arsenical pyrites and tourmaline and contains some cassiterite disseminated through it. The limestone wall rock has been converted into coarse white spar, much of which contains numerous small white prisms of tremolite. Cassiterite occurs embedded in this spar, and is locally somewhat rich. These bands of wall rock carrying tin ore, occurring on both foot and hanging walls, are nowhere more than 6 inches thick. Cassiterite also occurs in the wall rock intimately intergrown with pocket-like masses of danburite, which is a borosilicate related to topaz. The Dolcoath dike has been opened by four cuts, of which the extremes are 3,000 feet apart. An assay of ore from one of the crosscuts was reported to have yielded 1.15 per cent of tin.

A highly interesting mineral deposit, occurring opposite the mouth of Tin Creek, on the ridge between Lost River and Left Fork, was shown to the writer as a galena prospect. As pointed out at the time, however, wolframite is probably the most valuable part of the deposit and the presence of tungsten has subsequently been verified in the chemical laboratory of the Survey. In addition to the wolframite, considerable galena is present. Much of it is intercrystallized with a brown-black mineral which gives reactions for tin, cop-

[a] Bull. U. S. Geol. Survey No. 284, 1906, pp. 146-150.

per, zinc, iron, and sulphur, and has been identified as stannite. This is the only known occurrence of stannite in the Alaskan tin region. These various minerals occur embedded in a gangue of topaz, with some deep-purple fluorite. The topaz is crystallized in fine radial aggregates, a few of them half an inch in diameter. The high specific gravity of topaz (3.5) accounts for the unusual weight of the ore. Assays are claimed to show also returns in silver.[a] The surface ore is stained black by manganese derived from the decomposition of the wolframite. Some azurite is also present and is doubtless derived from the copper in the stannite. Little has been done to prove this property. The surface indications show that the mineralization has taken place along a fault zone, running east and west, which has been brecciated and recemented. An open cut shows stringers of ore occurring in a belt 1 foot thick, forming a stringer lode.

Stannite is not a valuable ore of tin. Its occurrence in amounts sufficient to form an ore is extremely rare. In only one place in recent years has it been found in such amounts—at the Oonah mine in Tasmania, where an argentiferous stannite is associated with pyrite and chalcopyrite. Here it was mined for silver and copper, and the tin was rejected as waste product. Arrangements were finally made with the smelter that for ore containing at least 8 per cent of tin $5 per ton should be paid in addition to the ordinary returns for silver and copper.[b] Wolframite, which occurs associated with both the cassiterite and stannite of the Lost River region, is valuable for its tungsten content. Wolframite is a tungstate of iron and manganese, the pure mineral containing 76 per cent of tungstic trioxide (WO_3). Tungsten ores which are used for steel hardening are paid for on the basis of their percentage of tungstic trioxide, the present price being about $10 per unit. Ores concentrated up to 60 or 70 per cent would therefore have a value of $600 to $700 per ton. Wolframite is distinguished by its high specific gravity, perfect cleavage, black color, and brilliant submetallic luster on its cleavage faces. It is softer than cassiterite and can be scratched with the knife. In the Lost River region the iron-rich zinc blende of Brooks Mountain resembles wolframite in color and luster, but differs in the fact that its cleavage faces show six different directions, whereas in wolframite all cleavage faces are strictly parallel. In the absence of chemical tests this is the only means of distinction between the two minerals.

[a] Since this paper was written returns from an assay made by Ledoux & Co., of New York, on a sample submitted by the Survey show 22.9 ounces of silver per ton.

[b] Waller, G. A., Report on the Zeehan silver-lead mining field, Govt. Geol. Office, Tasmania. 1904.

PLACERS.

BUCK CREEK.

Developments subsequent to 1905 have revealed few new facts of interest in regard to the placers of Buck Creek. The gravels have a length of about 4 miles and are of shallow depth. Work below the mouth of Sutter Creek has shown that the gravel is from 120 to 160 feet wide, averaging about 125 feet. A pit averaging 5 feet in depth has shown that the gravel may run as high as 25 pounds of concentrates per cubic yard. The richest gravel rests immediately upon bed rock and is exceedingly clayey and toughly bound together. It gives difficulty in washing, the clay having a tendency to roll up in balls and carry cassiterite nuggets over the sluice boxes. The bed rock is a broken shale or slate that is very clayey but contains no cassiterite. On Sutter Creek, the large southern branch of Buck Creek, there is a considerable body of gravel, and the discovery of stream tin has recently been reported. The other tributaries, gulches, and "benches" of Buck Creek contain little or no gravel, at least in amounts sufficient to warrant any considerable outlay for the purposes of placer mining.

The stream tin of Buck Creek is clearly derived from the erosion and concentration of the cassiterite occurring in the quartz stringers so abundant throughout the area. This source was partly supplemented by the cassiterite occurring in the actinolite rock, and to lesser extent by that contained in the quartz porphyry dikes. As these bed-rock sources are known to occur in place on the summit of the hills, at the head of Buck Creek, it is probable that the creeks flowing into Lopp Lagoon carry stream tin. But whether cassiterite is present in paying quantities is purely a matter of accurate sampling and not of opinion or theory.

Two companies were in operation on Buck Creek during the last season, but on account of the number of adverse circumstances the output was less than anticipated. Placer mining was confined to a small strip just below the mouth of Sutter Creek. The production for the season was approximately 50 tons.

At the beginning of the season the American Tin Mining Company was working its ground by means of an automatic scraper and belt conveyor operated by a 35-horsepower oil-burning engine. Early in August, however, extortionate freight rates on the transportation of crude oil from Nome to York and the imperfect adaptation of the scraper to the character of the gravel necessitated a change in the method of working. Shoveling in was then resorted to, with results at least more satisfactory than those attained with machinery.

GROUSE CREEK.

Assessment work was done on a number of claims on Grouse Creek and two of its tributaries, Sterling and Skookum creeks. The results are not known. Some gold sifted out of the concentrates from Sterling Creek was flat and coarse, not greatly waterworn, and with quartz still adhering to it.

FAIRHAVEN DISTRICT.

A sample of black-sand concentrate sent in for determination from Humboldt Creek proved to be a very rich tin ore, containing less than $5 per ton in gold. About two-thirds of the sample was pyrite. Another sample sent in from Kougarok River was found to contain considerable cassiterite, but far less than that from Humboldt Creek. It contained, however, 85 ounces of gold per ton. The sample was two-thirds pyrite and contained about 10 per cent of magnetite. As the headwaters of Humboldt Creek drain the Hot Springs granite area, the tin was probably derived from that region. Collier states that samples of tin ore purporting to come from it were brought to Nome late in the season of 1902.

RÉSUMÉ AND CONCLUSIONS.

The Alaskan lode tin deposits are associated with granitic intrusives. The ore occurs in a variety of ways:

(1) In highly altered quartz porphyry dikes.

(2) In tourmalinized margins of granite masses and granitic dikes.

(3) In contact metamorphic deposits.

(4) In quartz stringers cutting slates and limestones.

(5) In quartz veins cutting granite and accompanied by impregnation of the adjoining granite.

(6) In beds of actinolite rock interstratified with slates.

Inasmuch as the granite intrusives have in many places profoundly modified the sedimentary rocks surrounding and enveloping them, with the production of numerous unusual and heavy minerals, it has happened that the contact-metamorphic deposits have received the most attention. This tendency to regard the contacts as favorable ore horizons has been strengthened partly by the fact that some rich masses of tin ore have been found near tourmalinized limestone, and partly by the deceptive resemblance which the heavy contact minerals, such as garnet, bear to cassiterite. The chances of finding workable tin mines in deposits of this type are, however, extremely slight. Quartz porphyry dikes, locally known as lodes or even as quartz veins, have received considerable attention owing to the fact that the original discovery of lode tin in Alaska was made on a highly altered dike of this character. The unwelcome fact should be speedily realized that few of these dikes hold out any inducements whatever as prospective tin producers. Of the other types of occurrence, some of which are of promising character, it can be said that, from the point of view of the conservative mining man, their value remains yet to be proved.

Developments throughout the region are for the most part still in the prospecting stage. Many of the open cuts have not reached solid bed rock. No tonnage of ore, with one exception on Lost River, has yet been blocked out. It follows, then, that, on account of inadequate development, no data are available for a safe estimate of the future commercial importance of the Alaska tin deposits. The region is plainly not "a poor man's country," but appears, however, to offer a limited field for cautious exploration by capital.

The placer deposits, and those from a single stream only—Buck Creek—have so far supplied the bulk of the Alaskan tin.

THE MINERAL DEPOSITS OF THE LOST RIVER AND BROOKS MOUNTAIN REGION, SEWARD PENINSULA.

By Adolph Knopf.

INTRODUCTION.

Lost River is a small stream rising in the heart of the York Mountains, in the western part of Seward Peninsula. It flows southward into Bering Sea and has a total length of 9 miles. Its valley is broad and open and furnishes a good wagon roadway. The region is destitute of vegetation, even the arctic mosses being scarce. The general geologic features are described in the preceding paper. The Lost River region displays a varied mineralization, and prospecting has disclosed, in addition to the tin deposits previously described, occurrences of silver-lead, tungsten-lead, copper, and perhaps gold deposits.

ALASKA CHIEF PROPERTY.

The Alaska Chief is situated 4½ miles from Bering Sea on Rapid River, the large western branch of Lost River. The workings are located on a small gulch tributary to Rapid River. The country rock in the vicinity of this property is a tough, fine-grained limestone, lying nearly horizontal. Locally the strata are buckled and show crushing in the crests of the buckles. A fault breccia, 15 feet wide, consisting of small angular fragments of limestone cemented together by white calc-spar, is exposed in the creek one-third of a mile west of the mine. Basalt, in the form of a narrow dike 1 foot thick, is the only other rock known to be in place in the near vicinity. A few thousand feet to the east a number of quartz porphyry dikes can be seen cutting the limestone.

The original shaft was sunk on a heavy body of porous red iron oxide containing galena, reported to be 12 feet thick. At a depth of 35 feet work was suspended. An adit, 143 feet long, driven 85 feet below the collar of the shaft, encountered the same ore body 50 feet below the bottom of the shaft. The ore was still oxidized. About 7 feet of low-grade galena ore was exposed.

On the east side of the gulch a devious tunnel, about 600 feet in length, was driven to catch another body of galena indicated on the surface. The tunnel follows a zone of crushed limestone, in many places bounded by fine walls marked with striæ. The "ledge matter" consists of small fragments of limestone bound together by coarse calc-spar, clay, and red iron oxide. No ore was encountered. The tunnel on the west side of the gulch was then commenced, and the ore body already mentioned was struck late in August, 1907.

IDAHO CLAIM.

A few yards below the mouth of Tin Creek a copper prospect has been opened on the edge of the 15-foot bench fronting Lost River. Enough work had been done to expose the face of ore at this point. The deposit occurs in an irregular shatter zone in the limestone, 15 feet wide, and includes numerous horses of unmineralized limestone. The ore mineral is chalcopyrite, associated with abundant pyrrhotite (magnetic iron pyrites), and occurs in a gangue of calcite, fluorite, and small fragments of slickensided rock. Some of the fluorite is rose tinted and is locally known as ruby quartz. Stripping has shown that the same ore body extends at least 50 feet to the east, where a strong gossan has been uncovered. The relatively great width of the deposit, combined with the low chalcopyrite tenor and the large amount of pyrrhotite present, reduces the copper percentage to a small figure.

TIN CREEK.

On Tin Creek a galena prospect has been opened up on some gossan croppings at an altitude of 1,100 feet, or 800 feet above the bed of the creek. The deposit occurs in a fracture zone in the limestone, which has been coarsely recrystallized in the immediate vicinity, forming spar crystals up to an inch in size. The gossan consists of honeycombed masses of iron oxide containing abundant galena and numerous white and colorless crystals of cerusite (lead carbonate). It was planned to prove the value of this deposit during the winter of 1907.

A small trench, 650 feet below the galena prospect, has been dug in the effort to locate the bed-rock source of some loose bowlders composed of arsenopyrite flecked with a small amount of cupriferous pyrite. Assays made in Nome are reported to have yielded $12 to the ton in gold.

On the divide at the head of Tin Creek stibnite associated with a deep-purple fluorite was found by a member of the Survey party.

BROOKS MOUNTAIN.

Brooks Mountain is the dominant peak of the York Mountains, and lies in the watershed of the Bering and Arctic drainages. It is easily accessible from the coast by way of Lost River, a distance of 9 miles. The mineral deposits of Brooks Mountain are all of contact-metamorphic origin.

A large granite mass, 2 miles long by two-thirds of a mile wide, forms the southern flank of the mountain. The rocks surrounding the granite are chiefly limestones, excessively crumpled over much of the region. The granite is characterized by the presence of numerous large crystals of feldspar, commonly an inch in diameter, and large crystals of smoky quartz exceeding peas in size. Through the body of the rock are scattered many small flakes of black mica. Along the margin of the granite mass the granite has been strongly tourmalinized, and large masses of black tourmaline are of common occurrence. Theoretically, it might be expected that such a granite would have exerted a considerable influence on the surrounding rocks. This expectation is completely realized. A great variety of contact-metamorphic minerals have been produced, among which a green or brown-green vesuvianite is the most abundant. Much of the vesuvianite occurs in beautiful crystals embraced in a matrix of white spar, and the interesting discovery has been made that it contains boron, the element characteristic of tourmaline. Among the other minerals produced in the rocks adjoining the granite are garnet, magnetite, argentiferous galena, a brilliant black sphalerite, pyrrhotite, pyrite, arsenopyrite, fluorite, mica, tourmaline, a coal-black iron borate (as at Ear Mountain), a magnesian iron borate, and a fibrous green borate resembling ludwigite. This array of minerals, consisting of numerous species foreign to the prospector's acquaintance and of relatively high specific gravity, has naturally excited some attention, and a number of prospects have been opened on these contact-metamorphic deposits. It seems desirable to repeat the cautions given in connection with the similar types occurring on Ear Mountain. Contact-metamorphic deposits are, as a rule, characterized by extreme irregularity of form; they can not persist into the granite; furthermore, such deposits as occur in small masses of limestone, resting upon or embedded in the granite, can have only a very small extent. It is therefore advisable to consider carefully the geologic surroundings of even the most promising surface indications.

At the west end of the Brooks Mountain granite mass a prospect trench discloses a body of argentiferous galena ore. The deposit occurs 20 feet from the granite contact, in a coarsely crystalline white limestone. The strike of the ore body, as revealed in the open cut, is N. 15° W. (magnetic) and the dip 65° toward the granite. A body of solid ore 3½ feet thick is exposed. The galena is strongly mixed with lustrous black zinc blende. Some pyrrhotite is also present, but is comparatively rare. Where any gangue mineral is visible, it consists of fluorite. The ore body is frozen to both walls. The hanging wall shows a belt of finely granular fluorite several inches thick, succeeded by extremely coarse calcite containing a few crystals of diopside and some galena. The grain of the calcite decreases away from the ore body.

In the vicinity of the galena prospect contact-metamorphic rocks are found containing vesuvianite and a fibrous green boron mineral intercrystallized with galena. It is clear that the galena ore, with its unusual mineral associations, is of contact-metamorphic origin. Assays made in Nome yielded 34 per cent of lead and 11 ounces of silver per ton. Other assays were reported to give an ore value of $17 and $44 per ton.

In the same general locality some contact masses of vesuvianite have been prospected for nickel. The vesuvianite is finely granular and gives the rock a general green color. This feature and the unusual weight of the rock (that is, compared with quartz) are doubtless responsible for the nickel prospecting. No indications of nickel are present, and it may be added that such a mode of occurrence for nickel is totally unknown.

In the canyon below the galena claim some assessment work has been done on a showing of contact-metamorphic minerals. This deposit is interesting from a scientific standpoint, inasmuch as a hitherto unknown boron mineral has been discovered in it, but nothing of commercial importance has been found here. The minerals comprise brown garnet, much of it showing rhombic faces, green or yellowish-green vesuvianite, and abundant magnetite closely associated with the new mineral—a black mineral showing a fine cleavage and a bright submetallic luster. These various minerals are all included in a matrix of coarse white spar.

At the head of the same canyon some more contact-metamorphic deposits have received attention. Here, at an altitude of 2,000 feet, a small prospect hole exposes a mass of metamorphic minerals occurring in a white marble a few feet from the granite contact. Tourmaline, fluorite, calcite, pyrite, arsenopyrite, and brilliant black sphalerite (an iron-rich zinc blende) occur confusedly intergrown. The ore body is 4 feet thick and penetrates the marmorized limestone in irregular tongues. Some galena was noted in the ends of these tongues. The value of this deposit is problematic. A few hundred feet farther north the limestone has undergone an intense contact metamorphism. The resulting product consists of vesuvianite, calcite, and garnet interspersed with minute flakes of mica (phlogopite). Some of this rock contains sphalerite and other sulphurets, which on oxidizing give it a gossan appearance. High gold assays were claimed from this type of rock. Ledoux & Co., of New York, report on an assay sample submitted by the Survey: Gold, trace; silver, 0.23 ounce.

On the north side of Brooks Mountain, at an altitude of 1,850 feet, is located a small galena prospect. The galena occurs in a gossan, the skeleton of which consists of tourmaline. The iron oxide of the gossan contains lead and bismuth.

WATER SUPPLY OF THE NOME AND KOUGAROK REGIONS, SEWARD PENINSULA, 1906-7.

By Fred F. Henshaw.

INTRODUCTION.

The operation of the gold placers in Seward Peninsula had by 1906 reached such a stage of development that its 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 was little exact information as to the available water supply, and many of these hydraulic works have been failures owing to insufficiency of water. Most of these failures could have been averted had reliable data been at hand in regard to stream flow.

For these reasons the United States Geological Survey started systematic measurements of the flow of streams in Seward Peninsula in 1906.[a] Owing to the smallness of the funds available, the work was confined to the southern portion, and especially to the streams from which water could have been taken for working the rich placers near Nome, as shown on the Nome and Grand Central topographic sheets. In 1907 the work in this district was continued and the investigations were extended into the Kougarok region, north of the Kigluaik Mountains.

These investigations consisted in (*a*) determining both the total flow and the distribution of the flow of various streams during the mining season; (*b*) collecting facts in regard to general conditions affecting water supply; (*c*) gathering statistics in regard to the diversion and use of water.

[a] Hoyt, J. C., and Henshaw, F. F., Water supply of Nome region, Seward Peninsula, 1906: Water-Sup. and Irr. Paper No. 196, U. S. Geol. Survey, 1907; Bull. U. S. Geol. Survey No. 314, 1907, pp. 182–186.

MEASUREMENTS.

Discharge measurements were made at 45 points in 1906 and at 42 in the Nome region and 32 in the Kougarok in 1907. The detailed results of these measurements are given in Water-Supply Paper No. 218, from which the following summaries are taken. Table 1 shows the monthly discharge at stations where daily discharges could be computed. Table 2 gives the minimum flow of streams rising in the foothills, in the mountains, and in the Kougarok region. The results are in second-feet. To reduce to miner's inches of 1.5 cubic feet per minute, multiply by 40; for miner's inches of 1.2 cubic feet per minute, multiply by 50.

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7.*

STREAMS RISING IN FOOTHILLS.

NUGGET CREEK AT MIOCENE INTAKE.

[Drainage area, 2.1 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 9–31	12.0	3.8	5.7	2.71	2.32
August	10.6	2.8	6.2	2.95	3.40
September	40	6.8	11.0	5.24	5.85
84 days	40	2.8	7.8	3.71	11.57

JETT AND COPPER CREEKS (COMBINED).

[Drainage area, 2.25 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	40	5.9	17.3	7.69	8.87
August	15	3.9	7.1	3.16	3.64
September	49	2.9	9.6	4.27	4.76
92 days	49	2.9	11.3	5.04	17.27

DAVID CREEK AT MIOCENE INTAKE.

[Drainage area, 4.3 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	76	10.9	32.2	7.49	8.64
August	30	8.9	14.2	3.30	3.80
September	107	8.3	20.7	4.81	5.37
92 days	107	8.3	22.4	5.20	17.81

HOBSON CREEK AT MIOCENE INTAKE.

[Drainage area, 2.6 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
June 28–30	26.7	25.0	25.8	9.92	1.11
July	25.8	19.6	22.6	8.69	10.02
August	20.4	14.3	17.1	6.58	7.59
September	22.3	16.5	19.1	7.38	8.20
95 days	26.7	14.3	19.8	7.62	26.92

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906-7*—Cont'd.

STREAMS RISING IN FOOTHILLS—Continued.

SNAKE RIVER ABOVE GLACIER CREEK.

[Drainage area, 69 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
June 25-30	540	258	401	5.81	1.30
July	308	120	177	2.56	2.95
August	135	77	108	1.56	1.80
September 1-15	540	111	207	3.00	1.67
83 days	540	77	173	2.51	7.72

PENNY RIVER AT SUTTON INTAKE.

[Drainage area, 19 square miles.]

1907.					
July	181	55	78.7	4.14	4.77
August	88	33	59.0	3.11	3.58
September	175	45	71.1	3.74	4.17
92 days	181	33	69.6	3.66	12.52

STREAMS RISING IN KIGLUAIK MOUNTAINS.

NORTH FORK OF GRAND CENTRAL RIVER AT THE FORKS.

[Drainage area, 6.9 square miles.]

1907.					
July 8-31	80	32	48.7	7.06	6.30
August	152	27	58.1	8.42	9.71
September 1-23	238	21	64.7	9.38	8.02
78 days	238	21	57.2	8.29	24.03

NORTH FORK OF GRAND CENTRAL RIVER NEAR DITCH INTAKE.

[Drainage area, 5.4 square miles.]

1906.					
July (17 days)	----------	23	39.9	7.39	4.67
August	71	25	36.7	6.80	7.84
September 1-18	----------	25	31.6	5.85	3.92

NORTH FORK OF GRAND CENTRAL RIVER AT PIPE INTAKE.

[Drainage area, 2.3 square miles.]

1906.					
July 1-4, 20-31	48	21	30.3	13.2	7.86
August	53	19	27.4	11.9	13.7
September 1-18	31	17	22.2	9.65	6.46
65 days	----------	17	26.6	11.6	28.0
1907.					
July 8-31	64	26	39.0	16.9	15.1
August	110	20	43.5	18.9	21.8
September 1-23	171	15	46.5	20.2	17.3
88 days	171	15	43.0	18.7	54.2

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS—Continued.

WEST FORK OF GRAND CENTRAL RIVER AT THE FORKS.

[Drainage area, 7.7 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 8-31	140	42	84.5	11.0	9.82
August	291	42	81.0	10.5	12.1
September 1-23	406	34	100	13.0	11.1
78 days	406	34	87.8	11.4	33.0

WEST FORK OF GRAND CENTRAL RIVER AT DITCH INTAKE.

[Drainage area, 5.4 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1906.					
July 1-5, 10-31	162	22	62.0	11.5	11.5
August	54	21	32.5	6.02	6.94
September 1-18	44	19	25.5	4.72	3.16
76 days	162	19	41.3	7.65	21.6
1907.					
July 8-31	110	28	60.0	11.1	9.90
August	103	35	50.2	9.30	10.7
September 1-23	149	31	50.7	9.39	8.03
78 days	149	28	53.4	9.89	28.6

WEST FORK OF GRAND CENTRAL RIVER AT PIPE INTAKE.

[Drainage area, 2.8 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1906.					
July 1-4, 11-31	72	12	27.0	9.64	8.96
August	30	7.6	13.9	4.96	5.72
September	22	6	9.4	3.36	2.25
74 days	72	6	17.2	6.14	16.93
1907.					
July 8-31	48	12	26.4	9.43	8.42
August	52	11	17.6	6.29	7.25
September 1-23	74	10	20.5	7.32	6.26
78 days	74	10	21.2	7.64	21.93

CRATER LAKE OUTLET.

[Drainage area, 1.8 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1906.					
July 1-5, 10-31	69	8	22.3	12.4	12.4
August	31	5	11.8	6.56	7.56
September 1-18	13	3.1	5.2	2.89	1.93
76 days	69	3.1	14.0	7.78	21.9
1907.					
July 8-31	40	12	24.4	13.6	12.1
August	52	8	26.0	14.4	16.6
September 1-23	106	3.5	21.0	11.7	10.0
78 days	106	3.5	24.0	13.3	38.7

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906-7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS—Continued.

GRAND CENTRAL RIVER BELOW THE FORKS.

[Drainage area, 14.6 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1906.					
July 1-5, 9-31	370	56	144	9.86	10.27
August	210	53	85.2	5.84	6.73
September 1-18	100	47	62.0	4.25	2.84
77 days	370	47	101	6.92	19.84

THOMPSON CREEK.

[Drainage area, 2.5 square miles.]

1906.					
July 1-4, 11-31	52	10	20.5	8.20	7.62
August	40	9	16.6	6.64	7.66
September 1-18	19	5	7.6	3.04	2.10
74 days	52	5	15.7	6.28	17.38
1907.					
July 8-31	87	27	42.2	16.9	15.1
August	50	9	27.0	10.8	12.4
September 1-23	100	5	22.8	9.12	7.80
78 days	100	5	30.4	12.2	35.3

GOLD RUN.

1906.					
July 1-4, 11-31	69	13	29.0		
August	68	15	27.6		
September 1-18	30	10	15.3		
74 days	69	10	25.1		
1907.					
July 8-31	86	18	47.0		
August	90	13	41.1		
September 1-23	120	10	32.1		
78 days	120	10	40.1		

KRUZGAMEPA RIVER AT SALMON LAKE.

[Drainage area, 81 square miles.]

1906.					
May 28-31	3,270	2,180	2,720	33.6	5.00
June 1-7, 23-30	2,520	308	1,160	14.3	8.00
July	2,130	245	571	7.05	8.13
August	475	175	259	3.20	3.69
September	1,455	175	456	5.63	6.28
111 days	3,270	175	610	7.53	31.00
1907.					
June 15-30	2,360	935	1,480	18.3	10.9
July	875	295	548	6.77	7.80
August	555	229	335	4.14	4.77
September	1,560	217	477	5.89	6.57
October 1-5	205	178	187	2.31	.43
113 days	2,360	178	587	7.25	30.47

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS—Continued.

NOME RIVER AT MIOCENE INTAKE.[a]

[Drainage area, 15 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1906.					
July	260	21	51.4	3.43	3.95
August	176	20	50.4	3.36	3.87
September	194	25	64.4	4.29	4.79
92 days	260	20	55.4	3.69	12.61
1907.					
June 15–30	384	124	202	13.5	8.03
July	168	23	72.2	4.81	5.54
August	75	16	32.9	2.19	2.52
September	307	18	58.4	3.89	4.34
108 days	384	16	76.4	5.09	20.43

UPPER SINUK RIVER.

[Drainage area, 6.2 square miles.[b]]

1907.					
July	100	24	52.3	8.44	9.73
August	100	22	45.0	5.49	6.33
September 1–22	160	7	53.7	6.55	5.36
84 days	160	7	50.0	6.86	21.42

NORTH STAR CREEK.

[Drainage area, 2.3 square miles.]

1907.					
July	30	4	14.8	6.43	7.41
August	25	4	8.3	3.61	4.16
September 1–22	40	2	8.9	3.87	3.16
84 days	40	2	10.9	4.74	14.73

WINDY CREEK.

[Drainage area, 12 square miles.]

1907.					
July	140	40	91.5	7.62	8.78
August	125	32	59.2	4.93	5.68
September 1–22	200	15	68.1	5.68	4.65
84 days	200	15	73.4	6.12	19.11

STREAMS IN THE KOUGAROK REGION.

KOUGAROK RIVER AT HOMESTAKE INTAKE.

[Drainage area, 44 square miles.]

1907.					
July 15–31	29	6.3	12.4	0.28	0.18
August	110	3.2	22.8	.52	.60
September 1–20	351	26	79.1	1.80	1.34
68 days	351	3.2	36.8	.84	2.12

[a] These values are the natural flow of the river and have been 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] 8.2 after August 1.

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS IN THE KOUGAROK REGION—Continued.

TAYLOR CREEK AT CASCADE INTAKE.

[Drainage area, 74 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 15-31	186	8	29.9	0.40	0.25
August	186	3.9	54.2	.73	.84
September 1-20	441	35	119	1.61	1.20
68 days	441	3.9	67.1	.91	2.29

KOUGAROK RIVER ABOVE COARSE GOLD CREEK.

[Drainage area, 250 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 14-31	200	33	67.2	0.27	.18
August	490	16	141	.56	.65
September 1-20	1,240	130	388	1.55	1.15
69 days	1,240	16	193	.77	1.98

TABLE 2.—*Minimum daily flow of streams in Seward Peninsula, 1906–7.*

STREAMS RISING IN FOOTHILLS.

Stream.	Elevation.	Drainage area.	1906. Date.	1906. Minimum flow.	1906. Minimum run-off per square mile.	1907. Date.	1907. Minimum flow.	1907. Minimum run-off per square mile.
	Feet.	*Sq. m.*		*Sec.-ft.*	*Sec.-ft.*		*Sec.-ft.*	*Sec.-ft.*
Iron Creek below mouth of Canyon Creek.	450	50	Aug. 14	17.1	0.34	Aug. 11-14	33	0.66
Eldorado River below mouth of Venetia Creek.	400	51	Aug. 14	44	.86			
Jett Creek	800	1.4	Sept. 10	[a]4.2	3.0	Sept. 23	[b]2.9	1.3
Copper Creek	800	.85	Aug. 11	.8	.94			
Nugget Creek	785	2.1	June 28	[c].96	.46	Aug. 10-11	2.8	1.3
David Creek	590	4.3	Aug. 19	3.3	.77	Sept. 30	8.3	1.9
Dorothy Creek	500	2.7	Aug. 18	2.9	1.1			
Hobson Creek	500	2.6	July 4	10.5	[d]4.0	Aug. 19	14.3	5.5
Slate Creek (tributary to Stewart River).	700	2.1	Aug. 19	2.2	1.05			
Stewart River	400	36	Aug. 19	11.4	.32			
Snake River	40	69				Aug. 12	77	1.1
Penny River	120	19	Aug. 1	[a]36	1.9	Aug. 15	33	1.7

[a] Lowest measurements obtained. The flow was less on certain dates.
[b] Jett and Copper creeks combined.
[c] The lowest flow later in 1906 was 3.0 second-feet, or 1.4 second-feet per square mile, on August 11.
[d] The flow of Hobson Creek is from large limestone springs whose catchment area may not coincide with the surface watershed.

TABLE 2.—*Minimum daily flow of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS.

Stream.	Elevation.	Drainage area.	1906.			1907.		
			Date.	Minimum flow.	Minimum run-off per square mile.	Date.	Minimum flow.	Minimum run-off per square mile.
	Feet.	*Sq. m.*		*Sec.-ft.*	*Sec.-ft.*		*Sec.-ft.*	*Sec.-ft.*
North Fork of Grand Central River near ditch intake.	750	5.4	July 1	23	4.3	....	....	....
West Fork of Grand Central River at ditch intake.	850	5.4	Sept. 15–17	19	3.5	July 29	28	5.2
Crater Lake outlet	925	1.8	Sept. 15–17	3.1	1.7	Sept. 22–23	3.5	1.9
Thompson Creek	720	2.5	Sept. 16–17	5	2.0	Sept. 22–23	5	2.0
Grand Central River below forks.	600	14.6	Sept. 16–17	47	3.1	Aug. 15	72	4.9
Grand Central River below Nugget Creek.	455	39	Sept. 16–17	90	2.3	....	....	....
Grand Central River between station below the forks and station at Nugget Creek.	....	24.4	Sept. 16–17	43	1.76	....	....	....
Kruzgamepa River	442	81	Aug. 19 and Sept. 17.	175	2.16	Oct. 5	178	2.2
Crater Creek	550	11	Sept. 16–17	39	3.5	....	....	....
Fox Creek	550	11	Aug. 16	17.3	1.6	....	....	....
Nome River	575	15	Aug. 5	20	1.3	Aug. 15	16	1.1
Buffalo Creek	800	4.4	Aug. 3	9.1	2.1	....	....	....
Sinuk River	770	[b]6.2	Aug. 3	20	3.2	Aug. 15	[a]22	2.7
North Star Creek	900	2.3	Aug. 10	2.9	1.26	Aug. 7	[a]4	1.7
Windy Creek	650	12	Aug. 3	32	2.7	Aug. 15	[a]32	2.7
STREAMS IN THE KOUGAROK REGION.								
Kougarok River at Homestake intake.	....	44	....	....	....	Aug. 13	3.2	0.07
Kougarok River above Coarse Gold Creek.	....	250	....	....	....	Aug. 9–12	16	.06
Taylor Creek at Cascade intake.	....	74	....	....	....	Aug. 14	3.9	.05
Henry Creek at mouth	....	50	....	....	....	Aug. 13	6.8	.14
North Fork above Eureka Creek.	....	66	....	....	....	Aug. 15	9.6	.15
Noxapaga River	....	340	....	....	....	Aug. 16	62	.18
Turner Creek	....	13	....	....	....	Aug. 15	.7	.05
Budd Creek	....	58	....	....	....	Aug. 21	25	.43

[a] Minimum in midseason. [b] 8.2 after August 1, 1907.

AVAILABLE WATER SUPPLY.

In order to show the water supply available during 1906 and 1907 for the Nome and Kougarok regions the mean flow of streams in each drainage basin has been tabulated by weekly periods. The following table should not be taken as indicating the amount of water that could be used, which will, of course, be limited by the capacity of the ditches that have been or may be built.

The working season of the Miocene ditch was from June 20 to October 13, 1906, and from June 27 to October 3, 1907. The water of Hobson Creek was running in the ditch between these dates. The Nome River water was used from June 26 to October 12, 1906, and from July 3 to October 3, 1907. These dates mark the limit of the period during which water could have been used in any of the ditches of the Nome region. The season for Grand Central and Sinuk rivers would have been at least a week shorter at each end of both years, as the snow lasts longer and the slush ice begins to run earlier at the higher elevations where these streams rise. The working season may begin somewhat earlier in the Kougarok region than it does south of the mountain, as there is a lighter snowfall, and the ditches can be cleaned out earlier. The season closed on September 21, 1906, and September 20, 1907.

Especial attention is called to the small rate of run-off from the streams in the Kougarok region as compared with that of Grand Central, Nome, and Sinuk rivers. This is due to the extremely small rainfall in the northern area, as indicated by the records obtained at Shelton and Taylor. (See p. 282.) This condition is believed to prevail over the entire northern portion of Seward Peninsula. Caution should therefore be used in future hydraulic development in that section, to determine whether the water supply is sufficient.

Mean weekly water supply, in second-feet, available for use back of Nome, 1906–7.

Date.	Available for use at elevation 220 to 280 feet, Nome River low level.	Available for use at elevation 400 to 450 feet.				Total.
		Nome River high level.	Upper Grand Central River, Thompson Creek, and Gold Run.	Nugget, Copper, and Jett creeks.	Sinuk River, Windy and North Star creeks.	
1906.						
July 1-7	43	45	153	7	88	324
July 8-14	155	144	[a] 343	26	173	796
July 15-21	52	58	179	15	90	378
July 22-28	43	49	156	12	79	325
July 29-August 4	36	42	101	8	50	223
August 5-11	39	45	108	8	49	236
August 12-18	49	53	91	8	42	228
August 19-25	81	84	138	10	62	352
August 26-September 1	130	128	202	22	94	540
September 2-8	68	73	101	14	51	287
September 9-18	48	53	68	9	36	199
September 19-30	120	118	250	20	125	599
Mean	72	74	158	13	78	375
Maximum	155	144	343	26	173	796
Minimum	36	42	68	7	36	199
1907.						
July 1-7	135	199	([b])	36	152	522
July 8-14	102	152	292	27	172	745
July 15-21	84	107	228	21	143	583
July 22-28	60	77	183	15	105	440
July 29-August 4	44	59	144	11	77	335
August 5-11	36	49	107	8	50	250
August 12-18	49	62	190	13	95	409
August 19-25	47	61	245	15	86	454
August 26-September 1	72	89	318	18	124	621
September 2-8	51	63	142	14	72	342
September 9-15	176	204	418	40	167	1,005
September 16-23	60	76	115	24	62	337
September 24-30	45	56	([b])	15	([b])	116
Mean	74	96	216	20	109	473
Maximum	176	204	418	40	172	1,005
Minimum	36	49	107	8	50	116

[a] Too small; no record of highest water.
[b] No record. No water could have been used from Grand Central River the first week in July on account of snow, nor from either Grand Central or Sinuk rivers the last week in September on account of slush ice.

Mean weekly water supply, in second-feet, of Kougarok River drainage basin, 1907.

Date.	For Dahl Creek at elevation 300 to 350 feet.			For upper Kougarok at elevation 600 to 700 feet.					
	Kougarok River.	North Fork.	Total.	Kougarok River.	Taylor Creek.	Henry Creek.	Coarse Gold Creek.	North Fork.	Total.
July 15-21	57	22	79	14	16	19	12	5.2	66
July 22-28	88	22	110	13	53	14	9.6	3.0	93
July 29-August 4	33	12	45	6.7	7.3	7.3	3.8	1.2	26
August 5-11	21	10	31	5.4	5.0	6.3	3.3	1.0	21
August 12-18	26	13	39	4.5	9.0	5.4	3.9	1.0	24
August 19-25	328	73	401	60	117	28	29	30	264
August 26-September 1	262	83	345	33	117	21	26	27	224
September 2-8	331	76	407	57	100	33	27	21	238
September 9-15	584	117	701	133	181	94	100	44	552
September 16-20	228	45	273	46	68	33	39	17	203
Mean	196	47	243	37.3	67.3	26.1	25.4	15.0	171
Maximum	584	117	701	133	181	94	100	44	552
Minimum	21	10	31	4.5	5.0	5.4	3.3	1.0	21

SUMMARY OF DITCHES IN NOME REGION.

The following table has been prepared to show in a concise manner the flow of the ditches which take their water supply from Nome River and its tributaries, and from near-by streams. It is also of value for comparison with the discharge of the streams from which the water is taken, to show the percentage of flow that can be delivered by a ditch at the point where it is to be used.

Monthly discharge of ditches in Nome region, 1907.

Ditch.	Point of measurement.	Yearly maximum.	July.		August.	September.
		Sec.-feet.	*Days.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*
Campion	Black Point	18.0	25	9.0	12.9	12.5
Miocene	Black Point	42.6	29	28.0	34.4	38.7
	Clara Creek	37.0	29	25.4	28.7	33.7
	Above Hobson Creek	34.9	29	23.6	27.4	31.8
	Below Hobson Creek	54.7	31	43.8	45.3	47.9
	Flume	55.2	31	45.1	44.0	50.4
	David Creek branch	16.5	15	11.3	11.8	9.0
	Jett Creek branch	8.2	20	4.9	6.1	[a]6.1
	Grand Central branch	13.4	23	5.7	6.2	9.0
Seward	Nome River intake	29.0	21	23.9	26.2	25.7
	Hobson Creek branch		26	5.2	4.3	4.5
Pioneer	Nome River intake [b]	26.8	16	20.4	22.2	21.8
	Hobson branch					5.8
Sutton	Intake	35.0	31	23.9	23.8	31.8
Cedric	Penstock	17.8	10	12.3	12.9	9.6

[a] Mean for 14 days.
[b] Values for Pioneer ditch have been estimated at 85 per cent of those for Seward ditch; this was the proportion during the time for which records were obtained on both ditches.

RAINFALL.

In connection with the stream gaging, rainfall records were obtained at three stations in 1906 and at six in 1907. Observations of rainfall, precipitation, temperature, and barometric pressure were made during the winter at Nome by Arthur Gibson, C. E.

Monthly rainfall, in inches, at stations on Seward Peninsula, 1906–7.

Station.	Elevation.	June.	July.	August.	September.	Total, June to August.	Total, June to September.	Total, July to September.
1906.	*Feet.*							
Nome	40	Trace.	2.38	2.50	1.02	4.88	5.90	5.90
Salmon Lake	450	Trace.	4.92	3.33	3.26	8.25	11.51	11.51
Ophir	200	Trace.	3.57	1.91	([a])	5.48		
1907.								
Nome	40	1.31	2.08	2.68	1.41		7.48	6.17
Black Point	575	2.62	1.94	2.85	3.26		10.67	8.05
Salmon Lake	450	2.31	1.79	3.65	2.26		10.01	7.70
Grand Central	690	([a])	3.61	7.19	5.06			15.86
Shelton	60	([a])	.71	1.33	.47			2.51
Taylor	550	([a])	.66	.96	1.17			2.79

[a] No record.

Monthly summary of weather observations at Nome, December, 1906, to November, 1907.

	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Annual.
Rainfall,[a] inches	1.91	2.64	1.46	3.37	0.10	1.12	1.31	2.08	2.68	1.41	0.16	0.06	18.30
Snowfall, inches	20.8	25.2	13.9	28.8	......	......	......	......	......	......	1.7	1.5	91.9
Temperature (°F.):													
Monthly maximum	29	33	31	33	41	49	65	66	69	52	44	39	69
Monthly minimum	−15	−24	−31	−32	−14	15	30	34	30	29	3	−12	−32
Mean of daily maxima	13.3	19.7	−0.8	14.2	25.9	39.5	52.1	55.9	55.8	46.4	30.0	15.9	30.7
Mean of daily minima	−0.2	4.2	−14.4	−3.1	12.1	29.1	38.9	44.2	43.8	35.7	19.0	3.1	17.7
Mean	6.8	11.9	−7.6	5.6	19.0	34.3	45.5	50.0	49.8	41.1	24.5	9.5	24.2
Mean barometer, inches	30.17	30.24	30.02	30.01	30.01	30.03	29.91	29.88	29.74	29.64	29.74	29.65	29.92
Number of days—													
Clear	16	10	19	11	18	10	12	10	8	13	15	10	152
Partly cloudy	4	4	2	2	2	5	5	4	9	6	3	4	50
Cloudy	11	17	7	18	10	16	13	17	14	11	13	16	163

[a] Including melted snow.

NOTE.—The rainfall for October, 1906, was 0.93 inch, and for November, 1906, 0.32 inch.

The following statement gives briefly the climatic conditions existing in this area during the years 1899–1907:

1899. July, four rainy days; August, fourteen rainy days; September, fourteen rainy days; recorded at Teller.

1900. June and July, warm and dry; tundra fires common; August to end of September, rain.

1901. June to August, inclusive, cold and foggy with some rain; September and October, usually clear and cold with one or two hard rains of a few days' duration.

1902. June, dry; July, ten rainy days; August, six rainy days; September, three rainy days; recorded at Teller.

1903. Summer warm; little rain, but considerable fog.

1904. June, dry; rainy days as follows: Ten in July, ten in August, ten in September; temperature moderate.

1905. Very wet and cold the whole season.

1906. Very warm and dry; tundra fires common; maximum temperature 85°.

1907. A heavy snowfall and a late spring; rainfall not excessive, but water supply of Nome region good on account of its even distribution throughout the season.

HYDRAULIC DEVELOPMENTS IN 1907.

NOME REGION.

Construction work was done on several ditches in the Nome region during 1907, but so far as known no new ones were started.

The Nome River ditch of the Pioneer Mining Company was completed about July 15. Three siphons were required—one across Hobson Creek, 545 feet long, one across Banner Creek, 1,050 feet long, and one across Dexter Creek, 755 feet long.

The Independent ditch on Osborne Creek, which has been described by Moffit,[a] was completed in July and the water was used during about half of the season.

On the developments in upper Grand Central River little work was done, pending a settlement of the question of the ownership of the water rights. The Miocene Ditch Company built somewhat less than a mile of ditch. The Wild Goose Mining and Trading Company put together about a mile of its wood-stave pipe line. No work was done on the power plant at Salmon Lake.

IRON CREEK.

Two ditches were built to work ground on lower Iron Creek. One has its intake below Canyon Creek, and is 2 miles long and 6 feet wide on the bottom. A head of 50 feet is obtained. The other ditch, which was mentioned by Smith,[b] takes its water from Rock, Slate, and Willow creeks, tributaries of Kruzgamepa River, and conveys it over the divide to work ground on Bobs and Iron creeks. The ditch is 8 miles long and 3 feet wide on the bottom, but will probably be enlarged. A head of 350 feet above the bed of Iron Creek is obtained.

KOUGAROK REGION.

Much activity was shown in ditch building in the Kougarok region and in the territory immediately adjoining it. Of the ditches on Kougarok River and its tributaries which have been previously described,[c] those on Henry Creek and North Fork were not used in 1907. Much sodding and other repair work was done on the other four—the Homestake, North Star, Cascade, and Irving ditches—and water was turned into them on different dates in July and August. No ditch operator was able to mine throughout the season, on account of delay in starting and the extreme drought that occurred during the first half of August.

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[a] Moffit, F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 142.

[b] Smith, P. S., Geology and mineral resources of Iron Creek: Bull. U. S. Geol. Survey No. 314, 1907, p. 163.

[c] Moffit, F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, pp. 143–144. Brooks, A. H., The Kougarok region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 169–170.

A number of other ditches were begun in 1907. The Coarse Gold ditch takes its water from that creek about 5 miles above its mouth, and extends along its south bank to Twobit Gulch, a small tributary of Kougarok River, a distance of between 5 and 6 miles. The ditch is 8 feet wide, but it is planned to widen it and extend it eventually to Dahl Creek. The McKay Hydraulic Mining Company built about 17 miles of 4-foot and 5-foot ditch from Turner Creek to the benches of Noxapaga River near Goose Creek. Most of this ditch was built over ground ice, which caused much trouble by thawing and settling. The Pittsburg-Dick Creek Mining Company finished its ditch on Bryan Creek and began another which will take water from Quartz and Bismarck creeks. The Bryan Creek ditch is 6½ miles long and 6 feet wide, and gives a pressure of about 170 feet at the mouth of Dick Creek, a tributary of Bryan Creek which will be mined.

The Quartz Creek ditch is 8 miles long and 8 feet wide on the bottom. It will discharge into the Bryan Creek ditch, which is about 350 feet lower in elevation, but it is possible to extend it to the head of Dick Creek, a total distance of over 20 miles.

The Budd Creek ditch of the Ottumwa Gold Mining Company has its intake at the large spring on that creek and extends for 8 miles along the north bank to a point below the mouth of Windy Creek, giving a head at the lower end of 160 feet. This waterway is 9 feet wide, and has a grade of 3.7 feet per mile. A second ditch was built by the same company on Million and Ohio creeks, tributaries of Windy Creek.

FAIRHAVEN PRECINCT.

No member of the Geological Survey has visited the Fairhaven district since 1903. The following notes on some of the developments in that section have been compiled from reliable sources. Two of the longest ditches in Seward Peninsula have been built and a third has been begun.

The Fairhaven ditch was built during 1906 and 1907 by the Fairhaven Water Company. It takes its water supply from Imuruk Lake, the source of Kugruk River. A dam about 500 feet long has been constructed across the outlet of the lake to conserve the run-off.

The upper section of the ditch is 17 miles long, the first 8 miles of which is through a lava formation. The water is dropped into upper Pinnell River and flows down this stream for about 4 miles. The lower section takes the water from Pinnell River on its right bank and extends for 23 miles to Arizona Creek, where a head of 500 feet is obtained. The ditch is 11 feet wide on the bottom and has a grade of 5 feet to the mile.

The Candle ditch was built during 1907 by the Candle-Alaska Hydraulic Gold Mining Company to furnish water for mining on

Candle Creek. It has a total length of 33.6 miles, a bottom width of 9 feet, and a grade of 3.69 feet per mile. The estimated capacity is 35 second-feet.

It takes its supply from the western tributaries of Kiwalik River. The present intake of the ditch is on Glacier Creek. The water is carried across Dome Creek in a siphon 2,250 feet long composed of 28-inch pipe; across Bonanza Creek in 900 feet of 32-inch pipe; and across Eldorado Creek in a siphon 12,100 feet long composed of equal lengths of 35½, 37½ and 39½ inch pipe. Eldorado Creek will be tapped with a lateral ditch about 6 miles long. An extension 8.1 miles long of 6-foot ditch will be built to Gold Run. It will also be possible to divert the flow from the headwaters of First Chance Creek a tributary of Koyuk River, over a low divide into Gold Run.

The fall obtained is 250 feet at the mouth of Candle Creek and 132 feet at the mouth of Patterson Creek. The surveyed line crosses Candle Creek about 1 mile above the mouth of Willow Creek. Candle Creek was nearly dry during 1907, the flow some of the time being less than half a second-foot.

Construction was begun late in 1907 by the Miners' Hydraulic Ditch Company on a second large ditch to Candle Creek. It will have its intake on Quartz Creek, a tributary of Kiwalik River from the east, and will extend along the right bank of that stream, crossing Hunter and Lava creeks by means of siphons and picking up their flow in lateral ditches. The ditch will have a length of about 60 miles and a bottom width of 12 feet.

A ditch was built in 1907 on Bear Creek, a tributary of West Fork of Buckland River. It has its intake below the mouth of May Creek and extends along the right bank to Split Creek, diverting Eagle, Polar, and other small creeks. The ditch has a length of about 6 miles, a bottom width of 6 feet, and a grade of 4 feet to the mile. The head obtained at the lower end is about 200 feet.

INDEX.

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

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

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

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost.

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

GENERAL.

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.

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.

The mining industry in 1906, by A. H. Brooks. In Bulletin No. 314, 1907, pp. 19–39.

Railway routes, by A. H. Brooks. In Bulletin No. 284, 1906, pp. 10–17.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1904: Bulletin No. 259, 1905, pp. 13–17.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1905: Bulletin No. 284, 1906, pp. 1–3.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1906: Bulletin No. 314, 1907, pp. 11–18.

Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.

Markets for Alaska coal, by G. C. Martin. In Bulletin No. 284, 1906, pp. 18–29.

The Alaska coal fields, by G. C. Martin. In Bulletin No. 314, 1907, pp. 40–46.

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin No. 263, 1905, 362 pp. (Out of stock; can be purchased from Superintendent of Documents, Washington, D. C., for 35 cents.) Abstract in Bulletin No. 259, 1905, pp. 32–46.

Geographic dictionary of Alaska, by Marcus Baker, second edition by J. C. McCormick. Bulletin No. 299, 1906, 690 pp.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1907. Bulletin No. 345, pp. 5–17.

The distribution of mineral resources in Alaska, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1907. Bulletin No. 345, pp. 18–29.

The mining industry in 1907, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1907. Bulletin 345, pp. 30–53.

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, 159 pp.

Topographic maps.

Alaska, topographic map of; 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).

Map of Alaska; scale, 1:5000000; by Alfred H. Brooks.

In preparation.

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Second edition.

SOUTHEASTERN ALASKA.

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.
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.
Lode mining in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin No. 284, 1906, pp. 30–53.
Nonmetallic deposits of southeastern Alaska, by C. W. Wright. In Bulletin No. 284, 1906, pp. 54–60.
The Yakutat Bay region, by R. S. Tarr. In Bulletin No. 284, 1906, pp. 61–64.
Lode mining in southeastern Alaska, by C. W. Wright. In Bulletin No. 314, 1907, pp. 47–72.
Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. In Bulletin No. 314, 1907, pp. 73–81.
Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin No. 314, 1907, pp. 82–88.
Lode mining in southeastern Alaska in 1907, by C. W. Wright. In Bulletin No. 345, 1908, pp. 78–97.
The building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin No. 345, 1908, pp. 116–126.
Copper deposits on Kasaan Peninsula, Prince of Wales Island, by C. W. Wright and Sidney Paige. In Bulletin No. 345, 1908, pp. 98–115.

Topographic maps.

Juneau Special quadrangle; scale, 1:62500; by W. J. Peters. For sale at 5 cents each or $3 per hundred.
Topographic map of the Juneau gold belt, Alaska. Contained in Bulletin 287, Plate XXXVI, 1906. Not issued separately.

In preparation.

Physiography and glacial geology of the Yakutat Bay region, Alaska, by R. S. Tarr, with a chapter on the bed-rock geology by R. S. Tarr and B. S. Butler.
The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright.
Berners Bay Special map; scale, 1:62500; by R. B. Oliver. (In press.)
Kasaan Peninsula Special map; scale, 1:62500; by D. C. Witherspoon and J. W. Bagley.

CONTROLLER BAY PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall. Professional Paper No. 15, 1903, 71 pp. Contains general map of Prince William Sound and Copper River region; scale, 12 miles = 1 inch. (Out of stock; can be purchased from Superintendent of Documents for 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.
The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.
Geology of the central Copper River region, Alaska, by W. C. Mendenhall. Professional Paper No. 41, 1905, 133 pp.
Copper and other mineral resources of Prince William Sound, by U. S. Grant. In Bulletin No. 284, 1906, pp. 78–87.
Distribution and character of the Bering River coal, by G. C. Martin. In Bulletin No. 284, 1906, pp. 65–76.

Petroleum at Controller Bay, by G. C. Martin. In Bulletin No. 314, 1907, pp. 89–103.
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.
Mineral resources of the Kotsina and Chitina valleys, Copper River region, by F. H. Moffit and A. G. Maddren. In Bulletin No. 345, 1908, pp. 127–175.

Topographic maps.

Map of Mount Wrangell; 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. D. C. Witherspoon. Contained in Professional Paper No. 41. Not issued separately.
Controller Bay region Special map; scale, 1:62500; by E. G. Hamilton. For sale at 35 cents a copy or $21.00 per hundred.
General map of Alaska coast region from Yakutat Bay to Prince William Sound; scale, 1:1200000; compiled by G. C. Martin. Contained in Bulletin No. 335.

In preparation.

The Kotsina-Chitina copper region, by F. H. Moffit.
Chitina quadrangle map; scale, 1:250000; by T. G. Gerdine and D. C. Witherspoon.

COOK INLET AND SUSITNA REGION.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.
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. (Out of stock; can be purchased of Superintendent of Documents for 25 cents.)
Reconnaissance in the Matanuska and Talkeetna basins, by S. Paige and A. Knopf. In Bulletin No. 314, 1907, pp. 104–125.
Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska, by S. Paige and A. Knopf. Bulletin No. 327, 1907, 71 pp.

Topographic maps.

Kenai Peninsula, northern portion; scale, 1:250000; by E. G. Hamilton. Contained in Bulletin No. 277. Not published separately.
Reconnaissance map of Matanuska and Talkeetna region; scale, 1:250000; by T. G. Gerdine and R. H. Sargent. Contained in Bulletin No. 327. Not published separately.
Mount McKinley region; scale, 1:625000; by D. L. Reaburn. Contained in Professional Paper No. 45. Not published separately.

ALASKA PENINSULA AND ALEUTIAN ISLANDS.

Gold mine on Unalaska Island, by A. J. Collier. In Bulletin No. 259, 1905, pp. 102–103.
Gold deposits of the Shumagin Islands, by G. C. Martin. In Bulletin No. 259, 1905, pp. 100–101.
Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139. Abstract from Bulletin No. 250.
The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. In Bulletin No. 250, 1905, 64 pp.
Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin No. 259, 1905, pp. 151–171.
The Herendeen Bay coal field, by Sidney Paige. In Bulletin No. 284, 1906, pp. 101–108.

YUKON BASIN.

The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin No. 218, 1903, 71 pp.
The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, by L. M. Prindle. Bulletin No. 251, 1905, 89 pp.
Yukon placer fields, by L. M. Prindle. In Bulletin No. 284, 1906, pp. 109–131.
Reconnaissance from Circle to Fort Hamlin, by R. W. Stone. In Bulletin No. 284, 1906, pp. 128–131.
The Yukon-Tanana region, Alaska; description of the Circle quadrangle, by L. M. Prindle. Bulletin No. 295, 1906, 27 pp.
The Bonnifield and Kantishna regions, by L. M. Prindle. In Bulletin No. 314, 1907, pp. 205–226.
The Circle Precinct, Alaska, by Alfred H. Brooks. In Bulletin No. 314, 1907, pp. 187–204.
The Yukon-Tanana region, Alaska; description of the Fairbanks and Rampart quadrangles, by L. M. Prindle, F. L. Hess, and C. C. Covert. Bulletin No. 337, 1908, 102 pp.
Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin No. 345, 1908, pp. 179–186.
The Fortymile gold placer district, by L. M. Prindle. In Bulletin No. 345, 1908, pp. 187–197.
Water supply of the Fairbanks district in 1907, by C. C. Covert. In Bulletin No. 345, 1908, pp. 198–205.

Topographic maps.

Fortymile quadrangle; scale, 1:250000; by E. C. Barnard. For sale at 5 cents a copy or $3 per hundred.
Yukon-Tanana region, reconnaissance map of; scale, 1:625000; by T. G. Gerdine. Contained in Bulletin No. 251, 1905. Not published separately.
Fairbanks and Birch Creek districts, reconnaissance maps of; scale, 1:250000; by T. G. Gerdine. Contained in Bulletin No. 251, 1905. Not issued separately.
Circle quadrangle, Yukon-Tanana region; scale, 1:250000; by D. C. Witherspoon. Contained in Bulletin No. 295. Not issued separately.

In preparation.

Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, 159 pp.
Fairbanks quadrangle map; scale, 1:250000; by D. C. Witherspoon. Contained in Bulletin No. 337, 1908.
Rampart quadrangle map; scale, 1:250000; by D. C. Witherspoon. Contained in Bulletin No. 337, 1908.
Fairbanks Special map; scale, 1:62500; by T. G. Gerdine and R. H. Sargent.

SEWARD PENINSULA.

A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900, by A. H. Brooks, G. B. Richardson, and A. J. Collier. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 180 pp.
A reconnaissance in the Norton Bay region, Alaska, in 1900, by W. C. Mendenhall. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900."
A reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. Professional Paper No. 2, 1902, 70 pp.
The tin deposits of the York region, Alaska, by A. J. Collier. Bulletin No. 229, 1904, 61 pp.
Recent developments of Alaskan tin deposits, by A. J. Collier. In Bulletin No. 259, 1905, pp. 120–127.
The Fairhaven gold placers of Seward Peninsula, by F. H. Moffit. Bulletin No. 247, 1905, 85 pp.
The York tin region, by F. L. Hess. In Bulletin No. 284, 1906, pp. 145–157.
Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin No. 284, 1906, pp. 132–141.
The Kougarok region, by A. H. Brooks. In Bulletin No. 314, 1907, pp. 164–181.

Water supply of Nome region, Seward Peninsula, Alaska, 1906, by J. C. Hoyt and F. F. Henshaw. Water-Supply Paper No. 196, 1907, 52 pp. (Out of stock; can be purchased of Superintendent of Documents for 15 cents.)
Water supply of the Nome region, Seward Peninsula, 1906, by J. C. Hoyt and F. F. Henshaw. In Bulletin No. 314, 1907, pp. 182–186.
The Nome region, by F. H. Moffit. In Bulletin No. 314, 1907, pp. 126–145.
Gold fields of the Solomon and Niukluk river basins, by P. S. Smith. In Bulletin No. 314, 1907, pp. 146–156.
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 Adolph Knopf. In Bulletin No. 345, 1908, pp. 251–267.
Mineral deposits of the Lost River and Brooks Mountain regions, Seward Peninsula, by Adolph Knopf. In Bulletin No. 345, 1908, pp. 268–271.
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.

Topographic maps.

The following maps are for sale at *5 cents a copy*, or $3 per hundred:
Casadepaga Quadrangle, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.
Grand Central Special, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.
Nome Special, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.
Solomon Quadrangle, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.

The following maps are for sale at *25 cents a copy*, or $15 per hundred:
Seward Peninsula, northeastern portion of, topographic reconnaissance of; scale, 1:250000; by T. G. Gerdine.
Seward Peninsula, northwestern portion of, topographic reconnaissance of; scale, 1:250000; by T. G. Gerdine.
Seward Peninsula, southern portion of, topographic reconnaissance of; scale, 1:250000; by T. G. Gerdine.

In preparation.

Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, 159 pp.
Geology of the area represented on the Nome and Grand Central Special maps, by F. H. Moffit, F. L. Hess, and P. S. Smith.
Geology of the area represented on the Solomon and Casadepaga Special maps, by P. S. Smith.
The Seward Peninsula tin deposits, by A. Knopf.

NORTHERN ALASKA.

A reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak 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. (Out of stock; can be purchased of Superintendent of Documents for 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.

Fort Yukon to Kotzebue Sound, reconnaissance map of; 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. (Out of stock.) Not published separately.

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