INVESTIGATIONS OF MINERAL RESOURCES OF ALASKA IN 1907.

By ALFRED H. BROOKS and others.

ADMINISTRATIVE REPORT.

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accounts of investigations in progress or completed, and (3) statements of the results of minor investigations not to be published elsewhere.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.

	Per cent.
Cold test did not chill at 3° F. below zero.	
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	$4,686,714	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	2,861,000	145,300	99,087		
1897	118,011	2,439,500	116,400	70,741		
1898	121,760	2,517,000	92,400	54,575		
1899	270,997	5,602,000	140,100	84,276		
1900	395,030	8,166,000	73,300	45,494	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	77,813	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.

[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.

[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

[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

[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.