THE FUTURE OF ALASKA MINING.

By Alfred H. Brooks.

OUTLINE.

The Alaska mining industry, which has turned out products having a total value of $438,160,000, began in 1880 with the recovery of some $20,000 worth of gold from placers near Juneau. Of this total value 96 per cent is to be credited to the gold and copper deposits, but Alaska mines have also produced silver, platinum, palladium, tin, lead, antimony, tungsten, chromite, coal, petroleum, marble, gypsum, graphite, and barite, and development work has been done on deposits carrying nickel, iron, molybdenite, and sulphur.

The exploitation of Alaska's mineral wealth before the war showed a rather steady growth, with some fluctuations from year to year, such as are more or less inherent to mining in remote regions. This advance was made in spite of the handicaps imposed by isolation, the inadequacy of means of communication, and the long existing interdict on the development of the coal and oil fields. Then came the change of industrial conditions wrought by the war. Its first effect was to increase Alaska's output of copper enormously, owing to the high price of that metal, and this increase in 1916 brought the value of the total mineral output of Alaska up to over $48,632,000, a larger amount than that for any other year since mining began. (See Pl. I.) The decline in price and market demand for copper since 1916 has greatly reduced Alaska's output of copper. Meanwhile the world-wide depression of the gold-mining industry has also greatly affected Alaska. As a consequence the value of the total mineral output of the Territory in 1919 was only $19,621,000, as compared with $28,254,000 in 1918, and was the lowest annual value since 1914.

This very marked decline of Alaska's mining industry has been noted with alarm by many who are interested in the Territory and has been especially disconcerting to the general public, because it came at a time when large Government funds were being expended on a railroad intended primarily to open up the mineral resources of the interior. This decline is not due primarily to local causes, however, but is largely the result of world-wide industrial conditions brought on both by the wár and by the readjustments that have followed it. It is pertinent to inquire what the future holds forth for Alaska mining. If it is true that the decline in output is due to the general instability of industrial conditions recovery must await the improvement of these conditions. It would lead us too far afield to attempt here to discuss any of the broad problems connected with the present economic situation and its betterment. The purpose of this paper will be met by assuming that these conditions will improve.

Although many local factors affect the future of the Alaska mining industry, the most important consists of the mineral reserves. Unless the accessible reserves are large enough to support a future growth the mining industry, no matter how favorable may be the conditions of exploitation, will languish. Those who have inquired about the quantity of mineral reserves have usually received the stereotyped answer that Alaska has vast stores of mineral wealth awaiting development. However true this may be, the public has a right to know on what facts such statements are based. An attempt will be made here to summarize briefly these facts, which are scattered through scores of publications of the United States Geological Survey,[1] and to forecast, so far as may be, the future of Alaska as a producer of minerals.

Before considering the future of the mining industry, it will be desirable to examine briefly the record of the past as expressed by the value of the mineral output. The statistics of mineral production are given in a later section of this report (see pp. 59–76) and are expressed graphically by the accompanying diagram (Pl. I). On this diagram the value of the total mineral output and of the copper and gold is shown by curves, which give a measure of the mining industry for the last 40 years. The curves, though recording fluctuations from year to year, show on the average a rather uniform growth of output until the outbreak of the war in 1914, since when Alaska's mining industry has been unstable. If the pre-war curve showing the value of Alaska's total mineral output is projected over the last five years, it will indicate that under normal conditions the value would have been about $22,000,000 in 1919. It is significant that the actual value of the output in 1919 ($19,621,000) was only about 10 per cent below this normal value indicated by the curve. This in itself is very encouraging, for it indicates that the Alaska mines are on an average nearly holding their own, in spite of the present abnormally adverse conditions.

The pre-war curves might, of course, be projected also into the future, with a view of thus obtaining a rough estimate of the probable developments of the Alaska mines. Such an estimate would have little value, however, because the mineral output of the past does not

[1] A list of the principal publications of the Geological Survey relating to the geology and mineral resources of Alaska is appended to this volume.

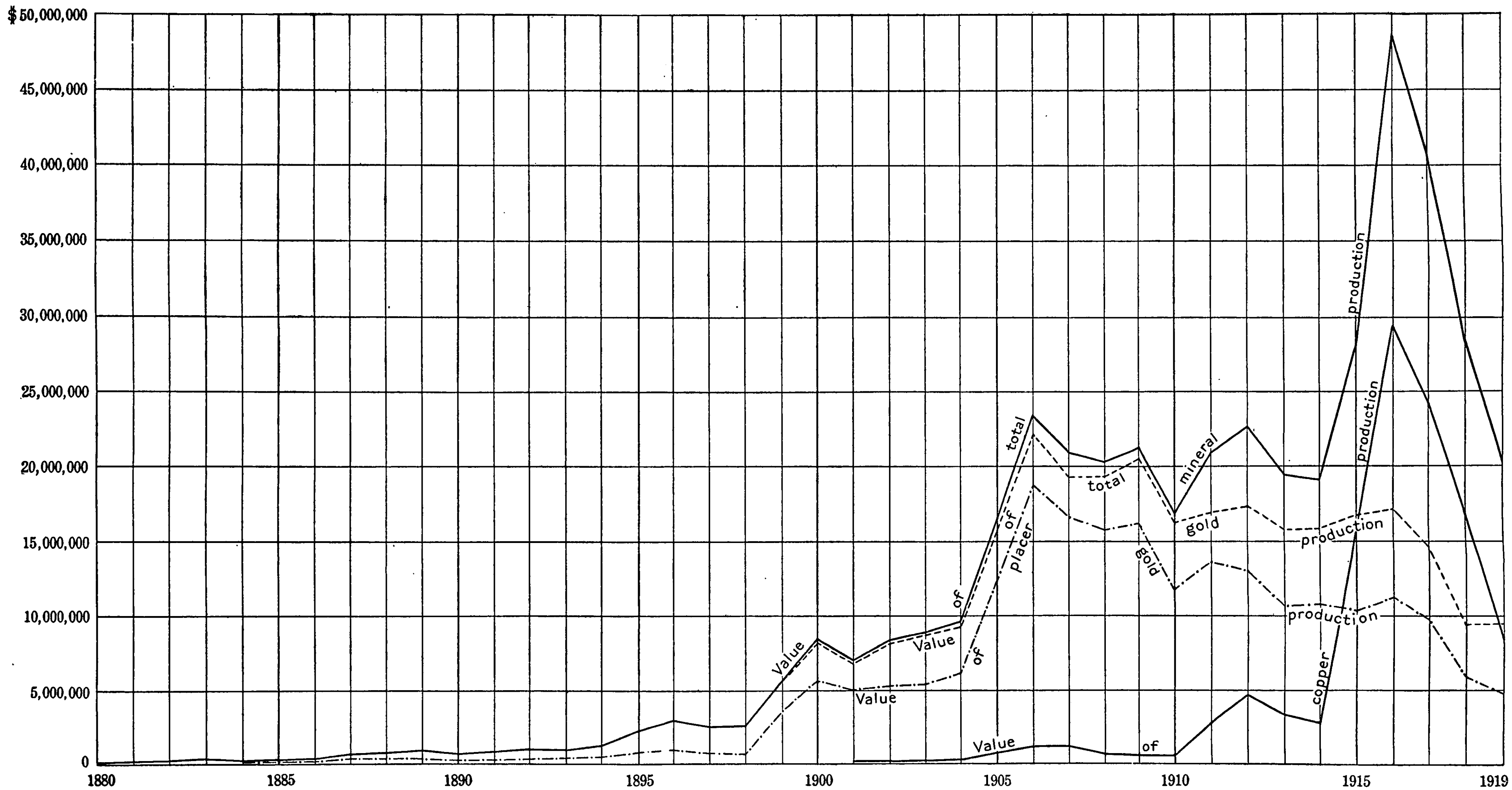

DIAGRAM SHOWING VALUE OF MINERAL PRODUCTION OF ALASKA, 1880-1919.

indicate the changes that will be brought about by the construction of the railroad and wagon roads, the reduction in freight charges, and the opening of the oil and coal fields. Moreover, such an estimate would assume, without proof, that Alaska's mineral reserves are ample to support a growth of the mining industry in the future at the same rate as that of the past. The quantity of the several minerals occurring in Alaska is evidently the significant element in the problem. In discussing these reserves it will be desirable to limit the estimate to those which are now or can soon be made available.

An estimate of Alaska's mineral reserves would be difficult enough even with complete geologic maps of the entire Territory. Only about 20 per cent of Alaska has been covered by even reconnaissance geologic surveys, and less than 1 per cent by detailed surveys. This meagerness of geologic data is in a measure offset by the fact that the areas surveyed cover much of the immediately accessible parts of the Territory, where the most extensive mining developments of the near future are to be expected. The information at hand, however, at best does not permit quantitative estimates of reserves. Nevertheless, it indicates the areal distribution of the mineral deposits (Pl. II), and a study of their geologic occurrence gives a basis of forecasting their availability to the miner. These data, considered in connection with the accessibility of the deposits and the probable market for their output, will afford a rough measure of their availability in the near future.

GOLD MINING IN THE PAST.

During 40 years of mining Alaska has produced gold to the value of $311,665,000, of which $218,000,000 is to be credited to the placer mines. The first notable impetus given to gold mining in the Territory was the discovery of the Nome placers in 1898 and their rapid development, which reached its maximum in 1906. Meanwhile the placer gold from the Fairbanks district, first developed in 1903, helped to swell the gold output, into a maximum production in 1909. Much the larger part of the placer gold recovered in these two fields, as well as in most other placer districts, such as Iditarod, Hot Springs, and Koyukuk, has been taken from relatively small and very rich or so-called bonanza deposits rather than from larger bodies of gravel having a lower gold content. The production of placer gold in the past has therefore been maintained by the exploitation of new bonanzas rather than by larger installations in the developed districts. Since 1911, however, there has been a gradual improvement in mining methods, notably in the use of gold dredges, by which over $20,000,000 worth of gold has been recovered.

Auriferous lodes in Alaska have yielded $92,000,000 worth of gold, of which more than 80 per cent has come from the six large low-grade mines of the Juneau district. Lode mining in the Juneau district rather steadily increased from the first large installation in 1887 to the depression that followed the outbreak of the war, which occurred at almost the same time as the wrecking of three of the Treadwell mines by an inflow of sea water. Successful lode mining at Juneau, in complete contrast to most of the placer operations, has been based on the exploitation of low-grade deposits on a very large scale. The mines have, indeed, been operated at a lower unit cost than any others in the world. The average value per ton of the gold and silver recovered from the ore produced in these mines since 1882 is $1.95. The small margin of profit was offset by the very large tonnage of ore handled. Because of the small margin these operations were naturally among the first to react to the economic conditions that have affected gold mining so adversely.

Most of the lode mines outside of the Juneau district have been small ventures that could practice none of the economies introduced at Juneau. Therefore, with the decline of mining at Juneau Alaska's auriferous lode-mining industry has received a serious setback.

To sum up, the production of placer gold has been founded principally on bonanza mining, while lode mining has been supported chiefly by the large-scale exploitation of low-grade ores. The tendency of bonanza mining has been to cause considerable fluctuations in the annual gold output, but these fluctuations have in a measure been offset by the steady production of the large Juneau mines.

The minor fluctuations in the annual gold output of Alaska are caused by the local mining conditions referred to above. There is, however, also a larger pulsation of this output, which is responsive to the general economic conditions, industrial, financial, and political, that affect the gold output of the entire world. The close parallelism between the gold output of Alaska and that of the world is shown in Plate III. This diagram shows that the larger oscillations of the world's gold production are clearly recognizable in the Alaska output, though Alaska at best has produced less than 5 per cent of the world's gold. This diagram also shows a tendency of the Alaskan gold output to lag a year or two in its adjustment to the general industrial conditions of the world. This delay is no doubt due to the isolation of many of the Alaska placer districts, which necessitates that preparations for mining be made a year or more in advance. The facts stated above show clearly that whatever local conditions may affect Alaska gold mining and however these may be improved by the construction of railways and roads and a betterment of the steamboat service, the progress of the industry is to a large extent controlled by factors that are world-wide in their effect. The gold miner now finds that, while his product commands

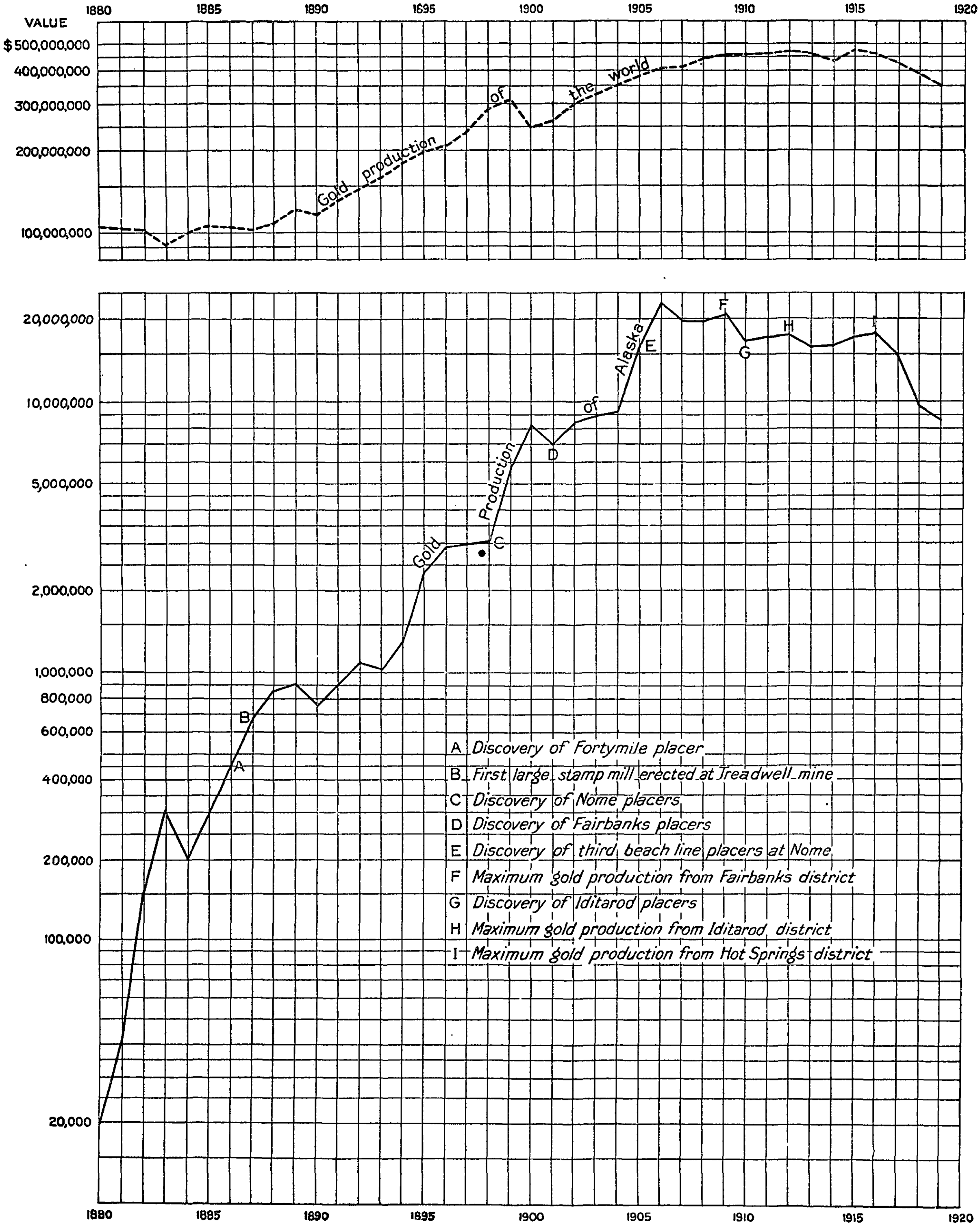

DIAGRAM SHOWING GOLD PRODUCTION OF ALASKA AND THE WORLD, 1880-1919.

The curves are logarithmic and therefore may be directly compared with respect to rate of increase or decrease. The same slope indicates the same rate of change, irrespective of the quantities involved.

the same price as in the past, yet his costs, like those in all other industries, have enormously increased. For the purpose of this paper it will be assumed that these conditions will change, without discussing when or how this change will be brought about.

GOLD PLACERS.[1]

Auriferous gravels are very widely distributed over Alaska (see Pl. II, in pocket), but it is only in comparatively small areas that their gold content is high enough to permit profitable exploitation or, in other words, to constitute a placer. The question whether a body of auriferous gravels is a placer depends on the cost of its exploitation. If it can be exploited at a profit it is a placer, no matter how small its gold content. At one locality a body of gravel carrying less than 25 cents worth of gold to the cubic yard may be a placer, whereas at another a body of gravel whose gold content has a value of several dollars to the cubic yard may be worthless. Some of the conditions that affect mining costs, such as physical character and thickness of the deposit, grade of streams, and availability of water, are fixed. Others, relating chiefly to accessibility, may be improved by betterment of means of communication. Thus a body of gravel whose gold content is too low for profitable exploitation at one time may, with improvements in transportation, become a valuable placer.[2] In the early days of mining at Nome gravels that carried less than $5 in gold to the cubic yard could not be profitably exploited, but in 1918 the 21 dredges operating on Seward Peninsula made an average gold recovery per cubic yard of only 40 cents. Again, the average value of gold in all the gravel mined in Alaska in 1911 was $2.17 per cubic yard; in 1918 it was $1.20. This change has been due to a cheapening of mining cost, both by larger installations and by better means of communication. These facts of themselves make it impossible to estimate closely the reserves of the Alaska placers, even if the quantity and gold contents of the auriferous gravels were known, for it is impossible now to forecast what part of these gravels will in the future prove to be workable placers. On the assumption, however, that profitable mining will be possible in the future on the same grade of placers as it has in the past, a rough measure of the placer reserves can be arrived at.

A careful scrutiny of all the available geologic, statistical, and mining data indicates that the original total length of creek gravels that probably carry enough gold to be classed as placers is about 1,050 miles. Of this total, deposits aggregating about 200 miles are on creeks whose alluvial floors are 15 yards or less in width, and the

[1] The geologic features of some Alaska placers are set forth by A. H. Brooks in U. S. Geol. Survey Bull. 328, pp. 111-139, 1908.

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

rest on streams whose valley floors are chiefly from 50 to 100 yards wide, with some that have a width of 300 yards or more. In this total mileage have been included only those stream gravels which have been mined or more or less prospected. The many large deposits of gravels which are known to be auriferous but about whose gold content no information is available are not included in this estimate.

It is believed that of this 1,050 miles of original gold placer ground, 250 miles has been mined out. The value of the total placer-gold output of Alaska is $218,000,000, of which about $18,000,000 is to be credited to beach and high bench placers that are not included in this estimate of stream gravels. Therefore, as nearly as can be determined, the stream gravel placers thus far exploited have yielded gold to the value of $800,000 to the mile. Much of the placer gold has been won from bonanza deposits, such as those of Nome, Fairbanks, and Hot Springs. The Fairbanks placers have produced about $2,000,000 worth of gold to the mile for the ground actually mined, and the recovery from the creek placers of the Seward Peninsula[3] has been about $500,000 to the mile. On the other hand, the recovery has been only $50,000 to the mile in some of the poorer districts.

Although it is quite possible that other very rich creek placers will be found in Alaska, notably in the Yukon and Kuskokwim basins, where there are many streams that have not yet been thoroughly prospected, yet a forecast of the future can not take account of such possible discoveries, and must include in the estimate of available reserves only placers about whose gold content there is some information based on actual development. If the gold-placer reserves are measured by the least valuable creek placers that have thus far been developed, namely, at $50,000 a mile, the total value will be $40,000,000; if the estimate is based on the average gold recovery of the past, the total value will be $640,000,000. The truth will lie somewhere between these two extremes. In the writer's opinion it will be conservative to estimate the value of the undeveloped creek placers at $200,000 a mile, a figure which will make the value of the total creek placer reserves $160,000,000. To these must be added the reserves of bench and ancient beach and gravel placers. Deposits of these types have been developed and tested only on Seward Peninsula. It was estimated some years ago that the value of the gold reserves in the gravel-plain, ancient-beach, and high-bench placers of Seward Peninsula was about $215,000,000.[4] Subtracting the amount of gold that has since been mined from these deposits leaves the value of the reserve $200,000,000. This very large reserve compared with those of other parts of Alaska is due largely to the fact that in Seward Peninsula the cost of mining has been much lower

[3] The richest ground in Seward Peninsula has been in the beach and high bench placers.

[4] Brooks, A. H., U. S. Geol. Survey Bull. 328, pp. 135-138, 1908.

than elsewhere in Alaska. Therefore deposits of a low gold tenor are included in the reserve.

Though the above estimates of available placer gold reserves may appear extravagant to some, a comparison will show that they are moderate. Recently a committee of experienced Fairbanks mine operators under the leadership of John A. Davis, of the Bureau of Mines, collected all available information on the dredging ground of the Fairbanks district. This information was carefully checked by Mr. Davis, and as a result it was estimated that the dredging ground on the creeks immediately tributary to Fairbanks includes a total of 218,000,000 cubic yards, with an average gold content of about 46 cents to the cubic yard and a total reserve of gold of the value of $100,200,000.[5] During the 17 years of mining at Fairbanks some $70,000,000 worth of placer gold has been mined out, yet there still remains in the ground, according to a conservative estimate, over $100,000,000 worth of gold.

In view of the above facts it is believed that the available placer-gold reserves in the developed districts of Alaska have a value of at least $360,000,000 and perhaps of twice that amount. There is also the possibility of discoveries of new deposits, of which not even a rough estimate can be made.

GOLD LODES.

Few of the Alaska gold-lode mines have blocked out ore to supply them for more than a few years in advance, and therefore there is no basis for estimating their reserves, which are developed from year to year. The large Juneau mines, where development work has usually been kept well in advance of the stoping, can for the present not be counted as a very definite source of gold. Most of the other auriferous lode mines are equipped with only small plants. Many of them are, indeed, only prospects with small mills, operated for only a part of the year. Were the future of Alaska's gold-lode mining dependent on the developed mines, the outlook would not be hopeful.

In the absence of developed ore bodies the future of lode mining must be gaged by considerations of the geologic occurrence and distribution of the ores. Such facts can not be interpreted in terms of reserve tonnage, yet they will serve to indicate the probability of discoveries.

The wide distribution of gold placers is in itself an indication of widespread mineralization. Gold placers by no means give definite evidence that the gold is sufficiently concentrated in its bedrock source to be profitably mined. Yet the placers show that the bedrock is mineralized, and this fact alone augurs well for the discovery

[5] Construction of Alaska Railroad: 66th Cong., 1st sess., Hearings before the House Committee on Territories on H. R. 7417, July 23, 24, 25, and 31, 1919, p. 142.

of auriferous veins. Moreover, some auriferous quartz veins have been found in nearly every placer district. (See Pl. II, in pocket.) The geology shows that the Alaska auriferous quartz is genetically related to intrusive granitic and kindred rocks.[6] Such intrusive rocks are widespread in the territory south of the crest of the Arctic Mountain system. The geologic conditions are therefore favorable to the occurrence of auriferous quartz veins. This fact has been generally recognized, and the question is often asked why more lode mines have not been developed. A partial answer to this question lies in the fact that in much of Alaska lode prospecting is beset by the difficulty that the bedrock is masked by a mat of moss and other vegetation. Therefore the lode prospector has little to guide his search except the distribution of placer gold. Moreover, there has been little incentive to lode prospecting. The inaccessibility of so much of Alaska has prohibited mining development except such as could be carried on with the simple tools and methods of the placer miner. Much of the placer mining has been done far from navigable rivers, where there were no roads and few, if any, trails. Under such conditions lode mining can not thrive.

On the other hand, where a region has been made even reasonably accessible small lode-mining industries have sprung up, as, for example, in the Willow Creek and Fairbanks districts. The evidence in hand indicates that gold-lode mining in Alaska has only begun, for there are many districts that contain evidence of the presence of auriferous veins. Though no quantitative statement of reserves of lode gold is possible, there can be little doubt that when normal economic conditions become reestablished and transportation is provided, lode mining will be undertaken in many localities. It is quite possible that the reserve of lode gold far exceeds that of the placers.

COPPER.

GENERAL FEATURES.

The total copper production of Alaska to the end of 1919 has been 545,007,336 pounds, recovered from 3,736,000 tons of ore. The first copper-mine developments were in the Ketchikan district, but production began in 1900 in both the Ketchikan and Prince William Sound districts. The first large shipments of copper ore from the great Kennecott mine, in the Chitina district, were made in 1911, after the completion of the Copper River Railroad. At about the same time the Beatson-Bonanza mine, on Latouche Island, in the Prince William Sound region, was opened on a large scale. In 1913 the Jumbo and Mother Lode mines of the Kennecott group began shipping ore. These two, together with the original Kennecott mine,

[6] Brooks, A. H., Geologic features of Alaskan metalliferous lodes: U. S. Geol. Survey Bull. 480, pp. 43-74, 1911.

are operated on very rich chalcocite ore, and it is their output which has so greatly swelled the copper output of Alaska. It was a fortunate coincidence that these rich mines should have been prepared to take advantage of the war prices of copper. The large output of

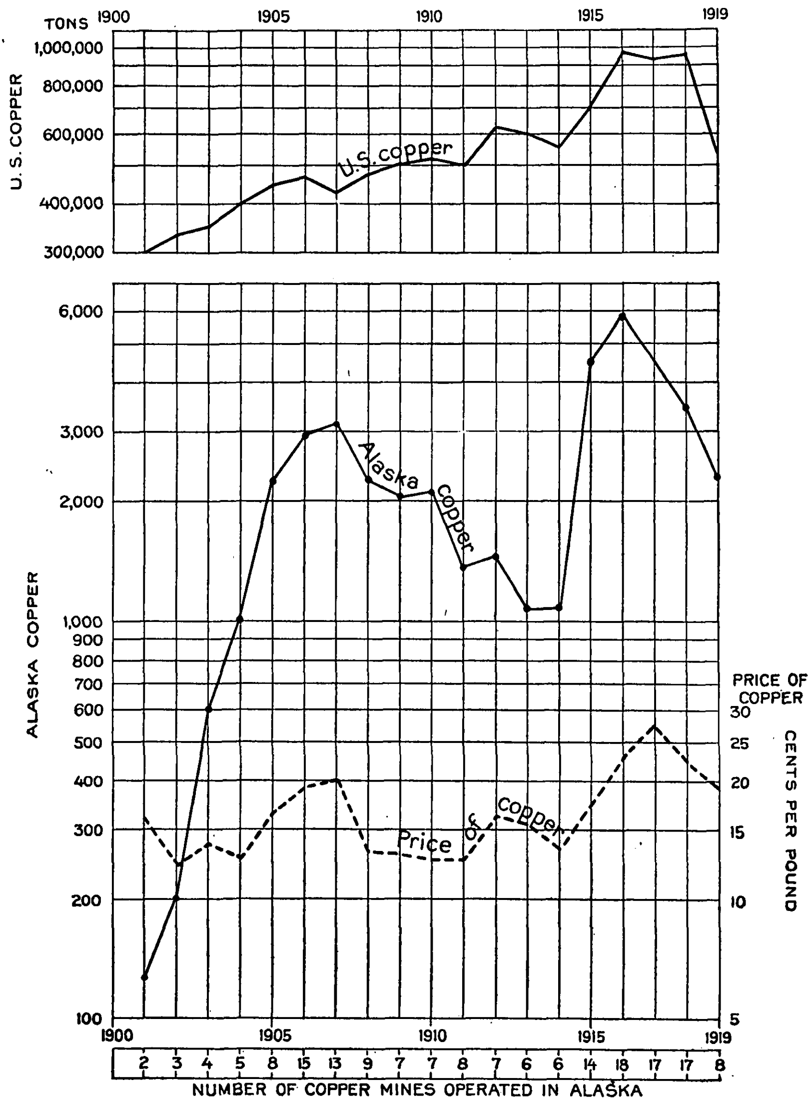

FIGURE 1.—Diagram showing progress of Alaska copper-mining industry. The curves are logarithmic and therefore may be directly compared with respect to rate of increase or decrease. The same slope indicates the same rate of change, irrespective of the quantities involved.

copper ore from these three bonanza deposits has greatly benefited the industries of Alaska and has stimulated other copper-mining ventures. The Beatson-Bonanza, the only other large copper mine in Alaska, is working a large body of copper ore of much lower grade than that of the Kennecott group. This ore is concentrated by oil flotation before shipment. Most of the other copper mines are small, and many are developing ore bodies which are not large and whose copper content is low. As a consequence of this condition and of high freight rates, many of the small mines have been operated only during the period of high price for copper. This fact is illustrated by the accompanying diagram (fig. 1). Even during the periods of high prices, especially during the war, lack of shipping or refusal of smelters to take the ore has prevented the operations of some small mines. As a consequence, there is general discouragement among the small producers, and their number is decreasing.

The history of the Alaska copper-mining industry is well illustrated by figure 1. This diagram shows the annual Alaska copper production, as well as the price of copper and the number of mines operated. For the sake of comparison the curve of the annual copper output of the United States is added. A comparison of the copper production of Alaska and that of the United States shows that the former represents an unstabilized industry. Although its larger fluctuations harmonize with those of the output of the United States, yet its pulsations very closely accord with changes in the price of copper. The production of copper in Alaska has in general been greatly on the ascendancy during the last decade, yet this rise must be credited to the mining of the very rich ores of the Kennecott group. No one can predict how long this bonanza copper mining will continue, but it probably can not be counted upon to support a permanent industry. For example, had there been no mining in the Kennecott group during 1919, only one large and four small producing copper mines would have been operating in all Alaska, Though there is no reason to believe that for the present Alaska's copper production will decline, except in so far as it is affected by world-wide industrial conditions, yet it is not to be expected that a large and growing permanent industry can be based on the present developments. In spite of these conditions the outlook for a larger copper production from Alaska in the years to come is very favorable. Though the tonnage of ore actually developed is small, the distribution or copper deposits is very wide. (See Pl. II, in pocket.)

In view of the importance of the copper resources of Alaska and of the considerable variety in their occurrence, they will here be considered in greater detail than those of the other valuable minerals. The geologic aspect of the subject, notably the genesis of the deposits, will receive only brief mention. This matter is more fully discussed in the many publications cited, which also contain descriptions of individual deposits.

That part of the geologic history bearing on possible enrichment of the copper deposits, however, deserves special mention. Most of the Alaska copper districts have been profoundly glaciated in recent times, and as a result the zone of surface oxidation and enrichment has been removed. Postglacial time has been too short to permit the formation of any deep zone of oxidation. Grant and Higgins have suggested the possibility that some of the chalcopyrite deposits of the Prince William Sound may have been enriched during preglacial time.[7] Neither the facts revealed by mining operations of the decade that has elapsed since the Grant and Higgins survey was made nor the detailed geologic investigations by B. L. Johnson in this province have given any support to this suggestion, which was only tentatively advanced by its authors. All the evidence points to the conclusion that these sulphide minerals are primary. The same is true of the copper sulphides of the Ketchikan district. Bateman and McLaughlin, in an exhaustive study of the Kennecott ore bodies, hold that although the evidence is not entirely conclusive, yet it points to the conclusion that these chalcocite ores are primary.[8]

The sulphide copper deposits of the Susitna, Iliamna, and Nabesna-White River districts all occur in glaciated regions. Little underground work has been done on these deposits, but their mineral character and geologic occurrence indicate that their ores are also primary. It may be added that this is in general also true of Alaska ores other than copper. Exceptions are to be looked for in the unglaciated regions, however, notably in the Yukon and Kuskokwim basins and on Seward Peninsula. In these regions there has been as yet no deep mining, so that positive evidence of a change in tenor with increasing depth is lacking. In places, however, some evidence of a deep zone of surface oxidation has been found. As the surface material is in general permanently frozen, this oxidation must have taken place before the formation of the permanent ground frost; and as the permanent ground frost is a survivor of the glacial climate of the past, this oxidation was preglacial.

The practical deduction from these facts is that no greater variation in the mineral composition and copper content of the Alaska ores is to be expected at depths to be reached by future mining than has already been noted within a few feet of the surface. This is true of all the important Alaska copper districts thus far discovered, but possibly it does not hold for ore deposits which may occur in the unglaciated or only slightly glaciated regions, such as the Yukon and Kuskokwim basins and Seward Peninsula.

THE DEPOSITS, BY DISTRICTS.

SOUTHEASTERN ALASKA.

All the productive copper mines as well as the largest developed cupriferous ore bodies of southeastern Alaska are in the Ketchikan

[7] Grant, U. S., and Higgins, D. F. Reconnaissance of the geology and mineral resources of Prince William Sound: U. S. Geol. Survey Bull. 443, pp. 58–60, 1910.

[8] Bateman, A. M., and McLaughlin, D. H., Geology of the ore deposits of Kennecott, Alaska: Econ. Geology, vol. 15, pp. 66–80, 1920.

district.[9] Copper is widely distributed in the Ketchikan district and, as will be shown, occurs in deposits of several distinct types. The most important so far as present production and extent of proved ore bodies are concerned are the contact deposits, which have yielded more than 98 per cent of the copper produced in the Ketchikan district.

The largest of the developed contact lodes are essentially chalcopyrite-magnetite deposits. Others which are less common consist mainly of chalcopyrite and pyrrhotite. All the ores carry pyrite, molybdenite, and specularite as accessory minerals. Some of the ores contain small amounts of nickel and traces of cobalt. The ores that have been mined carry enough gold to increase their value materially. In some localities a shallow surface zone of copper carbonates and other secondary minerals has been formed, but these deposits are not large enough to be of commercial importance.

These deposits occur in or near the contact-metamorphic zone caused by the intrusion of granitic and dioritic material into the sedimentary rocks among which limestone predominated. Such deposits have also been found in the contact zone of schists, greenstone tuffs, and graywackes.

The gangue of the contact deposits consists principally of minerals resulting from the alteration of the country rock and includes garnet, epidote, pyroxene, amphibole, and calcite. Calcite is sufficiently abundant in some of the ores to give them special value as flux. Quartz also occurs in all the deposits, but it is usually not abundant.

The typical contact deposits are masses of irregular outline, and some have very poorly defined boundaries. In some places a little copper occurs in zones about 200 feet wide, but the ores thus far mined have been taken from the smaller and much richer shoots, which are irregularly distributed through the contact rock or the larger bodies of low-grade ore. One difficulty that has beset the miner is the great irregularity in occurrence of the rich ore shoots. It is not uncommon to find an ore body whose horizontal cross section is almost square and which ends abruptly at the bottom. In many places search will reveal another ore shoot at greater depth. Hence there is little guide to the search for ore except the zone of contact metamorphism. The largest deposits thus far developed consist

[9] The copper deposits of the Ketchikan district are described in the following publications:

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

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

Chapin, Theodore, Mining developments in southeastern Alaska: U. S. Geol. Survey Bull. 642, pp. 83-100, 1916.

Smith, P. S., Lode mining in the Ketchikan district: U. S. Geol. Survey Bull. 592, pp. 75-94, 1914.

Chapin, Theodore, Mining developments in the Ketchikan and Wrangell districts: U. S. Geol. Survey Bull. 662, pp. 63-75, 1918.

of huge bodies of magnetite in which chalcopyrite occurs both finely disseminated and in shoots of massive sulphides.

Incidentally to the search for rich ore shoots, which are as yet the principal source of the copper produced, a considerable tonnage of concentrating ore has been blocked out. There are also much larger bodies of low-grade ore which contain too little copper to be now classed as commercial ores. The reserves of such ore have not been determined, and little is known of their average copper content. It is probably true, however, that if a magnetite ore carrying 0.5 per cent copper could be utilized (see p. 41), the developed reserves would be very large; also that the hope of finding other similar deposits is well founded.

Among the best examples of the contact copper deposits in the Ketchikan district are those at the Mount Andrew, Mamie, Poorman, and It mines, on Kasaan Peninsula; the Rush & Brown mines, on Karta Bay; and the Jumbo and Copper Mountain mines, on the west side of Prince of Wales Island.

Another type of the copper deposits of the Ketchikan district is represented by those occurring in cavities formed by shear zones. Though these deposits appear to be largely cavity fillings, there is evidence in some places that they are in part formed by replacement of the country rock. The principal metallic minerals of the shear-zone deposits are chalcopyrite and pyrite, but they also contain some magnetite, pyrrhotite, sphalerite, and galena, as well as some gold and silver. Country rock, quartz, and calcite form the gangue of these deposits. The shear-zone deposits follow zones of fracture that are parallel to the schistosity of the country rock. They are found in various kinds of country rock but primarily in greenstone schist, graywacke, and sheared diorite.

There are two phases of the shear-zone deposits. One consists of lenses or tabular deposits, many of which are made up largely of rich massive sulphide minerals. These have well-defined walls and are not unlike the cupriferous quartz veins described below. The other phase consists of disseminated deposits in which the sulphides are distributed through wide zones of sheared country rock, generally without well-defined walls. In some of the disseminated deposits the sulphide mineralization is rather evenly distributed through the entire mass, which may thus be a large body of low-grade ore. More commonly, however, the mineralization is concentrated along certain zones determined by the intensity of the shearing. In some of the deposits there has been marked silicification over a considerable width, but the sulphide minerals occur chiefly in ore shoots and stringer leads limited to certain parts of the whole mass. Practically all these disseminated deposits include ore shoots in irregular and tabular masses, and some are of sufficient size to form commercial ore bodies, as defined by the methods of mining and recovery that have existed in the past.

Up to the present time mining of the copper ore in shear zones has been confined to the lenses and tabular masses occurring either as separate deposits or as a part of the lower grade disseminated ore bodies. The larger bodies of low-grade disseminated ore have received relatively little attention, and little is known of their copper content. It will require much prospecting and careful sampling to determine whether they are of commercial importance.

Examples of the shear-zone deposits, including both the concentrated and disseminated phases, are found at the Rush & Brown mines, on Karta Bay; at Niblack Anchorage and McLean Arm, on the east side of Prince of Wales Island; at the Corwin and Red Wing properties, near Hetta Inlet, and on Big Harbor (Trocadero Inlet), on the west side of Prince of Wales Island; and on McLeod Bay, Dall Island.

There are also in the Ketchikan district some copper-bearing quartz veins and brecciated zones. The deposits of this type thus far developed are small and have been exploited chiefly because of their silica content. They are essentially chalcopyrite-bearing quartz veins but contain also pyrite, sphalerite, tetrahedrite, and galena. All carry gold and silver. In some the gangue includes calcite and barite. These veins occupy true fissures with well-defined walls and cut both sedimentary and igneous country rock. In some the sulphides are well disseminated, but more commonly they occur in massive shoots separated by more or less barren vein matter. Chalcopyrite-bearing quartz veins are found in many places in the Ketchikan district, but most of them are too small to warrant development. The largest developments on this type of deposit are at the Cimru property, on the north arm of Moira Sound, and at the south end of Gravina Island.

One other type of copper deposit in the Ketchikan district deserves mention, even though as yet only one example of it has been developed. This occurs in pyroxenite with gabbroic phases and appears to have been deposited in a very irregular zone of fracture. It carries bornite, chalcopyrite, and metals of the platinum group, chiefly palladium. The gangue is practically all country rock. This deposit, on which the Salt Chuck mine is located, was first opened as a low-grade copper deposit but its present importance is due to its content of palladium and platinum. (See p. 38.)

It has been shown that the best developed of the Ketchikan copper deposits are those composed essentially of chalcopyrite, magnetite, and pyrite. Some of these have a considerable percentage of lime. Much of the successful mining of the past has been done because of the smelter demand for base ores and the premium paid for a high iron content. The change in metallurgic practice has decreased this demand, producing an adverse effect on copper mining in the district. Limestone is abundant in southeastern Alaska.[10]

The Ketchikan copper deposits are not far from tidewater and are on good harbors open to navigation throughout the year. They are connected by sheltered waterways with the smelters at Anyox, Tyee, and Tacoma. This condition should give cheap freight rates. The strong topographic relief, excellent timber, and good water powers of the district all favor low mining costs.[11]

A total of 543,498 tons of copper ore has been produced in the Ketchikan district since mining began in 1901. This ore yielded 34,056,376 pounds of copper, gold to the value of $545,000, and 255,440 ounces of silver. The average copper content of this ore is 62.66 pounds to the ton, equal to 3.13 per cent. The average value of the gold and silver content is $1.31 a ton. The average value of the total metallic contents of the ore is $12.71 a ton. No attempt has been made to concentrate the Ketchikan ore except by hand sorting.[11a] The small mines have normally maintained their shipping grade of ore at 5 per cent or more.

The facts above set forth clearly indicate that the Ketchikan district contains copper deposits which are well worth investigating by those who have the capital to develop and reduce ores on a large scale. The physical conditions seem almost ideal for cheap operations. Special attention should be directed to devising methods by which the iron content of the chalcopyrite-magnetite ores, as well as the copper, can be utilized.

Some work has been done on copper deposits on Kupreanof and Woewodski islands, in the Wrangell district, adjoining the Ketchikan district on the north. These deposits are chiefly chalcopyrite-bearing quartz veins.[12] Copper has also been found in a shear-zone deposit on William Henry Bay, an indentation on the west side of Lynn Canal. (See p. 108.) There are also some copper deposits associated with greenstones on Glacier Bay. The occurrence of a nickel-bearing copper ore in the Sitka district is noted below. (See p. 40.)

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[10] Burchard, E. F., Marble resources of southeastern Alaska: U. S. Geol. Survey Bull. 682, 1920.

[11] The Granby Consolidated Mining, Smelting & Power Co. reports that in 1916–17 the cost per ton of ore produced, "including development and waste," at the Mamie mine was $3.733 (production 20,115 tons) and at the It mine $5.54 (production 14,881 tons). This included the cost of much diamond drilling on both properties. (See report of company for year ending June 30, 1917, p. 20.)

[11a] The palladium-copper ores of the Salt Chuck mine are concentrated by oil flotation.

[12] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, pp. 140–142, 1908.

Chapin, Theodore, Mining developments in the Ketchikan and Wrangell mining districts: U. S. Geol. Survey Bull. 662, pp. 73–74, 1918.

PRINCE WILLIAM SOUND.

Copper in the form of sulphides is very widely distributed on Prince William Sound, but as yet commercial ore bodies of this metal have been developed at relatively few localities. Though some shipments of copper ore have been made from a dozen different properties, only three large mines have been opened. Most of the mining has been done by those who had little capital and hence were forced to concentrate their efforts on the search for rich ore shoots that would promise immediate returns rather than on the prospecting of the larger ore bodies of lesser copper tenor, on which a more permanent industry could be established. As a consequence the present developments have not aided much in determining the potential value of the copper deposits of the region as a whole.

The following brief summary is based chiefly on the published reports dealing with the mineral resources of the region, especially those by B. L. Johnson, supplemented by some personal observations of the writer. Information regarding the copper deposits of Prince William Sound is contained in the following publications of the Geological Survey:

Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: Bull. 443, 1910.

Capps, S. R., and Johnson, B. L., The Ellamar district, Alaska: Bull. 605, 1915.

Johnson, B. L., The Port Wells gold-lode district: Bull. 592, pp. 195–236, 1914.

Johnson, B. L., Mining on Prince William Sound: Bull. 592, pp. 237–244, 1914; Bull. 622, pp. 131–139, 1915; Bull. 642, pp. 137–145, 1916; Bull. 662, pp. 183–192, 1917; Bull. 692, pp. 143–151, 1919.

Johnson, B. L., Copper deposits of the Latouche and Knight Island districts, Prince William Sound: Bull. 662, pp. 193–220, 1917.

Johnson, B. L., Mineral resources of Jack Bay district and vicinity, Prince William Sound: Bull. 692, pp. 153–173, 1919.

Copper has two essentially different modes of occurrence in this region. Chalcopyrite is found in many of the auriferous quartz veins but principally as an accessory mineral. It may occur in sufficient quantity in some of these veins to form a low-grade siliceous copper ore. These auriferous quartz veins are widely distributed on the sound, but the most valuable thus far developed are in the Valdez and Port Wells districts. Many occur in close association with intrusive granites, and a genetic relation of these veins to granites is fairly well established. The chalcopyrite-bearing quartz veins have not been mined for their copper content.

The only copper deposits that are as yet of commercial importance on the sound are those in shear zones. These deposits are confined to the regions where greenstones are present, and their genetic relation to the greenstones is therefore probable. The greenstones are chiefly ancient lavas, principally diabase. In places the greenstones include tuffs, and locally they are altered by shearing into greenstone schists, Some of the greenstones are intrusive sills, stocks, and dikes. Greenstones are rather widely distributed on the sound but are especially abundant near Cordova, in the Ellamar district, on Knight Island, and in the Columbia Glacier region. Though the copper lodes appear to be limited to the districts where greenstones are found, the largest deposits thus far developed are in the sediments and not in the greenstones.

The commercial bodies of copper ore on the sound as now known are essentially cavity fillings in zones of shearing and brecciation. There has also been some replacement of the country rock by mineral-bearing solutions, especially in the deposits occurring in some of the slates, which are more or less calcareous.

So far as now determined two conditions appear to be essential for the occurrence of copper ores in this region. One is the presence of greenstones, either as the country rock or in the vicinity of the deposit, and the other is the occurrence of shear zones of considerable magnitude. Sulphide mineralization is very common along planes of movement in the rocks of the sound, especially in the greenstone. It is only in the exceptional localities where the zone of shearing and brecciation has sufficient width that ore bodies can be expected. Evidently the minimum width of a shear zone that can be profitably mined depends on the grade of the ore it contains. Thus rich ore bodies only 4 to 10 feet wide have been profitably exploited. The future of the district, however, depends on the development of low-grade disseminated deposits. Such an ore body is being worked at the Beatson-Bonanza mine, on Latouche Island, where the zone of crushing and shearing is several hundred feet wide.

The shear zones in which the ore bodies occur were formed during a period of crustal disturbance that affected the entire province. These rock movements were intensified in certain localities that presented favorable conditions to the formation of ore bodies. It appears that the loci of intense movements were largely controlled by the physical character of the country rock. Among the diversified formations of the sound there were certain zones that were less resistant to movement than others, and here the largest shear zones were formed. The greenstones, for example, presented few lines of weakness, and in those rocks the movement was taken up by many fractures more or less generally distributed through the whole rock mass. Thus in the great greenstone masses of Knight Island there are innumerable fractures, many of which contain sulphides.

Many of the narrow shear zones, in which the mineralization is practically confined to a single fault plane, and may be traceable only a very short distance, have been accepted by the prospector as evidence of the presence of ore bodies. As a result many valueless claims have been staked and much useless development work has been done.

Much of this futile expenditure of time could have been avoided by obtaining a reliable sample by means of a short open cut.

In general it is true that the massive greenstone is not favorable for the development of wide shear zones, but exceptionally shear zones may be developed along a line of weakness presented by the contact of two ancient lava flows, as appears to have occurred at Rhea Cove, Knight Island. Tuffaceous beds within the greenstone, as on Orca Bay, may afford favorable conditions for the formation of shear zones. In other localities, as at Landlocked Bay, the presence of beds of slate within the greenstone may afford loci of weakness where shear zones are likely to be developed.

Among the sediments of Prince William Sound, which are chiefly graywacke and slates, the largest shear zones are within the weakest rocks. The slates are particularly favorable to shearing movements and hence to the formation of mineralized shear zones. Examples of this type of deposit are found at Ellamar, at the Midas mine, near Valdez, and at Horseshoe Bay, on Knight Island. Some of the deposits in the slates have a strikingly lenticular form, probably because they have replaced calcareous lenses in the slate. The Ellamar and Horseshoe Bay ore bodies are examples of this type.

In other localities the shear zones are developed along interbedded slates and graywackes. In these zones the slates are more intensely crushed and mineralized than the graywackes. The Beatson-Bonanza ore body, the largest thus far developed, is an example of this form of deposit. A similar deposit, adjacent to it on the north, is that of the Girdwood mine. Other examples of this mode of occurrence are at the Shlosser, the McIntosh, and the Mason & Gleason mines, near Fidalgo Bay.

One other fact in regard to the localization of considerable shear zones deserves mention. The shearing seems especially pronounced where weaker strata have been crushed against a hard, resistant rock mass. Thus, at the Beatson-Bonanza and Girdwood mines the slates and thin-bedded graywackes have been crushed against the massive footwall graywacke. The Midas ore body is in slate, folded against hard graywacke. At Fidalgo Bay massive graywackes are in juxtaposition to the mineralized shear zones developed along weaker rocks. At Ellamar and Landlocked Bay the mineralized shear zones lie along the margin of a mass of resistant greenstone. It appears, therefore, that where weaker rocks were buttressed against resistant masses the shearing was intense and probably deep-reaching openings were formed along which mineralizing agents could find passage, and the crushed rock was favorable to replacement.

The ore bodies are all of the same general form, with the exception of the lenticular deposits in the calcareous slates, already noted. Within the shear zones the most intense crushing or brecciation follows certain beds, usually the softest rock. Thus, in the deposits occurring in graywacke and slates, the slates are the most intensely crushed and mineralized. Thin-bedded graywackes may also be crushed and impregnated with sulphides, but heavier beds will be but little altered and may form horses in the deposit. The factors that control the distribution of mineralization in the greenstone are less evident. Here, too, the most intense mineralization is concentrated along certain zones. In addition the more massive parts of the shear zone may be impregnated by the sulphides, but each ore body includes horses of unaltered country rock. It appears that the ore bodies in the slate show less variation in their sulphide content.

Practically all the deposits contain rich ore shoots, of which many are made up of solid sulphides, irregularly distributed through the larger deposit of lower-grade ore. It is these rich shoots which have been sought for and mined by the smaller operators. The ore bodies upon which large-scale mining must be based are disseminated deposits of low copper tenor.[12a] Many deposits, notably those in the greenstone, have no well-defined walls, and their limits will be set by the minimum copper content that can be profitably recovered.

The shear-zone deposits do not differ greatly in their mineral composition, the variations being chiefly in the relative proportion of a few sulphides. Chalcopyrite is in most places the dominating copper mineral, though some deposits carry a large percentage of the less valuable chalmersite. Pyrite is present in all the deposits in large quantities, but the percentage of pyrrhotite varies considerably. Some of the deposits are essentially bodies of pyrite carrying more or less chalcopyrite (Horseshoe Bay). Another type is one in which pyrrhotite carrying disseminated chalcopyrite is the dominating mineral (Rhea Cove). Most of the ores contain sphalerite and galena as accessory minerals and some arsenopyrite. There is a little gold and silver in most of the deposits, and in some the gold amounts to several dollars a ton.

As the country rock in these shear-zone deposits is ground up and intimately mixed with the sulphides, it constitutes the principal part of the gangue. Exceptions to this rule were found in some of the deposits occurring in slate, where the zone of fracture is cleaner and there is less country rock included in the ore. This is notably true of some of the lenticular deposits. Both quartz and calcite occur as gangue minerals, as do also in less abundance chlorite and epidote. In many of the rich ore shoots there is but little gangue.

As a rule the ores are base, with a high percentage of iron. The copper-bearing auriferous quartz veins have not been developed except for their gold content, but form a possible source of siliceous

[12a] The ore mined at the Beatson-Bonanza mine in 1919 had an average copper content of 1.95 per cent (Kennecott Copper Corp. Fifth Ann. Rept., 1919, p. 5, New York, 1920).

ores. There is practically no limestone on Prince William Sound, but limestone is abundant in the tributary Copper River valley and also occurs at tidewater near Seldovia, on Cook Inlet.[13]

A little work has been done on the copper deposits near Cordova, which are in some respects different from the normal type. These occur along shear zones in a greenstone bedrock, which is in part an amygdaloidal basalt. They differ from the deposits described in containing considerable bornite as well as some native copper, with a gangue of quartz, calcite, and epidote. The native copper is probably secondary.

The geology of the deposits above described shows that the conditions which lead to the formation of ore bodies are not complex. There is good reason to believe that they have occurred also in localities not yet thoroughly explored underground. Therefore the outlook is favorable for finding other ore bodies of equal value to those already opened.

The first mining on Prince William Sound was done in 1900, and since then a total of 1,819,578 tons of ore has been produced, from which 94,185,716 pounds of copper, $1,099,176 worth of gold,[14] and 772,749 ounces of silver have been recovered. The average copper content of the ore mined was 51.76 pounds to the ton, or 2.58 per cent. On an average 60 cents' worth of gold and 0.43 ounce of silver were obtained from each ton of copper ore. This average gold value is somewhat misleading, because much the larger part of the ore contains only an insignificant amount of gold. The average has been greatly increased by the high gold content found in part of the Ellamar ore body. The average value of the total metallic contents of the copper ores produced on Prince William Sound during 20 years of mining is $11.32 a ton.

Much the larger part of the above-stated tonnage is the output of the Beatson-Bonanza mine, where the ores are concentrated by oil flotation. No other attempts have been made to concentrate the Prince William Sound ores, but a mill is in course of erection at the Girdwood mine. Only high-grade ores have been shipped by the small mines, where the attempt has been made to keep the grade up to 8 or 10 per cent. This is done by mining only the richer ore shoots and by hand sorting the shipping ore.

Nearly all the copper deposits of this region are readily accessible from tidewater, and the ore can usually be delivered at the beach by aerial trams. It is transported to the smelters of Washington and British Columbia by ocean routes open to navigation throughout the year. Given tonnage enough to justify the employment of

[13] Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, pp. 111-112, 1915.

[14] This of course does not include the gold recovered from the auriferous quartz veins of the Sound.

suitable carriers, freight rates should not be high. On the other hand, should a sufficient tonnage be developed and local smelting of the ores prove to be economical, the necessary fuel should be made available from the high-grade coking and steaming coals of the Bering River and Matanuska fields or from the Cook Inlet lignites. (See pp. 48–49.) It has been shown that some siliceous ores could be obtained locally and that limestone is not far distant.

The climate of Prince William Sound is no deterrent to operations throughout the year. Many of the ore bodies are topographically so located that they could be undercut. Timber, though not abundant, is ample for the purposes of mining. Small water powers are fairly abundant, and there are also some larger ones.[15] During the era of high prices there has been a shortage of labor in all Alaska mining camps. As a consequence miners' wages on the Sound have of late been about 10 per cent higher than in the lode-mining districts of the States. Should copper mining ever develop on a large scale, there is no reason to believe that this difference would continue. On the whole, the controlling physical conditions on Prince William Sound are favorable to fairly low operating costs, though probably higher than in southeastern Alaska.

COPPER RIVER REGION.

The richest copper lodes of Alaska are those developed by the Kennecott group of mines and are tributary to the Copper River & Northwestern Railroad. (See Pl. II, in pocket.) These deposits are near the east end of a copper-bearing belt, which has been traced some 50 miles westward along the southern foothills of the Wrangell Mountains and as measured by present discoveries is from 5 to 15 miles in width. The belt takes its name, the Kotsina-Chitina district, from the two principal rivers which carry its drainage into Copper River. There is evidence that this zone of mineralization extends eastward into the upper Chitina basin. Some cupriferous lodes have also been found southwest of the main belt, near the valley of Copper River. All these deposits may be regarded as a part of the same copper-bearing province, which finds outlet to tidewater over the railroad terminating at Cordova.

The enormous copper production of the Kennecott mines has focused public attention on the types of lodes which have yielded these rich ores almost to the exclusion of all other types. There are, however, within the district a number of other forms of copper occurrence that are not without promise, though as yet unproductive. To arrive at some measure of the potential value of the district as a future source of copper it will be desirable to sketch the

[15] Ellsworth, C. E., and Davenport, R. W., A water-power reconnaissance in south-central Alaska: U. S. Geol. Survey Water-Supply Paper 372, pp. 72–110, 1915.

salient geologic features of several types of copper lodes which it includes. It will not be necessary to present details, for these are contained in many publications, notably in the reports of F. H. Moffit, who has devoted many years to a study of the Copper River region. Most of the facts here to be presented will be taken from Moffit's reports. The following list of publications relating to the district includes those of most importance to the present discussion. They are all Geological Survey publications except the last.

Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: Bull. 374, 1909.

Moffit, F. H., Mining in the Kotsina-Chitina district: Bull. 379, pp. 153–160, 1909.

Moffit, F. H., Mining in the Chitina district: Bull. 442, pp. 158–163, 1910.

Moffit, F. H., and Capps, S. R., Geology and mineral resources of the Nizina district, Alaska: Bull. 448, 1911.

Moffit, F. H., The Chitina district: Bull. 520, pp. 105–107, 1912.

Moffit, F. H., Mining in Chitina Valley: Bull. 542, pp. 81–85, 1913.

Moffit, F. H., Geology of the Hanagita-Bremner region, Alaska: Bull. 576, 1914.

Moffit, F. H., Mineral deposits of the Kotsina-Kuskulana district: Bull. 622, pp. 103–117, 1915.

Moffit, F. H., Mining in the lower Copper River basin: Bull. 662, pp. 155–182, 1917.

Moffit, F. H., The upper Chitina Valley, Alaska: Bull. 675, 1918.

Moffit, F. H., and Mertie, J. B., The Kotsina-Kuskulana district, Alaska: Bull. — (in preparation).

Bateman, A. M., and McLaughlin, D. H., Geology and ore deposits of Kennecott, Alaska: Econ. Geology, vol. 15, pp. 1–80, 1920.

The copper lodes here to be considered are of five more or less distinct types and geologic association—(1) replacement deposits in limestones, (2) veins and disseminated deposits in greenstones, (3) contact deposits between limestone and intrusive diorite, (4) disseminated deposits in fractured diorite, and (5) fissure veins in various types of rock, in many of which copper occurs only as an accessory mineral.

The dominating feature in the economic geology of the district is the contact between the heavy Chitina limestone and a great series of the underlying ancient lavas called the Nikolai greenstone. Along the general zone of this contact, which is a very conspicuous feature in the landscape, occur the most valuable ore bodies yet found in the district. A little copper mineralization has occurred at many places along the actual line of demarcation, but the copper has not proved to be concentrated enough to form ore bodies. All the ore bodies as yet productive lie in the limestone above the contact, but the greenstones below also contain copper deposits, and some copper-bearing lodes cross the contact.

Up to the present time interest has largely centered on ore bodies lying entirely above the contact and within the limestone, for it is here that the very rich bonanza deposits occur, the source of all the copper as yet produced. These deposits are due to the replacement of limestone by copper sulphides along fractures produced by faulting. They consist mostly of chalcocite, with locally some covellite, bornite, enargite, and chalcopyrite. These deposits have several forms—well-defined veins, stockworks made up of sulphide-bearing veinlets in shattered limestone, and masses, some of which are very large, of solid sulphides having irregular outline. It is the last type that has yielded the very rich copper ores for which the district is so famous. Most of these replacement deposits include all the above-described phases. The massive sulphides as mined contain but little gangue, and this is chiefly lime. The stockwork deposits are of lower grade, and in these much calcite gangue is mixed with the ore. Ores of this class produced at the Kennecott mines are concentrated by oil flotation before shipment. The ores of the replacement veins in the limestone of some localities are made up of chalcocite and bornite in varying proportions and also carry but little gangue. The Kennecott ores carry no gold but an appreciable amount of silver. In 1919 the average copper content of the shipping ore from the Kennecott mines was 45.51 per cent and of the concentrating ore 10.24 per cent.[15a]

The limestone-greenstone contact, with which copper deposits of the type above described are associated, has been traced in the district for a linear distance of more than 60 miles. Sufficient evidence of mineralization in the limestone has been found in at least a score of localities to lead to the staking of claims, and on some of them considerable development work has been done. As yet, however, no large ore bodies have been proved except those of the Kennecott mines. This is perhaps not an encouraging result of 20 years of prospecting. It should be noted, however, that, as will be shown, copper-bearing minerals are much more widely distributed in the greenstone than in the limestone, and that much of the prospecting has been in the former.

The rather complete geologic information available about the district is interpreted by the writer as indicating that there is no reason why other workable deposits of the Kennecott type should not be uncovered. There are no special geologic conditions at the developed mines which are not found at other places.

One fact regarding the outcrops of such ore bodies should be noted. The outcrop that led to the discovery of the Bonanza lode, the first of the Kennecott group to be opened, was a very large one. Here by chance of erosion the outcrop was on one of the enormous ore shoots and stood up as a great mass of copper carbonate on a sharp crest. Had only one of the leaner parts of the lode appeared at the surface it would have been very inconspicuous and might not have received much attention. As it was, very little development work

[15a] Kennecott Copper Corp. Fifth Ann. Rept., 1919, p. 5, New York, 1920.

on the Bonanza lode revealed a sufficient tonnage to justify the construction of nearly 200 miles of railroad.

In contrast to the conditions above set forth are those which brought about the development of the Jumbo lode. The outcrop of this lode consisted of a zone of fracturing along which fine seams of chalcocite occurred. Though it was a very promising place for prospecting, there was nothing on the surface to justify a belief that an enormous ore body lay underneath, as proved to be the case. Had the development of the district depended on the surface showings of the Jumbo instead of those of the Bonanza, it would doubtless have been long delayed.

It is therefore reasonable to suppose that there may be other large ore bodies in the limestone at localities where there is little evidence of their presence on the surface, but these statements are not presented as an argument for haphazard underground exploration of the limestone for ore bodies that do not crop out. Such work is justified only at localities that show surface evidence of faulting and fracturing, as well as of some copper mineralization. The facts presented justify the belief that other workable deposits of the Kennecott type will be found.

Traces of copper are present in much of the unaltered greenstone in the district, and local mineralization of the ancient lava flows is also common. Bateman and McLaughlin [16] state that the examination of many greenstone localities shows "that hardly a greenstone specimen could be found which did not show appreciable copper, and numerous assays of greenstones from unmineralized areas yielded 0.11 to 0.60 per cent copper." Such occurrences are of course of no present commercial importance, but copper in more concentrated form occurs in many localities in the greenstone. Mineralization in the greenstone has produced both well-defined fissure veins and usually less well-defined and more disseminated deposits, which in general follow zones of fracturing and shearing. These deposits are in part cavity fillings and in part replace the country rock. With them may also be classed the ill-defined deposits of sulphides and native copper occurring along joint planes and as amygdaloidal fillings of lavas.

The cupriferous veins that cut the greenstone and in part cross the contact into the limestone have furnished the best-defined ore bodies of the greenstone. Of such a type is the Nikolai lode, in the eastern part of the field, the first copper deposit found in the district. Veins of this type are essentially sulphide deposits containing one or more of the minerals bornite, chalcopyrite, chalcocite, and pyrite, with very rarely tetrahedrite. The gangue minerals are quartz and calcite with some epidote, but some veins consist almost entirely of sul-

[16] Op. cit., p. 19.

phides. Many deposits of this type have been found and some have been opened, but as yet none have shown any large tonnage of ore by the underground work done. The best hope for veins of this type lies in those that carry a high content of copper, and such veins, if accessible to the railroad, might be profitably exploited.

The larger deposits of the disseminated type in the greenstone have the same mineral character as the veins but are found in zones of shearing rather than in fissures. They carry bornite, chalcopyrite, chalcocite, and some native copper. Many of those developed are narrow groups of fissures which do not include any considerable mass of bedrock. In others the shear zones are much wider, and such deposits give promise of being commercial ore bodies. Within the shear zones there may be one or more veins forming ore shoots, or the deposit may consist only of mineralized fractured rock. Though no mines have been developed on deposits of this type, the indications are sufficiently encouraging to justify the belief that some of them may prove to be commercial ore bodies. It will be impracticable to list here the very many copper deposits of this type that have been more or less prospected in the district.

Many of these deposits carry more or less native copper in slabs and slugs and as amygdaloidal fillings. The evidence thus far obtained indicates that this native copper is all secondary and has resulted from the oxidation of sulphides. Therefore the native copper will probably not be found to any considerable depth. It should be noted, however, that the evidence of the alluvial deposits indicates that some very large masses of native copper occur in the greenstone. On Nugget Creek, near the west end of the district, a mass of native copper, estimated to weigh two or three tons, has been found, and smaller nuggets are very common. Thousands of pounds of native copper have been won from the Nizina placers, in the eastern part of the district, incidentally to the mining of gold.

Some copper deposits of contact-metamorphic origin have been found in the Kuskulana River basin, in the western part of the district.[17] These lie in the contact zone between limestone and intrusive diorite, and they are made up of irregularly distributed masses and veins of magnetite carrying pyrite and chalcopyrite. These contact deposits are essentially low-grade concentrating ores with some richer shoots of sulphide ores. Their mode of occurrence, so far as determined, is similar to that of the contact deposits of the Ketchikan district. (See pp. 15–16.)

Another type of copper lode has been found on Clear Creek, in the Kuskulana River basin.[18] At this locality a dioritic rock is intruded

[17] Moffit, F. H., Mining in lower Copper River basin: U. S. Geol. Survey Bull. 662, p. 160, 1917.

[18] Moffit, F. H., Mineral deposits of the Kotsina-Kuskulana district: U. S. Geol. Survey Bull. 622, p. 113, 1915.

into the greenstone. The diorite and adjacent parts of the greenstone have been fractured along a shear zone and are more or less mineralized by pyrite and chalcopyrite. These sulphides are distributed in small gash veins and in larger veins along the planes of movement. In general this is a low-grade disseminated deposit with some richer ore shoots. A deposit of somewhat similar character occurs in the Taral region.[19] Here there is a shear zone in greenstone near an intrusive diorite contact. The ore consists of a series of parallel veins of pyrite and chalcopyrite, which lie in the zone of shearing.

Fissure veins, valuable chiefly for their gold and silver content, have been found at several localities in the district, and some of them carry more or less chalcopyrite. Such a vein has been opened at the Midas gold mine, where it cuts dioritic rocks. No large ore bodies of this type have yet been revealed, and it remains to be determined whether any such deposits could be counted upon as possible sources of siliceous ore.

The Kotsina-Chitina copper district is easily accessible by the Copper River & Northwestern Railroad, which extends inland for 192 miles from Cordova, a good harbor and ice-free port on Prince William Sound. Outgoing shipments are on a down grade, and if a large tonnage were available reasonable freight rates should be expected. This railroad passes within 38 miles of the Bering River coal field (see pp. 47–48), and a short distance beyond this is the Katalla oil field (see pp. 52). These geographic facts would seem to favor the use of the copper deposits here described for the upbuilding of a local industry. The high-grade ores, with calcareous gangue, would meet ores of lower grade from Prince William Sound at Cordova, while near by there are sources of excellent fuel.

There is no great amount of timber in the Kotsina-Chitina district, but it is sufficient to meet the immediate needs of a mining industry. The district is one of strong relief, and most of the ore bodies now known could be developed by adits. There are some large water powers in this general region, but most of them are not near the ore bodies. There are no climatic conditions in the district which prevent mining throughout the year, though some difficulties are caused by snowslides.

Although the conditions above described are in general favorable to the developments of the copper deposits, the present situation presents many drawbacks. The railroad traverses the southern margin of the copper belt, making the district accessible as a whole, but many of the prospects are 5 to 25 miles from the track. No spurs have been built, and there are few wagon roads. This condition makes development work expensive. In the event of the opening

[19] Moffit, F. H., Geology of the Hanagita-Bremner region, Alaska: U. S. Geol. Survey Bull. 576, pp. 51–52, 1914.

up of large ore bodies this situation would of course be met by providing connection with the railroad by spurs or aerial trams.

The present freight rates on the railroad are high. The rates on ore and concentrates from this district to the Tacoma smelter in 1920 ranged from $11.20 a ton on ore worth $25 a ton to $40.90 on ore worth $500. The railroad company contends that as it is not making expenses it can not afford to lower the rates.[19a] On the other hand, prospective operators hold that under the present rates no mining is possible except that of very high grade ore. Consequently but little development work is now under way. It would appear to be the part of wisdom to lower the rates with a view of encouraging a development that would produce enough ore to make the railroad a profitable venture in the future. As it is, no ore is shipped except the high-grade product of the Kennecott Mines Co., which controls the railroad. It should also be noted that there has not yet been a sufficient assured quantity of coal disclosed in the Bering River field to justify the extension of a branch line into the coal field, also that the Katalla oil field is as yet only a small producer. Aside from the question of freight rates, mining costs in the interior will certainly for a long time to come be higher than on the coast.

In view of these conditions an ore body of a given size and copper content which might if located on the coast be valuable if in the interior would at present be worthless. Nevertheless the situation of the Kotsina-Chitina copper deposits with reference to sources of fuel and to the ores of a different character on the Sound presents possibilities which should not be underestimated.

Productive mining in the Kotsina-Chitina district began in 1911. Up to the end of 1919 about 1,360,000 tons of copper ore had been mined, from which about 417,700,000 pounds of copper had been recovered. In 1919 the district produced 195,631 tons of ore, carrying 36,291,390 pounds of copper and 408,726 ounces of silver. (See p. 68.) No gold has been recovered from the copper of this district.

SUSITNA VALLEY REGION.

Evidences of copper mineralization have long been known at many widely separated localities in the basin of Susitna River, which flows into the head of Cook Inlet. Until the project of opening this province by a Government railroad was definitely entered upon in 1915 these deposits received but little attention. During the last five years there has been a good deal of prospecting for copper in this field, but as yet the amount of underground work is small and nowhere has any considerable quantity of ore been blocked out. Many of the prospects are far from the completed part of the railroad, and the cost of developing some of them has been prohibitive. As the railroad is pushed forward conditions improve, and the situation is also being helped by the construction of wagon roads and

[19a] The Copper River & Northwestern Railroad reported an operating loss for the year 1919 of $177,895.78 (Kennecott Copper Corp. Fifth Ann. Rept., 1919, p. 14, New York, 1920).

trails. Information about the geology and mineral resources of this region is to be found in the following Geological Survey publications:

Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: Bull. 500, 1912.

Capps, S. R., The Yentna district, Alaska: Bull. 534, 1913.

Martin, G. C., and Mertie, J. B., Mineral resources of the upper Matanuska and Nelchina valleys: Bull. 592, pp. 273–300, 1912.

Capps, S. R., The Willow Creek district, Alaska: Bull. 607, 1915.

Moffit, F. H., The Broad Pass region, Alaska: Bull. 608, 1915.

Capps, S. R., The Turnagain-Knik region: Bull. 642, pp. 147–194, 1916.

Chapin, Theodore, The Nelchina-Susitna region, Alaska: Bull. 668, 1918.

Capps, S. R., Mineral resources of the upper Chulitna region: Bull. 692, pp. 177–186, 1919.

Capps, S. R., Mineral resources of the western Talkeetna Mountains: Bull. 692, pp. 187–205, 1919.

Chapin, Theodore, Mining developments in the Matanuska coal field: Bull. 712, pp. 131–167, 1920.

Chapin, Theodore, Lode developments in the Willow Creek district: Bull. 712, pp. 169–176, 1920.

The best known of the copper deposits of this region were formed by replacement along shear zones that traverse mainly limestone and ancient volcanic rocks. A number of prospects have been found in the western part of the Talkeetna Mountains, notably in the drainage basins of Talkeetna and Kashwitna rivers. The geology of this area is relatively simple; a series of andesitic lavas, with which some limestone is associated, are intruded by great stocks of granitic and dioritic rocks which form the main mass of the mountains. It appears that the copper mineralization is genetically related to the intrusion, as is the auriferous lode of the Willow Creek district, lying along the southern margin of the same intrusive mass. This inference is supported by the fact that some chalcopyrite-bearing auriferous lodes have been found in the Willow Creek district.

The copper-bearing lodes of the Talkeetna region occur as replacement deposits along shear zones cutting the greenstones. Their metallic minerals include chalcopyrite, pyrite, bornite, and arsenopyrite, and assays show that they carry gold and silver. The gangue is mostly quartz and some calcite.

There has been but little underground work in this region, but the surface exposures indicate that these deposits are essentially of a disseminated type, though they include some rich shoots of sulphide ores, chiefly chalcopyrite. There are in this region extensive areas in which the geologic conditions above described prevail; hence there is good reason to believe that other copper deposits may be found.

Evidence of some copper mineralization has also been reported to occur on the west side of the Susitna Valley, but these occurrences are not verified at this writing. In this region granitic and dioritic rocks invade sedimentary rock. Gold placers in this part of the province are direct evidence of mineralization.

In the upper Chulitna Valley, sometimes called the Broad Pass district, considerable work has been done on some ore bodies of rather complex composition. These are disseminated replacement deposits along fracture zones, and have been found chiefly in a limestone country rock but also in tuffs and cherts. The walls of these deposits are not everywhere well defined, and the ore bodies are rather irregular. They contain arsenopyrite, pyrite, sphalerite, chalcopyrite, pyrrhotite, stibnite, and galena, and assays show the presence of gold. The gangue is country rock and includes much calcite and some quartz. So far as yet determined these occurrences are of a disseminated type and of rather low grade. They include, however, some rich ore shoots.

It is evident from the above summary that as yet there is no assurance that valuable copper-bearing lodes occur in the Susitna region. It is fair to infer, however, from the geologic information at hand that the region is not to be ignored as a possible source of copper.

The close proximity of the high-grade coals of the Matanuska field (see pp. 47–48) favors the development of copper. The railroad will give an outlet to the coast at Anchorage certainly for at least half the year and to a good harbor at Seward throughout the year. (See Pl. II, in pocket.) After the railroad is completed there will still be need of spurs and branches to reach the known deposits of copper.

The timber of the province is not of a high grade but will meet the immediate needs of the mining industry. There are no climatic obstacles to operations throughout the year. Little is known about the water-power resources, but no doubt some are available. On account of distance to the railroad, isolation, and scarcity of labor, the cost of preliminary developments will be high. Should a large mining industry be developed and a permanent population be attracted thereby, the cost of labor will be less. It is certain, however, that mining costs will always be greater in the Susitna basin than on the coast.

ILIAMNA REGION.

Iliamna Bay, on the west side of Cook Inlet, is a fair harbor and usually open to navigation at all times, though in winter difficulties with float ice are occasionally encountered.[20] Work has been done on some copper prospects about 10 miles inland from Iliamna Bay,[21] on contact deposits occurring in the zone of metamorphism between limestones and dioritic intrusives. The metallic contents of the ores are chalcopyrite, pyrite, and magnetite, and the gangue

[20] The conditions affecting transportation in this region are presented in Railway routes in Alaska: Alaska Railroad Comm. Rept., 62d Cong., 3d sess.. H. Doc. 1346, pp. 90–91, 105–106, 1913.

[21] Martin, G. C., and Katz, F. J., A reconnaissance of the Iliamna region: U. S. Geol. Survey Bull. 485, pp. 113–126, 1912.

consists of lime silicates, calcite, and some quartz. Information at hand indicates that the ores are chiefly calcareous. These occurrences are of the same general character as the contact deposits of the Ketchikan district (p. 15), but as yet no large ore bodies have been opened. The same region contains some auriferous quartz veins. Another occurrence of copper is reported about 30 miles southwest of those above described, near Kamishak Bay,[22] apparently in a contact zone between volcanic and intrusive rocks. The copper occurs as chalcopyrite, and the ore is said to be of low grade. There are some large water powers in this general province, and some local timber. Present knowledge does not warrant any predictions as to the value of the copper deposits of the Iliamna region.

NABESNA-WHITE RIVER REGION.

The occurrence of copper has long been known in the headwater regions of White River, a tributary to the Yukon, and on Nabesna River, a tributary to the Tanana. This province can now be reached from the established routes of transportation only by long overland journeys. Its development as a copper province will be possible only by large expenditures for railroad construction.[23]

The copper occurs in formations which stretch from the international boundary westward along the northern base of the Wrangell Mountains to Nabesna River, a distance of some 200 miles. Evidence of mineralization has been found at several places along this entire belt, but most of the important prospects are near its two ends.[24]

In the Nabesna region deposits of bornite and chalcopyrite, associated with garnet, calcite, epidote, hematite, and a little molybdenite, have been found. These minerals occur in irregular ore bodies that lie in the contact zone of limestone and diorite and carry some gold. In the basin of Chisana River, a tributary to the Tanana, some small chalcopyrite-bearing quartz veins cut ancient lava flows. In the White River basin native copper has been found as a primary mineral in the cavities of ancient amygdaloidal, basaltic lavas. This is the only region in Alaska in which primary native copper has been found. It should be noted that native copper which is clearly secondary also occurs in this region as slabs and nuggets in ancient lavas. These are of the same general type as those in the Chitina-Kuskulana district described above.

This belt contains some promising ore bodies, and evidence of copper mineralization is widely distributed. Its deposit of native

[22] Brooks, A. H., The Alaska mining industry in 1913: U. S. Geol. Survey Bull. 592, p. 64, 1914.

[23] A description of the various possible railroad routes into this region is contained in the report of the Alaska Railroad Commission (62d Cong., 3d sess.), H. Doc. 1346, pp. 44-53, 67-69, 70-71, 1913.

[24] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: U. S. Geol. Survey Bull. 417, 1916. Capps, S. R., The Chisana-White River district, Alaska: U. S. Geol. Survey Bull. 630, 1916.

copper especially gives promise of being valuable. Were the region not so inaccessible it would long ago have been thoroughly prospected. As it is, the developments have been confined to only a few claims.

MISCELLANEOUS LOCALITIES.

The districts above described are those that give the most promise of having important potential copper resources. There are also scattered occurrences of copper mineralization which for the sake of completeness will here be briefly recorded.

Some copper-bearing deposits have been found on the Alaska Peninsula, near Prospect and Balboa bays.[25] These deposits occur along shear zones in volcanic rocks and carry pyrite, galena, sphalerite, chalcopyrite, and quartz. There is no evidence at hand that any commercial ore bodies have been found. It has long been reported that copper has been found on some of the Aleutian Islands, but nothing is known of its form of occurrence or of the locality of the alleged discovery. A little auriferous mineralization has occurred on Unalaska Island along the margin of an intrusive granite. It is worthy of note that native copper was long ago found on Midni Island, of the Commander group, off the east coast of Siberia. These islands lie in an extension of the axis of the Aleutian chain and presumably belong to the same geologic province.

A little copper mineralization is reported by prospectors in the Alaska Range near the head of McLaren River, and they have brought back specimens of chalcocite. This fact would hardly be worthy of note except that the occurrence is reported to be in limestone near a greenstone contact, a position which suggests a similarity to some of the deposits of the Chitina-Kuskulana district. What is known of the geology of this region[26] confirms the description furnished by the prospectors who made the discovery. A little copper has also been found in association with greenstones and diorites in the Paxon region, traversed by the Valdez-Fairbanks wagon road. This general province is therefore a possible field for copper lodes.

A copper-bearing quartz lode has been prospected in the Russian Mountains, 12 miles from Kolmakoff, on Kuskokwim River.[27] It is composed chiefly of chalcopyrite and arsenopyrite and contains gold and silver. The newly discovered gold-bearing lodes of the Nixon Fork district, in the upper Kuskokwim Valley, carry a little copper.

Copper-bearing deposits have been found on Seward Peninsula, and some of these have been developed in a small way, and a few

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[25] Atwood, W. W., Geology and mineral resources of parts of the Alaska Peninsula: U. S. Geol. Survey Bull. 467, pp. 129, 131, 1911.

[26] Moffit, F. H., Headwater regions of Gulkana and Susitna rivers, Alaska: U. S. Geol. Survey Bull. 498, 1912.

[27] Maddren, A. G., Gold placers of the lower Kuskokwim: U. S. Geol. Survey Bull. 622, pp. 304–305, 1915.

test shipments of ore have been made. The best known of these deposits occur as impregnated zones along or near limestone-schist contacts. The ore minerals are chalcopyrite and bornite, with considerable copper carbonate near the surface.[29]

Copper-bearing lodes have been found in several places in the Noatak-Kobuk region of northern Alaska.[30] Considerable prospecting has been done on some of these lodes near Shungnak, in the middle Kobuk Valley. (See map, Pl. II, in pocket.) These lodes occur in limestone along zones of brecciation. They carry bornite, chalcopyrite, galena, and pyrite, and assays show the presence of gold and silver. Were these deposits not so isolated they would undoubtedly have attracted more attention.

In 1919 11 copper mines were operated in Alaska, producing 492,644 tons of ore, from which 47,220,771 pounds of copper was recovered. (See p. 68.) Of this total 451,445 tons of ore was concentrated by flotation at the mines, yielding 52,944 tons of concentrates. Nearly all this ore was treated at the Tacoma smelter. One small mine in the Ketchikan district shipped its ore to the Anyox smelter, in British Columbia.

The reserve tonnage of the present Alaskan copper developments is small. On the other hand, the evidence of strong copper mineralization in several of the accessible mining districts of Alaska and the widespread distribution of copper ores give every assurance for the future. It can therefore be confidently predicted that Alaska's copper industry will grow when transportation is improved and general industrial conditions are revived.

SILVER AND LEAD.

Alaska has produced about 9,000,000 ounces of silver and 4,184 tons of lead, practically all won incidentally to the mining of other metals. The silver has come from the gold placers and the gold and copper lodes. Its annual output has therefore fluctuated with the production of gold and copper. With an increased output of these metals more silver will be produced. Most of the lead has been obtained from the gold mines of the Juneau district.

Silver-lead ores in the form of galena have a wide distribution in Alaska. Such ores are found in the Ketchikan district, in Seward Peninsula, in the Koyukuk region, in the Fairbanks district, in the Mentasta Pass region (upper Tanana), and in the Kantishna, Ruby, and other districts. Little attention was paid to these ores until the recent great advance in the price of silver. Since then galena de-

[29] Mertie, J. B., Lode mining and prospecting on Seward Peninsula: U. S. Geol. Survey Bull. 662, pp. 440–441, 1918. Smith, P. S., Investigations of mineral deposits of Seward Peninsula: U. S. Geol. Survey Bull. 345, pp. 241–244, 1908.

[30] Smith, P. S., The Noatak-Kobuk region, Alaska: U. S. Geol. Survey Bull. 536, pp. 147–151, 1913.

posits have been sought for and prospected, especially those that carry a high percentage of silver. The most promising recent discovery is a lode in the Kantishna district. The evidence in hand does not indicate that any considerable bodies of galena ore have been found. With the improvement in mining conditions such ores will be developed, but there is as yet nothing to indicate that they form an important part of the potential mineral reserves of Alaska.

TIN.[31]

Alaska has produced about 972 tons of metallic tin, which has nearly all come from the placers of the York district at the west end of Seward Peninsula. Tin deposits, both placers and lodes, were discovered by the United States Geological Survey in 1900 and 1902. Developments began in a small way on placer tin in 1902 and the first dredge was installed in 1911. Since then two or three dredges have been employed in tin mining. A number of discoveries of lode tin have been made in the York district. Practically no tin has been produced from lodes, but lode developments have been underway since 1903. The only considerable underground exploration has been at the Lost River mine, where a mill is now under construction.

Some placer tin has also been produced incidentally to gold mining in the Hot Springs district of the Tanana Valley and in smaller amounts in other Yukon districts. Placer tin has also been found in the gravels of Yentna River, which is tributary to the Susitna.

Though there has been some systematic search for tin in Alaska during the last two decades, promising deposits have been found only in the York and Hot Springs districts. No new deposits of placer tin have been discovered in the York district in recent years, and there is no certainty that this form of tin mining will be continued there when the deposits now being exploited are worked out. No tin placers which, under present economic conditions, will warrant exploitation for their tin alone have yet been found in the Yukon districts. When costs of operation are reduced placer-tin mining may be developed in the Hot Springs and other districts. The distribution of the alluvial tin in this district also justifies the hope that tin-bearing lodes may yet be discovered. Meanwhile, the best hope of the continuation of Alaska tin mining is based on the lode tin of the York district. The Lost River mine, in this district,

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[31] Knopf, Adolph, Geology of the Seward Peninsula tin deposits, Alaska: U. S. Geol. Survey Bull. 358, 1908.

Eakin, H. M., A geologic reconnaissance of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 37–38, 1913; Tin mining in Alaska: U. S. Geol. Survey Bull. 622, pp. 81–94, 1915.

Chapin, Theodore, Tin deposits of the Ruby district: U. S. Geol. Survey Bull. 692, p. 337, 1919.

Harrington, G. L., Tin mining in Seward Peninsula: U. S. Geol. Survey Bull. 692, pp. 353–361, 1919.

Steidtmann, Edward, and Cathcart, S. H., The York tin deposits: U. S Geol. Survey Bull — (in preparation).

is the only property sufficiently developed to justify the belief that it will soon become a producer, yet there are other deposits in the region which deserve prospecting.

The above-stated facts do not show any large potential tin reserves in Alaska, but the rather wide distribution of the tin deposits gives hope of future discoveries. There is no evidence that the tin output will decrease in the near future, yet a large increase in production must depend on the development of deposits not yet discovered.

PLATINUM.

Small quantities of platinum and allied metals have been found at widely separated localities in Alaska. The only considerable deposit of these metals thus far developed is in the Ketchikan district, where the ores of the Salt Chuck copper mine (see p. 18) carry a sufficient percentage of palladium to be worked for that metal alone.

Small quantities of platinum have been recovered incidentally to gold placer mining in several districts.

Localities where placer platinum and minerals of allied groups have been found.

District.	Creek.	Notes.
Yentna (Susitna Basin) [a]	Cache Creek	Minute quantities.
	Poorman Creek	Do.
	Wilson Creek	Do.
	Long Creek	Do.
	Kahiltna River	Do.
Kodiak Island [b]	Canvas Point	Do.
Chistochina (Slate Creek) [c]	Slate Creek	Small quantities recovered.
	Miller gulch	Do.
Innoko district (Tolstoi) [d]	Boob Creek	Do.
Koyuk (southeastern part of Seward Peninsula). [e]	Dime Creek	Do.
Fairhaven (northeastern part of Seward Peninsula). [e]	Bear Creek	Do.
	Sweepstake Creek	Do.
Lower Kuskokwim [f]	Aloric River	Minute quantities.
Marshall [f]	Lower Yukon River	Do.

[a] Mertie, J. B., Platinum-bearing gold placers of Kahiltna Valley: U. S. Geol. Survey Bull. 692, pp. 233-263, 1917.
[b] Maddren, A. G., The beach placers of the west coast of Kodiak Island: Idem, p. 316.
[c] Chapin, Theodore, Platinum-bearing auriferous gravels of Chistochina River: Idem, pp. 137-141.
[d] Harrington, G. L., The gold and platinum placers of the Tolstoi district: Idem, pp. 339-351.
[e] Harrington, G. L., The gold and platinum placers of the Kiwalik-Koyuk region: Idem, pp. 369-400.
[f] Martin G. C., Mineral resources of Alaska, 1917: U. S. Geol. Survey Bull. 692, p. 7, 1919.

The total output of platinum, palladium, and other metals of the platinum group is about 915 ounces. Except at the Salt Chuck mine the recovery of these rare metals was only incidental to mining of placer gold. The record does not indicate that Alaska will become an important source of platinum minerals unless new discoveries are made.

ANTIMONY.

Antimony ore, in the form of stibnite, is one of the most widely distributed minerals in Alaska,[32] but most of the larger desposits are in the interior. The high price and ready market for antimony during the war led to the development of stibnite ores at several localities, especially in the Fairbanks and Nome districts. This temporary demand subsided at the end of the war and antimony mining ceased. A total of 2,492 tons of stibnite was produced between 1916 and 1918.

The facts in hand indicate that there are large reserves of antimony ore in Alaska and that they are mostly in the less accessible parts of the Territory. Their future development is dependent on market and on cost of transportation.

TUNGSTEN.

Tungsten-bearing lodes were developed at Fairbanks and Nome when the war needs led to an abnormal demand for this metal. Considerable tungsten ore[33] was shipped from these properties between 1916 and 1918, and some scheelite was also recovered from the concentrates of gold dredges at Nome and Iditarod. With the break in the tungsten market after the war all these operations ceased. In all about 86½ tons of Alaska scheelite concentrates have been mined and marketed.

Wolframite and scheelite occur in some of the tin ores of the York district, Seward Peninsula, but these deposits have been only slightly developed. Wolframite has also been found in association with some of the gold placers of the Yukon-Tanana region. In 1916 a little wolframite, won from the placers, was shipped from the Birch Creek district. A scheelite-bearing vein has been found on Baranof Island near Sitka.

These facts indicate that tungsten ores are rather widely distributed in Alaska. Should a market arise for this ore on the west coast, some of the deposits would no doubt be developed.

QUICKSILVER.

Quicksilver deposits, in the form of cinnabar-bearing veins, have long been known on Kuskokwim River.[34] Cinnabar is also not an uncommon accessory mineral of some of the gold placers, notably on Daniels Creek, in the Bluff region of Seward Peninsula, on some of the creeks of the Iditarod district, and on Candle Creek, in the Kuskokwim basin near McGrath. The only developed quicksilver mine in Alaska is the Parks property, on the north bank of the Kusko-

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[32] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, 1916.

[33] Mertie, J. B., Lode mining in the Fairbanks district: U. S. Geol. Survey Bull. 662, pp. 418–424, 1917, Lode mining and prospecting on Seward Peninsula: Idem, pp. 436–437.

[34] Smith, P. S., and Maddren, A. G., Quicksilver deposits of the Kuskokwim region: U. S. Geol. Survey Bull. 622, pp. 274–280, 1915.

kwim, about 330 miles from its mouth. Here some cinnabar ore has been retorted, and the quicksilver thus produced was sold to the placer miners of Alaska. There has been some prospecting of other quicksilver deposits in this general region, but none of the properties have been sufficiently developed to give assurance of a definite output.

There is reason to believe that the lower Kuskokwim will continue to be a producer of quicksilver, but no facts are at hand which indicate that quicksilver mining will become a large industry in Alaska.

CHROMITE.

Considerable bodies of chromite ore have been found at the southwest end of Kenai Peninsula,[35] and during the war the large demand for chromite led to the productive development of one of them, which lies directly on tidewater. The large tonnage of ore in sight and the accessibility of the deposit make it certain that this deposit will be mined when a market can be found for the product. What seems to be a large deposit of chromite has also been found at Red Mountain, which is about 7 miles from the one above described. Some chromite has been found in other parts of Alaska, but as yet no other commercial ore bodies are known.

NICKEL.

A nickel-bearing copper deposit has been developed in a small way on the west side of Chichagof Island, about 70 miles north of Sitka. Some nickel has been found in other deposits of similar geologic character in this general region.[36] These deposits are found in association with norite or diorite, which has a rather wide distribution in the district. Their geologic association is the same as that of the nickel ores of Sudbury, Canada. There is a possibility that commercially valuable nickel ores may be developed in this district.

Another nickel-bearing copper lode occurs on Canyon Creek, in the lower Copper River valley.[37] Traces of nickel have been found in gold ores sent to the Geological Survey from the McGrath district, in the Kuskokwim Valley. Some of the copper ores of the Ketchikan district contain traces of nickel (p. 15), and it is reported that the same is true of some of the copper ores of the Prince William Sound region. It will be evident from the above statements that information about the nickel deposits of Alaska is not complete enough to justify an estimate of their future value.

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[35] Gill, A. C., Preliminary report on the chromite of Kenai Peninsula: U. S. Geol. Survey Bull. 712, pp. 99-129, 1919; Chromite of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. — (in preparation).

[36] Overbeck, R. M., Geology and mineral resources of the west coast of Chichagof Island: U. S. Geol. Survey Bull. 692, pp. 125-133, 1919.

[37] Overbeck, R. M., Nickel deposits in the lower Copper River valley: U. S. Geol. Survey Bull. 712, pp. 91-98, 1919.

MOLYBDENITE.

Molybdenite is not an uncommon accessory mineral in some of the Alaska gold and copper ores and has also been found at several localities in more concentrated form. The best-developed Alaska molybdenite lode is near Shakan, on Prince of Wales Island.[38] A molybdenite lode has been found at Lemesier Island, in Icy Strait.[39] Some development work is reported on a molybdenite-bearing lode on the railroad near Skagway.[40] Molybdenite has also been found on Canyon Creek, a tributary to upper Chitina River and about 50 miles from McCarty,[41] and on Dry Delta River a tributary to the Tanana.[42] Except for that at Shakan, none of these deposits have been sufficiently developed to prove their commercial importance. There has been no molybdenite produced in Alaska.

BISMUTH.

A small bismuth-bearing vein has been found on Charley Creek, in the Nome district, but is undeveloped.[43] Bismuth has been found in gold prospects at two localities in the Tanana Valley—on Eva Creek,[44] a tributary to Totatlanika Creek, and on Melba Creek,[45] in the Fairbanks district—but little is known of the extent of these deposits. There has been no production of bismuth in Alaska.

IRON.

In the absence of any considerable iron industry on the Pacific coast there has been no incentive to search for iron ores in Alaska. The largest deposits known consist of magnetite associated with copper ores—the contact-metamorphic deposits of the Ketchikan district (p. 15). J. B. Mertie, who has made a rough estimate of the quantity available from these deposits, places the minimum reserve at 10,000,000 tons, with possibly an average copper content of 0.5 per cent. This estimate is based on an appraisal of the probable depth of the known deposits and on the assumption that all the ore would be available for mining. There are no accurate data at hand on the mean iron content of these ores, nor is it known whether the phosphorus contents are everywhere below the Bessemer limit. Some analyses of the Mount Andrew magnetite ore made many years ago gave a phosphorus content of 0.02 per cent.[46] The

[38] Chapin, Theodore, Mining developments in the Ketchikan district: U. S. Geol. Survey Bull. 692, p. 89, 1919.

[39] Knopf, Adolph, The Sitka mining district, Alaska: U. S. Geol. Survey Bull. 504, p. 17, 1912.

[40] Brooks, A. H., The Alaska mining industry in 1916: U. S. Geol. Survey Bull. 662, p. 25, 1918.

[41] Brooks, A. H., The Alaska mining industry in 1915: U. S. Geol. Survey Bull. 642, p. 54, 1916.

[42] Martin, G. C., The Alaska mining industry in 1918: U. S. Geol. Survey Bull. 712, pp. 23–24, 1920.

[43] Moffit, F. H., Geology of the Nome and Grand Central quadrangles, Alaska: U. S. Geol. Survey Bull. 533, p. 133, 1913.

[44] Overbeck, R. M., Lode deposits near the Nenana coal field: U. S. Geol. Survey Bull. 662, pp. 351–362, 1917.

[45] Chapin, Theodore, Lode mining near Fairbanks: U. S. Geol. Survey Bull. 592, pp. 330–331, 1914.

[46] Brooks, A. H., The Ketchikan mining district, Alaska: U. S. Geol. Survey Prof. Paper 1, p. 102, 1902.

possibility that these ores contain titanium should also be considered. On account of the presence of sulphides the sulphur content of the ores will be high. Similar deposits have been mined on Tuxedo Island, in British Columbia, and these contain an average of 55 to 60 per cent of metallic iron,[47] and the phosphorus content of most of them is low enough to make them fall within the Bessemer limit, but the sulphur content is high.

Deposits of iron ore of the segregated type occur near Haines, in southeastern Alaska, and have been developed in a small way, but their commercial value remains to be established. According to Knopf,[48] they consist of primary magnetite disseminated in a basic rock composed of pyroxene and hornblende. The best specimens seen carried a maximum of 30 per cent of magnetite. A microscopic examination showed the presence of apatite, and the analysis of one sample showed 3.91 per cent of titanium oxide.

A deposit of magnetite ore has been discovered on the north shore of Tuxedni Bay (Snug Harbor), an indentation of the west shore of Cook Inlet. The deposit has been described by prospectors to be of considerable magnitude and to occur near the contact of a granitic intrusive in volcanic rocks. The ore body has been staked but is undeveloped.

Schrader[49] described a magnetite ore body which appears to be a vein in the Nabesna region. This vein is well defined and occurs at a contact between limestone and diabase. Grant and Higgins [50] report the occurrence of hematite and magnetite bearing veins in the Prince William Sound region. Some magnetite also occurs in the contact copper deposits of the Iliamna region (pp. 33–34).

A little work has been done on some iron deposits on Seward Peninsula about 25 miles northwest of Nome. As exposed the iron-ore bodies consist principally of limonite veins and stockworks and their residual products,[51] occurring in limestone. Other minerals found in the deposits are hematite, galena, pyrolusite, and small quantities of gold. An analysis of the samples from one deposit showed 54 per cent of iron, no titanium, and 0.13 per cent of P_2O_5. The surface evidences indicated that the mineralizing agents had affected considerable areas.

The above brief review indicates that Alaska contains a number of iron-ore deposits, of which the most promising are those of the

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47 Lindeman, Eimar, Iron-ore deposits of Vancouver and Texedo islands, British Columbia: Canada Dept. Mines, Mines Branch, No. 47, Ottawa, 1910.

48 Knopf, Adolph, The occurrence of iron ore near Haines: U. S. Geol. Survey Bull. 442, pp. 144–146, 1910. Eakin, H. M., The Porcupine gold-placer district: U. S. Geol. Survey Bull. 699, pp. 27–29, 1919.

49 Mendenhall, W. C., and Schrader, F. C., Mineral resources of the Mount Wrangell district, Alaska: U. S. Geol. Survey Prof. Paper 15, pp. 65–66, 1903.

50 Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, pp. 78–79, 1910.

51 Eakin, H. M., Iron-ore deposits near Nome: U. S. Geol. Survey Bull. 622, pp. 361–365, 1915.

Ketchikan district. It would appear that the value of the Ketchikan deposits will depend on finding a commercial method of recovering the low copper contents, as well as utilizing the iron.

COAL.

GENERAL OCCURRENCE.

Formations that are known to be locally coal bearing are widely distributed in Alaska and occupy an aggregate area of more than 12,000 square miles. (See Pl. II, in pocket.) About 80 per cent of Alaska is unsurveyed, and some of the unexplored regions may contain coal. It is therefore not impossible that the total area of the coal-bearing formations may far exceed 12,000 square miles. Any additions that may be made to the known coal reserves as a result of future explorations will probably not greatly increase the immediately available stores of fuel, which alone are here under discussion. Most of the regions tributary to the existing lines of transportation or those under construction are sufficiently explored to indicate whether or not they contain coal. Outcrops of coal are not easily overlooked, either during hasty exploration or by the prospector, and, therefore, the coal-bearing areas already outlined in a rough way, though many have not been surveyed, probably include much the larger part of those that will be available for use in the immediate future. In any event, it is with reference to these known coal fields, and not to possible discoveries in unsurveyed tracts, that the future of the coal-mining industry must here be discussed. The Alaska reserves in general may be said to include enormous quantities of lignite, considerable low-grade bituminous coal, much smaller quantities of high-grade bituminous coal, and some anthracite. The bituminous coals are the highest-grade coals found on the west coast of the American continent and are comparable in composition to the best Appalachian fuels. It is on these high-grade coals that the present development of the coal-mining industry in Alaska depends, for they are the only fuels suitable for export.

PUBLICATIONS RELATING TO ALASKA COAL FIELDS.

Surveys and investigations of the Alaska coal fields were begun by the Geological Survey in 1902 and have been continued as funds were available up to the present time. Many geologists have taken part in this work, but nearly all the detailed surveys have been made by George C. Martin. The following is a list of the principal Survey and other official publications relating to Alaska coal. Some of these reports deal specifically with individual coal fields; in others the reference to coal is only incidental to the discussions of mineral resources.

U. S. GEOLOGICAL SURVEY.

GENERAL.[52]

Martin, G. C., Markets for Alaska coal: Bull. 284, pp. 18–29, 1906.

Brooks, A. H., Alaska coal and utilization: Bull. 442, pp. 47–100, 1911.

MATANUSKA COAL FIELD.

Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: Bull. 500, 1912.

Martin, G. C., and Mertie, J. B., Mineral resources of the upper Matanuska and Nelchina valleys: Bull. 592, pp. 273–300, 1914.

Martin, G. C., Geologic problems at the Matanuska coal mines: Bull. 692, pp. 269–282, 1919.

Chapin, Theodore, Mining developments in the Matanuska coal field: Bull. 712, pp. 131–167, 1920.

Chapin, Theodore, Mining develpoments in the Matanuska coal fields: Bull 714, pp. 197–199, 1921.

BERING RIVER COAL FIELD.

Martin, G. C., Geology and mineral resources of Controller Bay region, Alaska: Bull. 335, 1908. (This publication contains a detailed description of the Bering River coal field.)

SOUTHEASTERN ALASKA.

Wright, C. W., A reconnaissance of Admiralty Island: Bull. 287, pp. 151–154, 1906.

Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: Bull. 347, pp. 59–60, 1908. (Coal on Kupreanof Island.)

YAKUTAT AND YAKATAGA.

Tarr, R. S., and Butler. B. S., The Yakutat Bay region, Alaska: Prof. Paper 64, pp. 168–169, 1909.

Maddren, A. G., Mineral deposits of the Yakataga district: Bull. 592, pp. 147–148, 1914.

COOK INLET AND KENAI PENINSULA

Atwood, W. W., Mineral resources of southwestern Alaska: Bull. 379, pp. 116–121, 1908. (Tyonek coal field.)

Martin, G. C., Western part of Kenai Peninsula: Bull. 587, pp. 104–110, 1915. (Kachemak Bay coal field.)

SOUTHWESTERN ALASKA.

Atwood, W. W., Geology and mineral resources of parts of the Alaska Peninsula: Bull. 467, 1911. (Herendeen Bay, Chignik, and Unga coal fields.)

Martin, G. C., Mineral deposits of Kodiak and neighboring islands: Bull. 542, p. 136, 1913.

SUSITNA REGION.

Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper 70, p. 188, 1911.

Capps, S. R., The Yentna district, Alaska: Bull. 534, p. 72, 1913.

Capps, S. R., Mineral resources of the upper Chulitna Valley: Bull. 692, pp. 231–232, 1919.

Mertie, J. B., Platinum-bearing gold placers of Kahiltna Valley: Bull. 692, pp. 263–264, 1919. (Coal of Cache Creek.)

Moffit, F. H., The Broad Pass region, Alaska: Bull. 608, pp. 76–77, 1915.

NENANA COAL FIELD.

Capps, S. R., The Bonnifield region, Alaska: Bull. 501, 1912.

Martin, G. C., The Nenana coal field, Alaska: Bull. 664, 1919.

Capps, S. R., The Kantishna district, Alaska: Bull. 687, pp. 109–113, 1919.

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[52] Information on progress of Alaska coal mining and of coal production and consumption are contained in the annual reports on the mineral resources of Alaska, published as Bulletins 259, 284, 314, 345, 379, 442, 480, 520, 542, 592, 622, 642, 662, 692, 712, and 714.

UPPER YUKON BASIN.

Schrader, F. C., Reconnaissance on Chandalar and Koyukuk rivers, Alaska, in 1899: Twenty-first Ann. Rept., pt. 1, p. 485, 1900. (Coal at Tramway Bar, Koyukuk River.)

Prindle, L. M., A geologic reconnaissance of the Circle quadrangle, Alaska: Bull. 538, pp. 76–77, 1913. (Coal on Washington Creek.)

Maddren, A. G., The Koyukuk-Chandalar region, Alaska: Bull. 532, p. 56, 1913. (Coal on Dall River.)

Capps, S. R., The Chisana-White River district, Alaska: Bull. 630, pp. 125–126, 1916.

LOWER YUKON AND SEWARD PENINSULA.

Collier, A. J., Coal resources of the Yukon, Alaska: Bull. 218, 1903.

Smith, P. S., and Eakin, H. M., Geologic reconnaissance of southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska: Bull. 449, pp. 136–141, 1911.

Harrington, G. L., The Anvik-Andreafski region, Alaska: Bull. 683, pp. 65–66, 1918.

Harrington, G. L., Gold and platinum placers of the Kiwalik-Koyuk region: Bull. 692, pp. 383–385, 399, 1917.

Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. 247, pp. 25–26, 67, 1905. (Chicago Creek coal.)

Henshaw, F. F., Mining in Fairhaven precinct: Bull. 379, pp. 362–363, 1909. (Chicago Creek coal mine.)

Collier, A. J., and Hess, F. L., Gold placers of parts of the Seward Peninsula: Bull. 328, pp. 83–85, 908. (Coal of Sinuk River basin and St. Lawrence Island.)

Cathcart, S. H., Mining in northwestern Alaska: Bull. 712, p. 196, 1920. (Coal at Unalaklik, Norton Sound.)

KUSKOKWIM BASIN.

Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper 70, p. 188, 1908. (Coal on Big River, a southerly tributary of the upper Kuskokwim.)

Maddren, A. G., Gold placers of the lower Kuskokwim: Bull. 622, p. 305, 1914. (Reported occurrence of coal on Eek and Kanektok rivers.)

Mertie, J. B., and Harrington, G. L., Mineral resources of the Ruby-Kuskokwim region: Bull. 642, pp. 260–261, 1916.

Smith, P. S., The Lake Clark-central Kuskokwim region, Alaska: Bull. 655, pp. 154–156, 1917. (Coal near Iditarod.)

NORTHERN ALASKA.

Schrader, F. C., A reconnaissance in northern Alaska: Prof. Paper 20, pp. 106–114, 1904.

Collier, A. J., Geology and coal resources of the Cape Lisburne region, Alaska: Bull. 278, 1906.

Smith, P. S., The Noatak-Kobuk region, Alaska: Bull. 536, pp. 151–153, 1913.

MISCELLANEOUS OFFICIAL PUBLICATIONS.

Report on coal in Alaska for use in United States Navy: 63d Cong., 2d sess., H. Doc. 876, 1914. (Contains results of naval test of Bering River coal.)

Experimental tests of Matanuska coal for naval ships: 64th Cong., 1st sess., S. Doc. 26, 1915.

Reports of Alaskan Engineering Commission for the period from March 12, 1914, to December 31, 1915: 64th Cong., 1st sess., S. Doc. 610, pt. 2, p. 144, 1916. (Contains statements on cost of mining and transporting Matanuska and Bering River coal.)

Regulations governing coal-land leases in the Territory of Alaska, approved May 18, 1916, Dept. Interior, 1916.

Matanuska coal field, showing leasing units, Government reservation and topographic township plats, Alaska, Dept. Interior, 1916. (Maps.)

Bering River coal field, showing leasing units, Government reservation and topographic township plats, Alaska, Dept. Interior, 1916. (Maps.)

General information regarding lands offered for leasing in the Nenana coal field, Dept. Interior, 1918.

AVAILABILITY OF THE DEPOSITS.

The value of a coal deposit depends primarily on quality, quantity, cost of mining, cost of transportation, and markets. It is evident that the last three factors will vary with changing industrial conditions. The quality of a coal is fixed, but its value may also vary with changing conditions. A lignite that has no value for export may find a market with the development of metal mining or some other local industry. Measured by these considerations much of the Alaska coal has no present value, though it must be included in the ultimate coal reserves of the world. The coal without present importance comprises that which is inaccessible, that which is of too low grade to be exported and has no local market, and some of the high-grade coals in the accessible fields which are so folded and broken as to prohibit profitable exploitation under present conditions of cost and market.

The largest areas of inaccessible coals are those on the Arctic slope, where there are believed to be extensive coal fields. The coals are chiefly of low grade but include some excellent bituminous coals. Most of these coals are not now available, but some of them near Cape Lisburne might possibly be developed in a small way for use at Nome and in other parts of Seward Peninsula. On account of the shortness of the shipping season, however, this would be a doubtful venture. With these unavailable reserves should also be included much of the widely distributed lignite of Alaska, which if mined can supply only small local markets.

The enormous reserves of lignitic coal found in the Nenana and Cook Inlet fields, which are accessible, can not contribute much to the building up of a coal-mining industry, for under present methods of utilization they are not of good enough quality to find an export market and may not even compete in the local markets with the higher-grade Alaska coals.

The third group of unavailable coals includes those portions of the high-grade fuels of the Bering River and Matanuska fields which are so folded and broken as to make profitable exploitation under the present conditions of the coal market impossible. Though the surface outcrops in both these fields have been examined in great detail, yet definite determination of the quantity of coal now available for mining can be made only by underground explorations.

There are some fair bituminous coals at Chignik and Herendeen Bay, on Alaska Peninsula, which might find a small local market.

Alaska's annual coal consumption is now only about 165,000 tons, of which 60,000 tons is produced in the Territory. (See p. 74.) Even with a great expansion of territorial industries the local coal market will not be large enough to support more than a small coal-mining industry. Therefore the only hope of extensive mining is to furnish an export trade, and for this only the coals of the Bering River and Matanuska fields are of good enough quality. In both these fields high-grade bituminous steaming and coking coals have been found, as well as some anthracite. The bituminous coal is the best on the Pacific border of North America, and as much of it as can be mined at anything near a reasonable cost will find a ready export market. The possibility of using this coal for trans-Pacific shipping by a coaling station located on the great circle sailing route in the Aleutian Islands deserves consideration.

The Alaska coal-bearing areas that are accessible or can be early made accessible are listed in the following table. In the first figure column are given the areas of land which are pretty definitely known to contain coal beds, though it remains to be determined by underground exploration what part of them can now be profitably exploited. This table also contains estimates of the areas of the formations that are locally coal bearing in each of the more or less accessible fields.

Available coal fields of Alaska.

High-grade bituminous coal and anthracite.

Field or locality.	Area of probable coal lands (square miles).	Area of formations locally coal bearing (square miles).	Notes.
Matanuska	26	(?)	A part of this high-grade coal, suitable for export, is too much folded and broken to permit profitable exploitation at present.
Bering River	46	(?)	
Cape Lisburne (Arctic coast)	14	(?)	Accessible less than 2 months in the year.
	86		

Bituminous and subbituminous coals.

Field or locality.	Area of probable coal lands (square miles).	Area of formations locally coal bearing (square miles).	Notes.
Matanuska	22	....	Valuable for use in Alaska.
Alaska Peninsula	66	500	Present local market very small.
Yukon River	162	600	Local market very small.
Corwin (Arctic coast)	200	Large.	Accessible less than 2 months in the year.
	450	1,100	

Lignite.

Field or locality.	Area of probable coal lands (square miles).	Area of formations locally coal bearing (square miles).	Notes.
Cook Inlet	460	5,000	Includes an enormous tonnage of lignite, but of no present value for export.
Susitna Basin	30	1,000	Coal found at many localities under gravel cover. Valuable for local use only.
Nenana	120	600	Includes an enormous tonnage of lignite. Valuable for local use only.
Seward Peninsula and Norton Bay.	50	170	Available only for local use.
	660	6,770	

The above table shows that the accessible reserves of Alaska lignite are ample for all demands that can now be foreseen. Also that the lignitic and low-grade bituminous coals are widely distributed and can be exploited for local use at many localities. The quantity of lignitic coal that will be mined will be determined by the local demand, which in the immediate future will probably not exceed 50,000 to 100,000 tons a year, and this quantity will probably be distributed among several small mines.

The Nenana coal field will supply Fairbanks and other inland gold districts. Some lignitic coal will continue to be mined in the Cook Inlet region to supply local industries, but it may now find a strong competitor in the better coals from the Matanuska and Alaska Peninsula fields. Small quantities of lignitic coal will also be mined for local use in the Susitna basin, on Yukon River, in Seward Peninsula, and in the Norton Bay region. It is possible that the higher-grade coals of the Cape Lisburne region might be profitably mined for use on Seward Peninsula when gold placer mining revives on a large scale. The shortness of the shipping season, less than two months, has thus far discouraged such development and may prove an insurmountable obstacle.

The only exportable coal in Alaska is that of the Matanuska and Bering River fields. In both these fields very high grade coals, both bituminous and anthracite, have been found. Unfortunately the quality of the coal seems to be more or less directly proportional to the amount of deformation that the coal beds have undergone—that is, the best coal occurs in the most highly folded and broken beds and is the most difficult to mine.

One mine has been opened on a considerable scale near the west end of the Bering River field. This mine is at present difficult of access, but it could be connected with the Copper River Railroad by a branch line about 38 miles long. Such a branch would give connection over very easy grades with a good harbor at Cordova. Some work has also been done at a coal mine in the eastern part of the Bering River field, where the coal is semianthracite. This mine is connected by a railroad, now partly out of repair, with tidewater on the lower reaches of Bering River. Some small test shipments of semianthracite have been made from this mine.

The Alaskan Engineering Commission has opened two mines in the Matanuska field, both on the railroad. A little development work has also been done on some other properties in this field. The largest of the two mines is at Eska, where the coal is a low-grade bituminous coal, and from this mine the Engineering Commission and the towns of Anchorage and Seward are supplied with fuel. These operations show that the Eska coal can be mined on a commercial scale. At the other mine, at Chickaloon, some coal of very high grade has been produced, but the operations are still in a more or less experimental stage, because the irregularities in the coal beds make mining very expensive.

In the opinion of the writer coal tracts that can be mined under present industrial conditions will be found in both the Matanuska and the Bering River fields. To select such tracts, however, will require more underground testing than has thus far been done. There can be no question that high-grade coal will be produced in both fields, yet the localities where the most favorable underground conditions exist still remain to be determined. The present developments give assurance that there is sufficient tonnage for all local needs, but it is not yet definitely established that there are coal reserves from which a large tonnage can be mined for export. The quality of the high-grade coals from these fields leaves little to be desired, though here, as in many other coal fields, washing of the product will be necessary.

There has been a little mining of lignitic coal at various places in Alaska since 1888. It was not, however, until the high quality of the Bering River and Matanuska coal was established by both public and private surveys and examinations, made between 1898 and 1905, that these northern coal fields excited any special interest. An Alaska coal-land law was enacted in 1904, but it proved, as interpreted, ineffective in encouraging mining development, nor did the supplementary legislation of 1908 serve to improve the situation.[53] Meanwhile, all Alaska coal lands were withdrawn from entry by Executive order dated November 12, 1906. Many coal claims were staked previous to this withdrawal, but patent was refused to all except a few that were isolated and too small in area to permit economic exploitation.

The Alaska coal situation was further embarrassed by the rapid increase in the petroleum output of California. As a result, the shortage of fuel on the Pacific seaboard that was threatening at the time of the first attempted development of Alaska bituminous coal was changed to an excess of production. The net result of these conditions was to prevent all coal-mining development in Alaska and to force Alaskan industries to draw on foreign sources for fuel.[54] Furthermore, the projects for private railroad construction to the coal fields were necessarily abandoned. The logic of the situation forced the Government to enter the field of railroad construction and also to undertake the underground exploration of the coal fields at public expense.

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[53] Brooks, A. H., Alaska coal and its utilization: U. S. Geol. Survey Bull. 442, pp. 62–66, 1911.

[54] All Alaska oil lands were withdrawn in 1910. (See p. 53.)

The long and bitter controversy regarding an Alaska coal-land policy ended in 1914 with the enactment of a leasing law. As a consequence of the relative decrease in the market for coal, because of the large use of petroleum and the unsettled financial conditions brought about by the war, no great eagerness has been shown by capitalists to enter upon the development of the Alaska coal fields. Furthermore, the little underground work thus far done has more than confirmed the incomplete evidence obtained from surface exposures as to the greatly folded and broken condition of the coal beds in both the important fields. Most American coal mining has been done on beds that are but little disturbed. Hence those engaged in the industry have had little experience in the exploitation of greatly disturbed coal beds such as those of Alaska, which are, however, comparable to some of those mined in France and Belgium. Many have also contended that the terms of the coal leases are not sufficiently liberal, in view of the isolation and unprospected condition of the Alaska field. As a result of these conditions only one considerable coal-mining operation under leasehold is under way, and this has not yet reached a productive stage.

Between 1899 and 1919 Alaska mines produced a total of 243,677 tons of coal, of which 190,000 tons is the output of the last three years and is chiefly from the Government mines. During the same two decades the Territory has consumed a total of 2,411,947 tons of coal. Of this amount 1,276,600 tons has been imported from the Vancouver fields in British Columbia. (See p. 74.)

The market for these high-grade bituminous fuels is ample to absorb all the coal that can be produced for a number of years to come. The coal consumption of the Pacific Coast States and Alaska, exclusive of that used on railroads and steamers, is now about 3,200,000 tons annually, of which 200,000 to 300,000 tons is imported from British Columbia. Railroads in the Pacific Coast States consume about 2,000,000 tons, practically all used in Washington. The bunker coal supplied to steamers at American Pacific ports amounted to 343,000 tons in 1915 and 474,000 tons in 1918.[55] This bunker trade is one for which the Alaska coals are especially well suited. Some of the Alaska coals are also well adapted for coking. About 200,000 tons of coking coal is used in the Pacific Coast States. Of the Pacific coast coals only those from Alaska are of sufficiently high grade to be suitable for Navy use. An estimate of the needs of the Navy at 200,000 tons, of Alaska at 100,000 tons, and of coking coal at 200,000 tons would give a certain market for 500,000 tons. In addition to this the Alaska fuel should be a strong competitor in the bunker trade. Furthermore, the increased cost of petroleum will

[55] Brooks, A. H., U. S. Geol. Snrvey Bull. 662, pp. 25–30, 1917.

soon enlarge the market for coal on the Pacific seaboard. One adverse factor that should be considered is the competition of the high-grade Alaska coals with those from the East brought through the Panama Canal. Owing to the physical conditions under which the eastern bituminous coals occur they are cheaper to mine than those in Alaska, and another advantage lies in the more favorable industrial conditions. It is probably safe to assume, however, that even under this competition Alaska coal should have a market for at least 1,000,000 tons. Whether any such production can be reached in the immediate future can be determined only by further prospecting.

PEAT. [56]

Peat is found in nearly every part of Alaska except in the high ranges. The humidity of the Pacific coastal zone and the consequent luxuriant vegetation favor the accumulation of peat. Southeastern Alaska is heavily forested, and much of it has a dense growth of underbrush with a flooring of moss. In southwestern Alaska timber is entirely absent, but all the lowland and much of the upland area are covered with moss, grass, and small shrubbery. The prevailing humidity in both these regions favors the accumulation of vegetable refuse. Though there has been no prospecting for peat in this part of the Territory, deposits at least 15 to 20 feet thick are known and are believed to be of good quality.

Central and northern Alaska have a much smaller precipitation. Here, however, the soil is nearly everywhere mantled by a dense blanket of moss and other vegetation. This is especially striking in the extensive timberless areas of tundra which lie along Bering Sea and the Arctic Ocean. In these two provinces the subsoil is usually frozen, so that the waters are retained at the surface. The moss, except in excessively dry weather, is usually saturated with water. All these conditions, which promote vegetable growth and retard evaporation and oxidation, are favorable to the formation of peat. As a matter of fact, there is nearly everywhere a layer of peaty material underneath the soil. In some natural exposures in these provinces peat deposits having a depth of 30 to 40 feet have been observed. Although the widespread surface layer of peat is of an inferior quality, some of the deeper-lying beds are probably of high grade. There are no data whatever at hand to estimate the available supply of peat, but as it is found in every part of Alaska and on the great tundras of the north, occupying at least a quarter of the Territory and comprising layers of greater or less thickness, the supply must be enormous and possibly exceeds that of the entire United States.

[56] Brooks, A. H., Mineral resources of Alaska: U. S. Geol. Survey Bull. 394, pp. 188–189, 1909. Davis, C. A., The possible use of peat fuel in Alaska: U. S. Geol. Survey Bull. 379, pp. 63–66, 1909; The preparation and use of peat as fuel: U. S. Geol. Survey Bull. 442, pp. 101–132, 1910.

In the presence of more easily available fuel there has been no occasion to utilize any of the peat beds, so practically nothing is known of their fuel value, extent, or thickness, except what has been stated. One of the few deposits of this mineral fuel in Alaska that has been exploited is a peat bed saturated with petroleum residue near Cold Bay, on the Alaska Peninsula, where some years ago the material was used for fuel at the neighboring oil wells. Here, however, it is the petroleum residue rather than the peat which gives the deposit its chief value.

The peat deposits have at present no value, for lignitic and better-grade coals are too widely distributed to encourage the use of a less available fuel. Moreover, the time appears very remote when these peat deposits will be utilized, except at localities where coal is absent. Certainly recourse to the peat will take place only when the more valuable mineral fuels are not obtainable.

PETROLEUM.

As all the available data relating to the occurrences of oil in Alaska have been recently compiled and discussed by Martin,[57] the petroleum resources need only brief mention here. Petroleum seepages are known in five widely separated districts in Alaska and have been reported from a number of others. As drilling has been confined to one field, there are no data upon which to estimate petroleum reserves or possible output. The quality of Alaska petroleum leaves little to be desired. It is a high-grade refining oil similar in composition to that from Pennsylvania.

Oil seepages (see map, Pl. II, in pocket) are known at Katalla, near Controller Bay, 60 miles east of Cordova, and at Yakataga, 60 miles east of Katalla; near Iniskin Bay, on the west shore of Cook Inlet; and on the Alaska Peninsula, notably near Cold Bay. There is also a seepage near Douglas River, near the southwest shore of Cook Inlet, at the base of the Alaska Peninsula. More or less definite reports have been received as to the presence of seepages at other places in the Alaska Peninsula. If these reports are confirmed, they indicate a possible wide distribution of seepages in the Alaska Peninsula and consequently a rather large area in which wildcat drilling might be justified. The structure of the Katalla field is very complex, but the incomplete information at hand indicates that the folding is simpler at Yakataga, on Cook Inlet, and on the Alaska Peninsula. There has, however, been no detailed geologic mapping in the latter fields. All these districts are fairly accessible to ports on the Pacific, open to navigation throughout the year.

There are also indications of the presence of petroleum in the extreme northern part of Alaska, near Smith Bay, about 100 miles

[57] Martin, G. C., Preliminary report on the oil resources of Alaska: U. S. Geol. Survey Bull. 719 (in press).

southeast of Point Barrow. This area is entirely unknown geologically. To judge by the results of Schrader's exploration of the Colville River Basin,[58] 100 miles to the east, the structure is likely to be favorable for the presence of oil pools. The region is so inaccessible that capital is not likely to undertake its prospecting except under very liberal terms, both as regards size of leaseholds and royalties.

Martin has also listed a number of other isolated localities in Alaska where oil or gas seepages are known or reported and has presented the geologic evidence bearing on the possible presence of oil pools. His conclusions are largely adverse. The localities where oil or gas are reported include as widely separated localities as Admiralty Island and Cape Spencer, in southeastern Alaska; Seward, on Kenai Peninsula; Tyonek, on Cook Inlet; Nushagak, on Bristol Bay; and Healy Creek, in the Tanana Valley.

Alaska petroleum first attracted attention about 1898, when the Klondike excitement carried so many people North. Between 1901 and 1904 there was some drilling in the Iniskin and Cold Bay districts, and rather extensive operations were undertaken in the more accessible Katalla field. By 1906 most of the excitement had died down, owing largely to the rapid development of the California oil fields, which drew the speculative oil operators out of Alaska. In 1910 all the oil lands of Alaska were withdrawn from entry, so that no one could get title to any claims. Only in the Katalla field was any work continued, and there chiefly on one claim to which title had been earned previous to the withdrawal. It was the withdrawal of the oil lands that has checked nearly all prospecting during a decade and not any lack of promise in the Alaska fields.

The enactment of the oil leasing law in 1920, combined with the worldwide search for petroleum, has again attracted public attention to Alaska oil. Many claims have been staked, and preparations are being made to start drilling at several places in 1921. There is good reason to believe that productive oil fields will be developed, though there are no facts at hand to prove that startling discoveries will be made. It is certain, however, in view of the present relative scarcity of high-grade refining oil, that drilling is fully justified at a number of localities in Alaska. It is believed that petroleum is one of the resources that will help swell the value of the total mineral production of the Territory. In fact, it is the development of this resource which promises most for the relief of the present stagnation in Alaska mining. The search for oil will stimulate migration northward and will lead to the improvement of conditions of transportation, especially to some of the more isolated districts. Should drilling reveal commercial pools of petroleum a very early revival of the Alaska mining industry as a whole can be confidently predicted.

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[58] Schrader, F. C., A reconnaissance in northern Alaska: U. S. Geol. Survey Prof. Paper 20, 1904.

STRUCTURAL MATERIAL, ETC.

Nearly $2,000,000 worth of marble has been produced in Alaska since quarrying began in 1904, but all of this has come from the Ketchikan district of southeastern Alaska. Marble is widely distributed in southeastern Alaska,[59] and there are many undeveloped deposits that apparently carry commercial stone. The broken shore line, with its many harbors, and the water powers favor the marble industry in this field. It is to be expected that with the increased demand for marble in the States of the west coast the Alaska output will be greater.

Granite and granitic rocks, in part suitable for building stone, are also widely distributed in southeastern Alaska, but are undeveloped.

Gypsum has been mined for many years at Iyoukeen Cove, Chichagof Island, in the Sitka district.[60] Though no other gypsum deposits have been found there is no reason to believe that the geologic conditions by which the gypsum deposit was formed may not have been duplicated in other localities.

A promising deposit of barite was discovered by E. F. Burchard on Castle Island in Duncan Canal, near Wrangell, in 1913.[61] A rough estimate indicates that about 50,000 tons of barite is in sight above the level of tidewater. This deposit is not yet developed. A barite deposit at Lime Point, on the west side of Prince of Wales Island, near Sulzer, in the Ketchikan district, has been opened for a distance of 100 feet and is about 30 feet wide.[62] Some shipments of barite were made from this deposit in 1915 and 1916.

Clay is found in many parts of Alaska, but little is known of its quality. Some clay has been used for brickmaking at Anchorage. Limestones of varied composition are widely distributed in Alaska, notably in southeastern Alaska, in the Copper and Susitna River basins, in the Yukon Valley, and on Seward Peninsula. Lime for many purposes could be produced, should there be a local demand.

There are some deposits of pumice in the Alaska Peninsula and adjacent islands, the ejecta of Mount Katmai. The largest accessible deposits known are on the shores of Amalik Bay, on the east side of the peninsula, and these are 20 feet or more in thickness. Finer pumice or tuff is widely distributed over the north end of Kodiak Island, and a few shipments of this material for use as an abrasive have been made from this region. Graphite in considerable quantities has been found in the Kiwalik Mountains, 40 miles north of Nome but more accessible to the sea from Imuruk Basin, which is connected by tidal estuary with Port Clarence. The graphite in

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[59] Burchard, E. F., Marble resources of southeastern Alaska: U. S. Geol. Survey Bull. 682, 1920.

[60] Brooks, A. H., U. S. Geol. Survey Bull. 542, pp. 50–51, 1913.

[61] Burchard, E. F., A barite deposit near Wrangell: U. S. Geol. Survey Bull. 592, pp. 109–117, 1914.

[62] Chapin, Theodore, Mining developments of southeastern Alaska: U. S. Geol. Survey Bull. 642, p. 104, 1916.

this district occurs as lenses in quartz-biotite schists, which are themselves graphitic.[63] These deposits are of sufficient size to justify the hope that they can be profitably exploited, provided they can meet the competition with that from more accessible regions.

Sulphur deposits have been found in association with some of the volcanic rocks in southwestern Alaska.[64] A commercial deposit of sulphur is being opened on Akun Island, near the east end of the Aleutian chain. The reduction plant was to be installed in 1920, and the mine was then to be placed on a productive basis.

A little potash has been found in some of the shallow lakes on the flats of Yukon and Porcupine rivers, near Fort Yukon. Little is known about this occurrence, and there is no evidence that the quantity is sufficient to justify development, even for local use.

A few garnets have been mined near Wrangell, in southeastern Alaska, where, according to E. F. Burchard,[65] they occur in a mica schist. These garnets are not suitable for gems but may have value as abrasives.

Jade implements and ornaments have long been in wide circulation among the Alaska Eskimo. For many years it was believed that this jade all came from Asia, but it is now known that it came in part from the so-called Jade Mountains of the Kobuk River region.[66] Some of the so-called jade from this source has proved to be serpentine, some green quartzite, and some is nephrite, which commercially is classed as jade. Attempts to exploit these deposits have thus far been unsuccessful.

WATER.

Though water is to be counted among mineral resources its value to the mining industry is chiefly indirect by affording a source of power, and the largest use of water under hydrostatic head has been in placer mining. The richest of the Alaska placers lie in the interior and on Seward Peninsula, where water for mining is not abundant.[67] This scarcity is due to the small precipitation and the character of the topography, which gives low stream gradients. Hydraulic mining has therefore played no great part in the production of gold in Alaska. The chief operations have been in the Nizina district, of the Copper River basin. There are other localities in the Pacific slope region of Alaska where hydraulic mining will be undertaken.

[63] Harrington, G. L., Graphite mining in Seward Peninsula: U. S. Geol. Survey Bull. 692, pp.363-367, 1919.

[64] Maddren, A. G., Sulphur on Unalaska and Akun islands and near Stepovak Bay: U. S. Geol. Survey Bull. 692, pp. 283-298, 1919.

[65] Brooks, A. H., The mining industry in 1912: U. S. Geol. Survey Bull. 542, p. 51, 1913.

[66] Smith, P. S., The Noatak-Kobuk region, Alaska: U. S. Geol. Survey Bull. 536, pp. 154-155, 1913.

[67] Henshaw, F. F., and Parker, G. L., Surface water supply of Seward Peninsula, Alaska: U. S. Geol. Survey Water-Supply Paper 314, 1913. Ellsworth, C. E., and Davenport, R. W., Surface water supply of the Yukon-Tanana region, Alaska: U. S. Geol. Survey Water-Supply Paper 342, 1915.

The largest water-power developments are in southeastern Alaska, including notably those for the mines of the Juneau district. Smaller projects for other industries have also been installed at several places along the Pacific seaboard. Other large undeveloped water powers occur in the panhandle of Alaska and in time will be utilized for wood-pulp and other industries.

There are but few power developments in the Copper River, Prince William Sound, and Cook Inlet and Susitna basins. Little is known about the water powers of this province, but a reconnaissance [68] made some years ago shows that they are worthy of further investigation. There are also some water powers in the Iliamna Lake region, in the Alaska Range, and in other parts of the Territory about which little is known.

Mineral and hot springs are widely distributed in Alaska.[69] Some years ago an attempt was made to develop a mineral spring in southeastern Alaska, and bottled water from it was put on the market but met with failure. It is not known whether the water in any of the Alaska mineral springs is of a sufficiently distinctive composition to justify its development as a potable water. The hot springs have, however, played a somewhat important part in the hygienic life of the people.

SUMMARY AND CONCLUSIONS.

It has been shown that the value of Alaska's gold placer reserves is greater than that of the placer gold that has been produced during 40 years of mining; also that the future of the gold-mining industry depends as much on the improvement of the general industrial conditions as on the construction of railroads and wagon roads and improvements in steamship service. Lode gold mining in Alaska is at present on the wane, because the largest auriferous lode mines, those in the Juneau district, have been working on so low a margin of profit that they can not all hope to continue under present industrial conditions. On the other hand, auriferous lodes are known to be widely distributed in Alaska and it is certain that they will be developed when means of communication are bettered and industrial conditions improve.

Alaska's copper production of the past has been based chiefly on the output of a few mines operating on very rich ores. Smaller mines on the coast have been hampered by lack of shipping and smelter capacity. Copper ore is widely distributed in the Territory. The mining of copper will continue to increase if transportation rates are lowered, and the Territory will long be an important source of copper.

Silver-lead ores are widely distributed, but no large deposits have been found. Tin deposits have been found in several localities, but

[68] Ellsworth, C E., and Davenport, R. W., A water-power reconnaissance in South-central Alaska: U. S. Geol. Survey Water-Supply Paper 372, 1915.

[69] Waring, G. A., Mineral springs of Alaska: U. S. Geol. Survey Water-Supply Paper 418, 1917.

the outlook for any large increase of the tin output on the basis of the deposits now known is not hopeful. Only one deposit of the metals of the platinum group has been found that gives promise of making any considerable output. Quicksilver, in the form of cinnabar, has been developed in only one district and that only on a small scale. Nickel-bearing ores have been found at three localities, but the evidence in hand does not justify an opinion on the future of the nickel-mining industry. The known deposits of chromite, tungsten, antimony, and molybdenite seem to justify the hope of an output of these metals, provided there is a market for them. Little is known of Alaska iron ores, but there is reason to believe that some of the deposits of this metal will be utilized when an iron and steel making industry develops on the Pacific coast.

The deposits of lignitic coal in Alaska are much more than sufficient to supply all future local needs. Alaska also contains the best high-grade bituminous coal on the Pacific seaboard. It seems probable that an export trade in these fuels will be developed, though the cost of mining will be high on account of their mode of occurrence. The evidence of petroleum in Alaska justifies the opinion that an oil-producing industry will be developed.

Alaska also contains a great variety of other mineral deposits, many of which have been more or less developed. Although the output from such deposits will probably be small compared with that of the gold, copper, coal, and petroleum, yet it will help to swell the total value of Alaska's mineral products.

The foregoing summary indicates that the Alaska mining industry has a most promising outlook and that the mineral output of the past is but a small fraction of that which will be produced in the future. It is not to be denied, however, that the immediate prospect for a large expansion of Alaska mining is not so hopeful. Alaska's great gold reserves must to a large degree lie dormant until the changes in economic conditions give better assurance than now exists of profitable ventures. Nor will the present price of copper encourage an expansion of the copper-mining industry.

Coal mining has only begun, and much underground exploration must be done before a large expansion is assured. The testing of the oil fields awaits the driller but will probably be undertaken at once.

Aside from the improvement in general and worldwide economic conditions, what the Alaska mining industry most needs is a lowering of costs of transportation, including not only reduction of the rates on existing lines but the expansion of land and water routes, including the construction of roads and trails.

THE ALASKAN MINING INDUSTRY IN 1919.

By Alfred H. Brooks and George C. Martin.

GENERAL STATEMENT.

Gold and copper mining have always been the principal mineral industries of Alaska, and in 1919 both were subject to great depression throughout the world. Hence the value of Alaska's mineral output decreased from $28,253,961 in 1918 to $19,620,913 in 1919, when it was the lowest for any one year since 1914. Stimulated by the high price of copper during the war, Alaska made an enormous output of copper, which was chiefly the product of three large mines. With the fall in the price of copper (see fig. 1) the Alaska copper industry reverted to more normal pre-war conditions. Meanwhile the world-wide depression in gold mining consequent upon high operating costs brought on by the war has seriously crippled gold mining in Alaska. As a consequence of the increase in costs the value of the annual output of gold from Alaska declined from $16,700,000 in 1916 to $9,426,000 in 1919. The Alaska gold-mining industry is particularly sensitive to present conditions because many of the enterprises were not on a very sound economic basis. Gold production has been kept up for many years by the exploitation of bonanza placers rather than by the systematic development of large deposits of lower grade. The mining of placer gold has been carried on as a gamble rather than as a business venture. As the purchasing power of their product was reduced many gold-mining operators have been attracted to other fields, such as oil drilling in the States, in which the chances of large speculative profits were greater than in placer mining. It is especially unfortunate that all but one of the large quartz gold-mining ventures in Alaska are the lode mines near Juneau, where the margin of profit is so small that the increased cost of operation due to the war has imperiled the success of the undertakings.

The outlook for gold mining in Alaska under present economic conditions is not hopeful, yet the continued success of certain larger operations, like dredging, shows that it is by no means hopeless, and such operations and the mining of bonanza deposits will no doubt be continued. Alaska still contains large reserves of gold-bearing gravels (see pp. 9–11) that can be mined profitably when transportation and industrial conditions are improved. No one can foretell whether any more bonanza camps will be found, and therefore the only certain future success lies in the development of deposits of lower grade.

The large demand for tungsten, antimony, and chromite during the war greatly stimulated the search for and mining of ores carrying these metals. Valuable deposits of these ores were found and mined, and mining of them will in time be renewed, though it is not justified by the present demand because of the high cost of operation and transportation.

Alaska has not yet recovered from the interdict placed on the development of mineral fuels by the withdrawal from entry of the coal lands in 1906 and of the oil lands in 1910. The leasing law of 1913 opened up the coal fields, but some of its provisions appear to be not liberal enough to encourage large developments. In 1920 an oil-land leasing act was passed, and this will no doubt lead to development and eventually to oil production.

The greatest need of the Alaska mining industry is cheaper and better land and water transportation. This need calls for the completion of the railroad, the building of wagon roads, and the lowering of ocean and river freight and passenger rates. Yet, except for the work done on the railroad and on the construction of wagon roads and trails, practically no advance was made in 1919, and, indeed, the transportation conditions have been the worst in many years. Ocean freight and passenger rates have been increased and the service has been decreased. The Yukon River steamer service in 1919 was very inadequate. The most important event of the year for the future of mining in the Territory was the continuation of the work on the Government railroad and the assurance by congressional action of the money needed to complete the line. It is now certain that in three years there will be a standard-gage railway connecting tidewater on the Pacific with Fairbanks and navigable waters on the Yukon. To give its full benefit to the mining industry, however, the Alaska Railroad must be connected with mining centers by good wagon roads.

Mineral output of Alaska, 1918 and 1919.

	1918		1919		Decrease or increase in 1919.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold............fine ounces..	458,641	$9,480,952	455,984	$9,426,032	− 2,657	− $54,920
Copper..............pounds..	69,224,951	17,098,563	47,220,771	8,783,063	−22,004,180	−8,315,500
Silver...........fine ounces..	847,789	847,789	629,708	705,273	− 218,081	− 142,516
Coal.............short tons..	75,606	411,850	60,674	343,547	− 14,932	− 68,303
Tin, metallic..........do....	68	118,000	56	73,400	− 12	− 44,600
Lead..................do....	564	80,088	687	72,822	+ 123	− 7,266
Miscellaneous metallic products, including palladium and platinum............	....	[a] 96,100	....	[b] 73,663	....	− 22,437
Miscellaneous nonmetallic products, including petroleum, marble, and gypsum..................	....	[c] 120,619	....	143,113	....	+ 22,494
	....	28,253,961	....	19,620,913	....	−8,633,048

[a] Included chrome ore, tungsten, antimony, platinum, and palladium in 1918.
[b] Palladium and platinum only in 1919.
[c] Included lime in 1918.

Regular mining in Alaska may be said to have begun in 1880, when the Juneau gold placers were first exploited. It is estimated that since that time Alaska has produced mineral wealth to the value of more than $438,000,000.

Value of total mineral production of Alaska, 1880–1919.

By years.				By substances.	
1880-1890	$4,686,714	1906	$23,378,428	Gold	$311,664,993
1891	916,920	1907	20,850,235	Copper	114,526,096
1892	1,098,400	1908	20,145,632	Silver	6,303,528
1893	1,051,610	1909	21,146,953	Coal	1,440,460
1894	1,312,567	1910	16,887,244	Tin	918,152
1895	2,388,042	1911	20,691,241	Lead	522,258
1896	2,981,877	1912	22,536,849	Antimony	237,500
1897	2,540,401	1913	19,476,356	Marble, gypsum, petroleum, etc.	2,548,079
1898	2,587,815	1914	19,065,666		438,161,066
1899	5,706,226	1915	32,854,229		
1900	8,241,734	1916	48,632,212		
1901	7,010,838	1917	40,710,205		
1902	8,403,153	1918	28,253,961		
1903	8,944,134	1919	19,620,913		
1904	9,569,715		438,171,032		
1905	16,480,762				

DISCOVERIES AND NEW DEVELOPMENTS.

The most notable mining advances during the year were those made near McGrath, in the Georgetown district of the middle Kuskokwim region. Here a gold dredge, installed in 1918, was operated during the entire season, but more significant was the discovery of numerous gold-bearing ledges which give promise of being of commercial importance. The discovery of a valuable silver-bearing galena lode in the Kantishna district drew many prospectors to this little-known part of Alaska. Still greater excitement was caused by the development of rich deposits of gold and silver in the Canadian part of the Portland Canal district. (See pp. 129–142.) Some of these deposits are readily accessible only through Alaska. The town of Hyder, on Portland Canal, was established on the Alaska side of the boundary to serve this district, and from Hyder a road has been built to the Canadian mines. Prospecting has been done in the Alaska part of the Portland Canal district, but so far as known no ore bodies of proved commercial value have been developed.

Many oil claims are now being staked under the oil-leasing law of 1920. Coal was mined in 1919 in the Matanuska field for the use of the Alaskan Engineering Commission and for the town of Anchorage. Systematic prospecting of a group of claims held under lease in the Bering River coal field was underway in 1919. The railroad connection of the Nenana lignite field with the town of Fairbanks, established in 1919 (except for a bridge at Tanana River), has stimulated systematic prospecting.

GOLD AND SILVER.

TOTAL PRODUCTION.

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

Gold and silver produced in Alaska, 1880–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.
1880	967	$20,000	10,320	$11,146
1881	1,935	40,000		
1882	7,256	150,000		
1883	14,561	301,000		
1884	9,724	201,000		
1885	14,512	300,000		
1886	21,575	446,000		
1887	32,653	675,000		
1888	41,119	850,000	2,320	2,181
1889	43,538	900,000	8,000	7,490
1890	36,862	762,000	7,500	6,071
1891	43,538	900,000	8,000	7,920
1892	52,245	1,080,000	8,000	7,000
1893	50,213	1,038,000	8,400	6,570
1894	62,017	1,282,000	22,261	14,257
1895	112,642	2,328,500	67,200	44,222
1896	138,401	2,861,000	145,300	99,087
1897	118,011	2,439,500	116,400	70,741
1898	121,760	2,517,000	92,400	54,575
1899	270,997	5,602,000	140,100	84,276
1900	395,030	8,166,000	73,300	45,494
1901	335,369	6,932,700	47,900	28,598
1902	400,709	8,283,400	92,000	48,590
1903	420,069	8,683,600	143,600	77,843
1904	443,115	9,160,000	198,700	114,934
1905	756,101	15,630,000	132,174	80,165
1906	1,066,030	22,036,794	203,500	136,345
1907	936,043	19,349,743	149,784	98,857
1908	933,290	19,292,818	135,672	71,906
1909	987,417	20,411,716	147,950	76,934
1910	780,131	16,126,749	157,850	85,239
1911	815,276	16,853,256	460,231	243,923
1912	829,436	17,145,951	515,186	316,839
1913	755,947	15,626,813	362,563	218,988
1914	762,596	15,764,259	394,805	218,327
1915	807,966	16,702,144	1,071,782	543,393
1916	834,068	17,241,713	1,379,171	907,495
1917	709,049	14,657,353	1,239,150	1,021,060
1918	458,641	9,480,952	847,789	847,789
1919	455,984	9,426,032	629,708	705,273
	15,076,793	311,664,993	9,019,016	6,303,528

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

Gold and silver produced in Alaska from different sources, 1880–1919.

	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
Siliceous ores [a]	4,446,528	$91,917,907	1,428,580	$1,053,130
Copper ores	83,886	1,734,094	5,815,886	4,213,418
Placers	10,546,379	218,012,992	1,774,550	1,036,980
	15,076,793	311,664,993	9,019,016	6,303,528

[a] Including small amounts of lead ore.

The above table shows that about 29.5 per cent of the total gold produced in Alaska has been obtained from siliceous ores mined from auriferous lodes. In 1919 the lode-gold production was 46.6 per cent; in 1918, 36.6 per cent; in 1917, 31 per cent; in 1916, 38 per cent; in 1915, 37 per cent; in 1914, 32 per cent; in 1913, 31.6 per cent; and in 1912, 29 per cent. In the following table the production of precious metals in 1919 has been distributed as to sources:

Gold and silver produced in Alaska, 1919, by sources.

Source.	Ore (tons).	Gold.		Silver.	
		Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
Siliceous ores	3,262,573	212,474	$4,392,237	108,691	$121,734
Copper ores	492,644	3,086	63,795	488,034	546,598
Placers	....	240,424	4,970,000	32,983	36,941
	3,755,217	455,984	9,426,032	629,708	705,273

LODE MINING.

Twenty-three gold-lode mines and two prospects were operated in Alaska in 1919 and produced gold worth about $4,392,237. Twenty-five mines were operated in 1918 and produced gold worth $3,473,317. The increase in 1919 came from the four large mines in the Juneau and Sitka districts. The increased production at Juneau does not assure the continued prosperity of the lode-mining industry, for these mines are working on too small a margin between the value of gold recovered and the cost of operation to make it certain that they will be able to pay the continually increasing expense of mining. The only other large gold-lode mine in Alaska is in the Sitka district, where operations in 1919 were on a somewhat larger scale than in 1918.

Of the producing mines, seven were in southeastern Alaska, one in the Copper River district, three on Kenai Peninsula, five in the Willow Creek district, six in the Fairbanks district, and one on Seward Peninsula. In 1919 the average value of the gold and silver contents for all siliceous ores mined was $1.38 a ton; the average for 1918 was $1.70 a ton. These averages reflect the dominance in the total lode production of the large tonnage produced from the low-grade ores of the Juneau district.

The production, by districts, of gold and silver in 1918 from gold-lode mines is given in the following table:

Gold and silver produced from gold-lode mines in Alaska, 1919, by districts.

District.	Mines operated.	Ore mined (short tons).	Gold.		Silver.		Average value for ton of ore in gold and silver.
			Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.	
Southeastern Alaska	[a] 7	3,253,848	201,937	$4,174,407	107,359	$120,242	$1.32
Kenai Peninsula	3	96	435	8,987	284	318	9C.93
Willow Creek	5	6,730	7,882	162,944	508	569	24.30
Fairbanks district	6	1,384	2,027	41,893	378	424	30.58
Other districts [b]	2	515	193	4,006	162	181	8.13
	23	3,262,573	212,474	4,392,237	108,691	121,734	1.38

[a] Also shipment from one prospect.
[b] Includes 1 mine in the Copper River district and 1 in Seward Peninsula; also 1 prospect on Prince William Sound.

The prospecting and development of gold lodes in 1919 was most active in the Willow Creek district, which lies adjacent to the railroad, but where no property has yet been opened up and equipped on a large scale. There is good reason to believe that lode mining in the Willow Creek district will make substantial gains in 1920. At Fairbanks lode mining and prospecting have almost ceased, the only operations being those of a few owners who continue a little development with the plan of blocking out ore to be mined when the railroad is completed. Incidental to this work a little ore is recovered and milled, and there are many small auriferous lodes in the Fairbanks district which can be profitably exploited when the economic conditions improve. Comparatively little work was done on the lodes of Seward Peninsula in 1919. A gold-lode mine near Bluff was operated and made a small output, and some ore was mined but not shipped from the silver-lead prospect on Kugruk River.

PLACER MINING.

During 39 years of mining Alaska has produced gold to the value of more than $311,000,000, and $218,000,000 of this amount is to be credited to her placer mines. For reasons already discussed there was less placer mining in 1919 than in 1918, and the outlook for a revival of the industry as a whole under present economic conditions is not hopeful. In the following table a comparison is made between the placer-mining industry in 1919 and in 1918:

Alaska placer mining in 1918 and 1919.

	Summer.		Winter.		Value of output.
	Mines.	Miners.	Mines.	Miners.	
1918	574	3,000	153	613	$5,900,000
1919	466	2,177	88	318	4,970,000
Decrease	108	823	65	295	930,000

A most unfortunate effect of the decline in the production of gold, especially by placer mining, is the discouragement of the prospector. Though many prospectors devote their attention to the search for copper and other minerals, prospectors as a class are held to their vocation by the hope of finding rich placers which they can develop by individual effort. The loss of over 1,100 men in the placer-mining industry, as shown by the above table, means the loss of an equal number of at least potential prospectors. Many prospectors have been drawn away from Alaska by the high wages and good business opportunities which war conditions have created in the States. It is, indeed, no longer necessary to go to Alaska to obtain high wages. As a consequence probably half, possibly three-quarters, of the prewar Alaska prospectors have sought other fields.

The value of the placer-gold output of Alaska decreased from $5,900,000 in 1918 to $4,970,000 in 1919, and the output will be less in 1920. The decrease was general for all Alaska districts except for some in the Seward Peninsula and the Kuskokwim regions. It is largely due to conditions that affect gold mining adversely throughout Alaska. Shortage of labor, lack of transportation, and unfavorable seasonal climatic conditions have also operated to curtail the placer-gold output of certain districts. The depletion of bonanza placers also helped to decrease placer mining. No important discoveries of placer gold were made during the year, and there was a marked decrease in prospecting for placer gold.

About 466 placer mines were operated in the summer of 1919 and 88 during the previous winter, but many for only a part of the season. About 2,177 men were engaged in productive placer mining in the summer and 318 in the winter. In addition several hundred men were engaged in prospecting or other nonproductive work relating to placer mining. No important new placer-bearing areas were discovered in 1919. The output and operations of placer mines in 1919, by regions, are shown in the following table:

Gold and silver produced from placer mines in Alaska, 1919, by regions.

Region.	Gold.		Silver.		Gravel handled (cubic yards).	Recovery per cubic yard.	Number of mines.		Number of miners.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.			Summer.	Winter.	Summer.	Winter.
Southeastern Alaska	1,209.37	$25,000	204	$229	20,000	$1.26	9	......	29	......
Copper River region	8,949.38	185,000	912	1,021	340,000	.55	18	......	115	......
Cook Inlet and Susitna region	5,321.25	110,000	827	926	191,000	.58	21	......	81	......
Southwestern Alaska	241.88	5,000	22	25	3,000	1.67	5	......	10	......
Yukon basin	140,771.25	2,910,000	19,461	21,796	1,616,000	1.81	274	76	1,246	255
Kuskokwim region	16,931.25	350,000	4,431	4,963	205,000	1.73	20	2	101	3
Seward Peninsula	65,790.00	1,360,000	6,940	7,773	2,165,000	.63	103	10	555	60
Kobuk region	1,209.37	25,000	186	208	8,000	3.15	16	......	40	......
	240,423.75	4,970,000	32,983	36,941	4,548,000	1.10	466	88	2,177	318

The following table shows approximately the total bulk of gravel mined annually since 1907 and the value of the gold recovered per cubic yard. This table is based in part on returns made by placer-mine operators and in part on known facts or assumptions concerning the richness of the gravels in the several districts. Although the table is thus in part an estimate it is probably nearly correct.

Gravel sluiced in Alaskan placer mines and value of gold recovered, 1908–1919.

Year.	Total quantity of gravel (cubic yards).	Value of gold recovered per cubic yard.	Year.	Total quantity of gravel (cubic yards).	Value of gold recovered per cubic yard.
1908	4,275,000	$3.74	1914	8,500,000	$1.26
1909	4,418,000	3.66	1915	8,100,000	1.29
1910	4,036,000	2.97	1916	7,100,000	1.57
1911	5,790,000	2.17	1917	7,000,000	1.40
1912	7,050,000	1.70	1918	4,931,000	1.20
1913	6,800,000	1.57	1919	4,548,000	1.10

The table shows that from 1908 to 1914 there was a decline in the average gold content of the gravels mined. This decline reflects the improved methods of placer mining that have been introduced, more especially the increase in the use of dredges, which is brought out in the following table:

Relation of recovery of placer gold per cubic yard to proportion produced by dredges.

	Percentage of placer gold produced by dredges.	Recovery per cubic yard.		
		Dredges.	Mines.	All placers.
1911	12	$0.60	$3.36	$2.17
1912	18	.65	2.68	1.70
1913	21	.54	3.11	1.57
1914	22	.53	2.07	1.26
1915	22	.51	2.33	1.29
1916	24	.69	2.64	1.57
1917	26	.68	2.21	1.40
1918	24	.57	1.84	1.20
1919	27	.67	1.31	1.10

Gold dredging continues to hold an important place in Alaska placer mining. In 1919 there were 28 dredges in operation for the whole or part of the season and they produced gold to the value of about $1,360,000, compared with $1,425,000 worth of gold produced by 28 dredges in 1918. Two of these dredges were operated in 1919 in the Fairbanks district, 2 in the Iditarod district, 1 in the Birch Creek district of the Yukon basin, 1 in the Mount McKinley (McGrath) district of the Kuskokwim basin, and 22 on Seward Peninsula. These dredges handled about 1,760,000 cubic yards of gravel, compared with about 2,490,000 cubic yards of gravel handled in 1918. The average recovery of gold per cubic yard was about 67 cents in 1919 and 57 cents in 1918. The gold dredges of Seward Peninsula produced gold worth $450,000 from about 865,000 cubic yards of gravel, making an average recovery of 52 cents a cubic yard in 1919 compared with 40 cents a cubic yard in 1918. The dredges of the Yukon and Kuskokwim districts produced gold worth $910,000 from 895,000 cubic yards of gravel, and the value of gold recovered per cubic yard was therefore about $1.02. In 1918 the dredges of the Alaska Yukon districts produced gold worth $881,000 from 1,125,000 cubic yards of gravel, the value of gold recovered per cubic yard being about 78 cents.

Though dredges were built for use in the Alaska Yukon as early as 1898 and at Nome in 1900, this method of placer mining did not reach a profitable stage until 1903, when two small dredges were successfully operated in Seward Peninsula. Dredging began in the Fortymile district in 1907; in the Iditarod, Birch Creek, and Fairbanks districts in 1912; in the Yentna district in 1916; and in the Kuskokwim region in 1918. The new dredge on Candle Creek, in the Kuskokwim region, which was completed and operated for a short period in 1918, did not begin regular operations till 1919. The fact that this dredge and also one of the Fairbanks dredges, which likewise was first operated in 1919, had successful seasons shows that dredging can be profitable even under present adverse conditions. This fact and the successful gold dredging in Seward Peninsula during the last 15 years proves that this type of mining has an important future in Alaska. In nearly every placer-mining district of Alaska there are large areas underlain by auriferous gravels which justify exhaustive prospecting for the purpose of finding dredging ground. The successful use of cold-water thawing in connection with dredging should give a further stimulus to this form of mining. Up to the end of 1919 gold to the value of $20,395,000 had been mined by dredges. The distribution of this output by years is shown in the following table:

Gold produced by dredge mining in Alaska, 1903–1919.

Year.	Number of dredges operated.	Value of gold output.	Gravel handled (cubic yards).	Value of gold recovered per cubic yard.
1903	2	$20,000		
1904	3	25,000		
1905	3	40,000		
1906	3	120,000		
1907	4	250,000		
1908	4	171,000		
1909	14	425,000		
1910	18	800,000		
1911	27	1,500,000	2,500,000	$0.60
1912	38	2,200,000	3,400,000	.65
1913	35	2,200,000	4,100,000	.54
1914	42	2,350,000	4,450,000	.53
1915	35	2,330,000	4,600,000	.51
1916	34	2,679,000	3,900,000	.69
1917	36	2,500,000	3,700,000	.68
1918	28	1,425,000	2,490,000	.57
1919	28	1,360,000	1,760,000	.67
		20,395,000		

COPPER.

The copper output of Alaska in 1919 was 47,220,771 pounds, valued at $8,783,063. This is less than the output in 1918, which was 69,224,951 pounds, valued at $17,098,563. During the year, 11 copper mines were operated, compared with 17 in 1918. Of these mines, 3 are in the Ketchikan district, 5 in the Prince William Sound district, and 3 in the Chitina district. The curtailment of copper mining was due to the fall in the price of copper, the uncertainty of the market, and high freight rates. Throughout the war the small operator has been hampered by lack of shipping to transport his ore and of smelters to reduce it, conditions that have blocked the development of a number of properties and discouraged the copper-mining industry. Largely for these reasons there has been relatively little prospecting for copper during the last few years. Should freight rates decrease or the price of copper go up, many small mines would resume operations and the larger low-grade ore bodies would be opened up. Under present industrial conditions there is no likelihood of any improvement during 1920.

Output of Alaska copper mines in 1919, by districts.

District.	Mines operated.	Ore (tons).	Copper.		Gold.		Silver.	
			Quantity (pounds).	Value.	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
Ketchikan district	3	8,936	629,100	$117,013	674.11	$13,935	5,261	$5,892
Chitina district [a]	[b] 3	195,631	36,291,390	6,750,198			408,726	457,773
Prince William Sound	5	288,077	10,300,281	1,915,852	2,412.00	49,860	74,047	82,933
	11	492,644	47,220,771	8,783,063	3,086.11	63,795	488,034	546,598

[a] Also a small amount of placer copper. [b] Kennecott Corp. Ann. Rept. for 1919.

The average copper content of the ores mined in 1919 was 4.8 per cent. The ores also yielded an average of $0.129 in gold and $1.11 in silver to the ton. The average yield for 1918 was 4.8 per cent of copper, $0.149 to the ton in gold, and $0.996 to the ton in silver.

Copper produced in Alaska, 1880–1919.

Year.	Ore mined (tons).	Copper produced.	
		Quantity (pounds).	Value.
1880	a 40,000	3,933	$826
1901		250,000	40,000
1902		360,000	41,400
1903		1,200,000	156,000
1904		2,043,586	275,676
1905	52,199	4,805,236	749,617
1906	105,729	5,871,811	1,133,260
1907	98,927	6,308,786	1,261,757
1908	51,509	4,585,362	605,267
1909	34,669	4,124,705	536,211
1910	39,365	4,241,689	538,695
1911	68,975	27,267,878	3,408,485
1912	93,452	29,230,491	4,823,031
1913	135,756	21,659,958	3,357,293
1914	153,605	21,450,628	2,852,934
1915	369,600	86,509,312	15,139,129
1916	617,264	119,854,839	29,484,291
1917	659,957	88,793,400	24,240,598
1918	722,047	69,224,951	17,098,563
1919	492,644	47,220,771	8,783,063
	3,735,698	545,007,336	114,526,096

a Estimated.

The copper industry in the three developed copper fields of Alaska is described in the account of mining in those districts given on subsequent pages. In southeastern Alaska the Rush & Brown mine was the largest copper producer. Copper was also produced at the Salt Chuck mine, better known for its output of palladium, and some ore was shipped from the Jumbo mine, at Sulzer. The three large mines, the Bonanza, Jumbo, and Mother Lode, of the Kennecott group, were the only producing mines of the Chitina district in 1919, though some development work was done on other properties. Some placer copper was also recovered incidental to gold-placer mining in the Nizina district.

On Prince William Sound the Beatson-Bonanza and Ellamar copper mines were the only properties worked systematically throughout the year. Some ore was, however, also produced incidental to development work at the Fidalgo or Schlosser mine of the Alaska Mines Corporation, at the Fidalgo or Mackintosh mine of the Fidalgo Mining Co., and at the mine of the Ladysmith Smelting Corporation, on Latouche Island.

Most of the prospecting for copper in 1919 was done in the Susitna basin, tributary to the Alaska Railroad. A number of copper lodes of some promise have been found in this region, but they have not been sufficiently developed to prove their value.

LEAD.

The lead produced in Alaska in 1919 is estimated at 687 tons, valued at $72,822, compared with 564 tons, valued at $80,088, in 1918. The output of lead in 1919 was derived wholly from the concentrates of the gold mines at Juneau.

During 1919 development work was done on galena ores in southeastern Alaska, in the Seward Peninsula, in the Yukon Basin, and probably in other regions. In the course of this work some ore was produced, but so far as known no ore was shipped. The information at hand indicates that the most promising discovery of silver-bearing galena was that made in the Kantishna district. The following table shows the production of lead in Alaska, so far as it can be determined from available data:

Lead produced in Alaska, 1892–1919.

Year.	Quantity (tons).	Value.	Year.	Quantity (tons).	Value.
1892	30	$2,400	1907	30	$3,180
1893	40	3,040	1908	40	3,360
1894	35	2,310	1909	69	5,984
1895	20	1,320	1910	75	6,600
1896	30	1,800	1911	51	4,590
1897	30	2,160	1912	45	4,050
1898	30	2,240	1913	6	528
1899	35	3,150	1914	28	1,344
1900	40	3,440	1915	437	41,118
1901	40	3,440	1916	820	113,160
1902	30	2,460	1917	852	146,584
1903	30	2,520	1918	564	80,088
1904	30	2,580	1919	687	72,822
1905	30	2,620			
1906	30	3,420		4,184	522,258

TIN.

The tin mines of Alaska produced 86 tons of ore containing 112,000 pounds of tin, valued at $73,400 in 1919, compared with 104½ tons of ore containing 136,000 pounds of tin, valued at $118,000, in 1918. The following table shows the production of tin in Alaska since mining began, in 1902:

Tin produced in Alaska, 1902–1919.

Year.	Quantity (tons).		Value.	Year.	Quantity (tons).		Value.
	Ore.	Metal.			Ore.	Metal.	
1902	25	15	$8,000	1912	194	130	$119,600
1903	41	25	14,000	1913	98	50	44,103
1904	23	14	8,000	1914	157.5	104	66,560
1905	10	6	4,000	1915	167	102	78,846
1906	57	34	38,640	1916	232	139	121,000
1907	37.5	22	16,752	1917	171	100	123,300
1908	42.5	25	15,180	1918	104.5	68	118,000
1909	19	11	7,638	1919	86	56	73,400
1910	16.5	10	8,335				
1911	92.5	61	52,798		1,574.0	972	918,152

The York district, of Seward Peninsula, continues to be the center of the tin-mining industry of Alaska. Two dredges and one small open-cut mine were operated in 1919. The dredge of the American Tin Mining Co., on Buck Creek, and of the York Tin Dredging Co., on Grouse Creek, were both in operation. Three men were engaged in shoveling into sluice boxes on Buck Creek above the dredge. A total of 25 men were engaged in tin mining and produced about 56 tons of concentrates, estimated to contain about 76,000 pounds of metallic tin, valued at $49,810. In addition to the tin recovered in the York region a few hundred pounds of tin concentrates were saved in connection with gold mining on Humboldt Creek, a tributary of Goodhope River. These concentrates were not shipped in 1919.

Developments were also continued at the Lost River tin-lode mine, in the York district, where about 12 men worked during the winter of 1918–19 and about 25 men during the summer of 1919. The winter work consisted mainly of retimbering, enlargement of drifts and shafts, and deepening of shafts. A number of buildings were erected, and a compressor plant was installed to furnish air for drills and for ventilation. A large warehouse was also built on the beach at the mouth of the river. A shipment of mining machinery and supplies for this property was landed at the mouth of Lost River in October, 1919.

In the Hot Springs district tin ore was produced from the gold placers in about the same quantity as in recent years. The tin output of the Hot Springs district in 1919 is estimated about 30 tons of concentrates containing about 36,000 pounds of metallic tin, valued at $23,590.

PLATINUM METALS.

The output of platinum, palladium, and other metals of the platinum group in Alaska in 1919 is estimated at 569.52 fine ounces, valued at $73,663, compared with 284 fine ounces, valued at $36,600, in 1918. The larger part of the output in 1919, as in 1918, was derived from the copper-palladium ore of the Salt Chuck mine, in the Ketchikan district, which was operated on a larger scale than before.

Platinum was recovered from the gold placers of Dime, Bear, and Sweepstakes creeks, in the Koyuk or Dime Creek district, Seward Peninsula. The production reported from these creeks in 1919 is only about half as large as in 1918, but the returns for 1919 may not be complete. Platinum was recovered from the gold placers of Slate Creek, in the Chistochina (Copper River) district, in about the same quantity as in 1918. Some platinum may have been saved on Boob Creek, in the Tolstoi (Yukon) district, in 1919, as in previous years, but no returns have been received. The total production of platinum metals in Alaska since they were first saved in 1916 is shown below.

Platinum metals produced in Alaska, 1916–1919.

Year.	Quantity.		Value.
	Crude ounces.	Fine ounces.	
1916	12.0	8.33	$700
1917	81.2	53.40	5,500
1918	301.0	284.00	36,600
1919	579.3	569.52	73,663
	973.5	915.25	116,463

COAL.

The output of coal in Alaska in 1919 was 60,674 tons, valued at $343,547, compared with 75,606 tons, valued at $411,850, in 1918. This output was about 20 per cent less than that in 1918 but was greater than that in any previous year. The most important features of the Alaska coal-mining industry in 1919 are the continuation of systematic mining in the Matanuska field by the Alaska Engineering Commission, the systematic prospecting of a lease held in the Bering River field, and the beginning of the mining of the Nenana lignitic coal. The larger part of the output in 1918 came from the Matanuska field, which yielded 44,553 tons. The remainder came from eight small mines in different parts of the Territory. All these mines, except those in the Matanuska and Bering River fields, produced coal for local use under free-use permits. About 10 mines were operated, employing about 166 men for an average period of 280 days.

In the Matanuska field mining and underground exploration were carried on throughout the year at the Eska and Chickaloon mines by the Alaska Engineering Commission and 44,553 tons of coal was mined, compared with 63,092 tons in 1918. The production of coal from these mines was advisedly limited to the needs of the commission and near-by localities. At the Eska mine, where the coal is low-grade bituminous, about 150,000 tons of coal have been blocked out and some evidence has been obtained that there is an additional reserve of about 1,000,000 tons. The coal beds at this mine are not greatly folded, but some large faults have complicated the extraction of the coal. At Chickaloon, where the coal is high-grade bituminous, the beds are much folded and faulted, and the conditions increase greatly the cost of mining. The work of the commission has resulted in blocking out about 100,000 tons of coal at the Chickaloon mine. A more complete account of mining in the Matanuska field is given elsewhere in this volume.

No details are yet available about the developments made on the lease held in the western part of Bering River field, but extensive and systematic underground work has been done, and the results appear to have encouraged the lessees to continue. The coal at this locality is high-grade bituminous. Some developments were also continued in 1919 on a patented claim in the northeastern part of the field, where the coal is semianthracite. A little coal has been mined at this locality and marketed at Cordova. The mine is connected by a railroad with barge navigation on Bering River.

The connecting link of the Alaska Railroad between Fairbanks and the Nenana coal field was completed in 1919, except for a bridge over Tanana River,[1] and the Nenana lignite is therefore now available for use in the Fairbanks district and should stimulate the gold-mining industry. Several thousand tons of lignite were produced at "Mile 363 mine" and at "Mile 387 mine" and other developments in the field are under way.

Small lignitic coal mines were operated in 1919 at a number of widely separated localities in Alaska and their product was consumed locally.

The following table gives the estimated production of coal in Alaska since 1888. The figures for 1888 to 1896 are estimated from the best data available but are only approximate. The figures for 1897 to 1919 are based for the most part on data supplied by operators. Most of the coal mined before 1916 was lignite. A small quantity of bituminous coal was produced from the west end of the Bering River field in 1906. The table does not include 855 tons of coal mined in the Bering River field in 1912 and 1,100 tons mined in the Matanuska field in 1913 for test by the United States Navy.

Coal produced in Alaska, 1888 to 1919.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1888-1896	6,000	$84,000	1909	2,800	$12,300
1897	2,000	28,000	1910	1,000	15,000
1898	1,000	14,000	1911	900	9,300
1899	1,200	16,800	1912	355	2,840
1900	1,200	16,800	1913	2,300	13,800
1901	1,300	15,600	1914	....	....
1902	2,212	19,048	1915	1,400	3,300
1903	1,447	9,782	1916	13,073	52,317
1904	1,694	7,225	1917	53,955	265,317
1905	3,774	13,250	1918	75,606	411,850
1906	5,541	17,974	1919	60,674	343,547
1907	10,139	53,600			
1908	3,107	14,810		252,677	1,440,460

[1] The temporary bridge over Nenana River has been carried out by a flood.

The following table shows the coal consumption of Alaska, including both local production and imports, since 1899. Most of the coal shipped to Alaska was bituminous, but a little was anthracite:

Coal consumed in Alaska, 1899–1919, in short tons.

Year.	Produced in Alaska, chiefly subbituminous and lignite.	Imported from States, chiefly bituminous from Washington.	Total foreign coal, chiefly bituminous from British Columbia.	Total coal consumed.
1899	1,200	10,000	a 50,120	61,320
1900	1,200	15,048	a 56,623	72,871
1901	1,300	24,000	a 77,674	102,974
1902	2,212	40,000	a 68,363	110,575
1903	1,447	64,626	a 60,605	126,678
1904	1,694	36,689	a 76,815	115,198
1905	3,774	67,713	a 72,612	144,099
1906	5,541	69,493	a 47,590	122,624
1907	10,139	46,246	a 93,262	149,647
1908	3,107	23,893	a 86,404	113,404
1909	2,800	33,112	69,046	104,958
1910	1,000	32,098	58,420	91,518
1911	900	32,255	61,845	95,000
1912	355	27,767	68,316	96,438
1913	2,300	69,066	56,430	127,796
1914	....	41,509	46,153	87,662
1915	1,400	46,329	29,457	77,186
1916	13,073	44,934	53,672	111,679
1917	53,955	58,116	56,589	168,660
1918	75,606	51,520	37,986	165,112
1919	60,674	57,166	48,708	166,548
	243,677	891,580	1,276,690	2,411,947

a By fiscal year ending June 30.

PETROLEUM.

The petroleum produced in Alaska in 1919, as in previous years, was derived wholly from the single patented claim in the Katalla field. The old wells on this claim and the refinery were operated as usual, and two new productive wells were drilled. The total production in 1919 was considerably larger than in 1918.

The new leasing law, which applies to the oil lands in Alaska, has caused a renewal of interest in those lands which have been withdrawn from entry for nearly 10 years. Indications of petroleum have been found in five districts in Alaska, four of which, the Katalla or Controller Bay district, the Yakataga district, the Iniskin Bay district, and the Cold Bay district, are on the Pacific seaboard; and the fifth, which includes areas near Smith Bay, is on the Arctic coast. The oil fields in Alaska began to attract considerable attention in 1896, when claims were staked under the placer law in the Katalla, Yakataga, and Cook Inlet districts. The first well at Katalla was drilled in 1901, and a well was drilled on Cook Inlet at about the same time. There was much activity in the supposed oil fields of Alaska from 1902 to 1904, when many claims were staked in all the fields on the Pacific coast of Alaska and when most of the wells in the Katalla, Iniskin, and Cold Bay districts were drilled. All oil lands in Alaska were withdrawn from entry November 3, 1910, but in the meanwhile patent had been granted to one claim of 151 acres in the Katalla field and other claims were pending. Assessment work has been continued on some of the claims staked before the withdrawal, especially in the Katalla field, and applications for patents have been made. Drilling for oil has been done only in the Katalla, Iniskin, and Cold Bay fields. About 40 wells, aggregating about 35,000 feet of drilling, have been sunk in Alaska, of which 31 wells, aggregating 28,431 feet of drilling, are in the Katalla field. Oil has been produced commercially only in the Katalla field, which has yielded since 1904 about 56,000 barrels of crude oil for use locally as fuel and for distillation in a small refinery that has been operated since 1912.

Petroleum products shipped to Alaska from other parts of the United States, 1905–1919, in gallons.[a]

Year.	Heavy oils, including crude oil, gas oil, residuum, etc.	Gasoline, including all lighter products of distillation.	Illuminating oil.	Lubricating oil.
1905	2,715,974	713,496	627,391	83,319
1906	2,688,940	580,978	568,033	83,992
1907	9,104,300	636,881	510,145	100,145
1908	11,891,375	939,424	566,598	94,542
1909	14,119,102	746,930	531,727	85,687
1910	19,143,091	788,154	620,972	104,512
1911	20,878,843	1,238,865	423,750	100,141
1912	15,523,555	2,736,739	672,176	154,565
1913	15,682,412	1,735,658	661,656	150,918
1914	18,601,384	2,878,723	731,146	191,876
1915	16,910,012	2,413,962	513,075	271,981
1916	23,555,811	2,844,801	732,369	373,046
1917	23,971,114	3,256,870	750,238	465,693
1918	24,379,566	1,086,852	382,186	362,413
1919	18,784,013	1,007,073	3,515,746	977,703
	237,949,492	23,605,406	11,807,208	3,600,533

[a] Compiled from Monthly Summary of Foreign Commerce of the United States, 1905 to 1918, Bureau of Foreign and Domestic Commerce.

STRUCTURAL MATERIAL, ETC.

Marble was produced from one quarry in southeastern Alaska, but in about the same amount as in recent years. The production of gypsum continued at the mine on Chichagof Island. There was no report in 1919 of the production of bricks, quicklime, graphite, or barite, all of which have been produced in previous years. Some developments were made on a sulphur deposit on Akun Island in the Aleutian chain in 1919, and plans were made for the production of sulphur in 1920.

REVIEW BY DISTRICTS.

The following review summarizes briefly the principal developments in all the districts. Many of the districts were not visited by members of the Geological Survey in 1919 and some operators failed to make reports, so that the information at hand about mining in some of the districts is incomplete. Therefore the space here devoted to any district is not necessarily a measure of its relative importance. The arrangement of the discussion is geographic, from south to north.

SOUTHEASTERN ALASKA.

The mineral output of southeastern Alaska in 1919 was derived from 7 gold-lode mines, 3 copper mines, several small placer mines, 1 gypsum mine, and 1 marble quarry. The value of the minerals produced increased from $3,825,495 in 1918 to $4,679,632 in 1919. The largest mining operations in 1919, as in previous years, were at the gold mines in the Juneau district and at the Chichagof mine, in the Sitka district. Several discoveries of auriferous lodes in the Sitka district are reported. All the copper produced was mined in the Ketchikan district, the largest operations being at the Rush and Brown mine. Placer mining was limited to the Porcupine district and to small beach operations at Lituya Bay and at Yakataga. A more detailed statement of mining developments in southeastern Alaska is presented in a later section of this report (pp. 105–128).

Mineral production of southeastern Alaska, 1919.

	Ore mined (tons).	Gold.		Silver.	
		Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
Gold-lode mines	3,253,848	201,937	$4,174,407	107,359	$120,242
Copper mines	8,936	674	13,935	5,261	5,892
Placer mines	....	1,209	25,000	204	229
	....	203,820	4,213,342	112,824	126,363

	Copper.		Lead.		Palladium, marble, gypsum, etc. (value).
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	
Gold-lode mines	....	....	1,373,327	$72,822	....
Copper mines	629,100	$117,013	....	....	....
Placer mines	....	....	....	....	....
	692,100	117,013	1,373,327	72,822	$150,092

COPPER RIVER REGION.

The productive mines of the Copper River region in 1919 included three copper mines and one gold-lode mine in the Chitina Valley and about 21 gold-placer mines in the Nizina, Chistochina, and Nelchina districts. The mineral output of the region included copper, silver, gold, and platinum having a total value of $7,395,669.

The mining developments in the Chitina district are summarized in a later chapter of this volume.

The hydraulic placer mines of Nizina district were worked on a large scale. Gold worth about $120,000 was recovered by seven mines operating in the summer. About 77 men were employed. Some placer copper was also recovered.

The Chistochina placer mines are said to have had a very successful season and to have produced gold worth $60,000 from the summer operations of about 10 mines, employing about 30 men. A small amount of platinum was recovered.

PRINCE WILLIAM SOUND.

The value of the minerals produced on Prince William Sound in 1919 was $2,048,892, compared with $3,990,914 in 1918. This amount is the value of the product at five copper mines and one gold-lode prospect.

By far the larger part of the copper output of Prince William Sound in 1919, as in previous years, came from the Beatson-Bonanza mine. Work was continued at the Ellamar copper mine in 1919 on about the same scale as in the past.

Work was continued during the year at the Girdwood mine, which adjoins the Beatson-Bonanza on the north, and incidentally some copper ore was produced and shipped. This property, now controlled by the Ladysmith Smelting Corporation, is being developed in a large way. Developments were also continued at the Schlosser and McIntosh (Fidalgo) mines, on Fidalgo Bay. Assessment work was also done on a number of other copper properties in Prince William Sound. During 1919 gold mining, except for assessment work, was almost at a standstill in the district.

WILLOW CREEK DISTRICT.

The gold-lode mines of the Willow Creek district report a very successful season. The Gold Bullion, Alaska Free Gold, Mabel, Talkeetna, and War Baby mines were operated, producing an aggregate amount of gold worth $162,944 and silver worth $569 from 6,730 tons of ore. A more complete account of mining in the Willow Creek district is given by Mr. Chapin elsewhere in this volume.

YENTNA DISTRICT.

The Cache Creek placers, in the Yentna district, produced in 1919 gold worth about $95,000 from the operation of 15 mines. About 60 men were employed in productive mining and a few were doing dead work. Mining was curtailed during part of the season by shortage of water, but on the whole the season was favorable.

The dredge on Cache Creek did not operate in 1919 but will resume work in 1920.

UPPER SUSITNA REGION.

A little placer mining was done at several localities in the upper Susitna basin, the largest operations being at Valdez Creek. Prospecting for copper has been continued at several localities with encouraging results, but no large developments have yet been made. In general property owners are awaiting the completion of the railroad before attempting systematic developments. To make the copper deposits of this district accessible wagon roads and trails must also be built.

KENAI PENINSULA.

The value of the mineral output of Kenai Peninsula in 1919, including placer gold, lode gold, a small amount of silver obtained incidentally to the mining of the gold, and some lignite mined at Bluff Point, was about $37,500. Of this amount $22,000 is the value of the gold.

There was very little activity in lode-gold mining, and no extensive developments are reported. Three small gold mines were operated during the summer of 1919, and placer mining was continued on a small scale at several localities in Kenai Peninsula.

MATANUSKA, COOK INLET, AND SUSITNA COAL FIELDS.

The coal mines of the Matanuska field supplied the larger part of the Alaskan coal output in 1918, yielding about 44,553 tons of coal, valued at $267,318. A more complete account of mining in the Matanuska field is given by Mr. Chapin in another part of this volume.

The Bluff Point lignite coal mine, at Kachemak Bay, was operated during the summer of 1919 and supplied a local market on Cook Inlet. Some of this lignite was also sold at Anchorage for domestic use. Some lignitic coal was also produced near Snug Harbor for the use of a near-by cannery. Small lignitic coal mines were also operated at Little Susitna and at Hobbs, on the Alaska Railroad.

SOUTHWESTERN ALASKA.

Some development work was continued in 1919 on the McNeil copper property, near Kamishak Bay. A little beach mining was done in 1919, as in the past, at the north end of Kodiak Island. The most important mining event of the year in southwestern Alaska was the installation of a plant to develop a sulphur deposit on Akun Island in the Aleutian chain.

YUKON BASIN.

GENERAL FEATURES.

In spite of the adverse conditions affecting gold mining the value of the mineral product of the Alaska Yukon in 1919 was $3,049,061, as compared with $4,390,237 in 1918. The sources of the product in 1919 and the total mineral product since mining began in 1886 are shown in the following tables:

Mineral production of Yukon basin, Alaska, in 1919.

	Placer mines.		Lode mines.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold............fine ounces..	140,771	$2,910,000	2,027	$41,393	142,798	$2,951,393
Silver....................do....	19,461	21,796	378	424	19,839	22,220
Tin (metal)..........pounds..	36,000	23,590	....	....	36,000	23,590
Coal....................tons..	....	....	....	....	10,639	51,878
		2,955,386		41,817		3,049,081

Total mineral production of the Yukon basin, Alaska, 1886–1919.

	Placer mines.		Lode mines.		All mines.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold............fine ounces..	6,209,350	$128,357,000	59,779	$1,235,230	6,269,129	$129,592,230
Silver....................do....	1,070,542	642,322	18,754	8,922	1,089,296	651,244
Tin (metal).........pounds..	316,410	158,740	....	....	316,410	158,740
Antimony (crude ore)..tons..	....	....	2,251	218,500	2,251	218,500
Tungsten..........................	....	....	....	107,000	....	107,000
Platinum (crude)....ounces..	45	3,100	....	....	45	3,100
Lead....................tons..	....	....	10	1,672	10	1,672
Coal....................do....	....	....	....	....	21,599	146,203
		129,161,162		1,571,324		130,878,689

In 1919 the Alaska-Yukon placers produced about $2,910,000 worth of gold; in 1918, $4,261,000. The decrease of output is rather evenly distributed among all the districts, but the Iditarod showed the greatest percentage of loss as compared with the previous year. About 274 placer mines, giving employment to 1,246 men, were operated in the Yukon districts during the summer of 1919, and 76, employing about 255 men, were operated during the previous winter. In 1918, 355 placer mines, employing 1,965 men, were worked in the summer, and 121 mines, employing 490 men, in the winter.

Estimated value of gold produced from principal placers of Yukon basin, 1919.

Fairbanks....................	$730,000	Koyukuk......................	$110,000
Iditarod.......................	725,000	Hot Springs....................	100,000
Tolovana......................	525,000	Marshall.......................	100,000
Ruby..........................	165,000	All others......................	170,000
Innoko and Tolstoi............	150,000		
Circle...........................	135,000		2,910,000

FAIRBANKS DISTRICT.

The value of the total mineral production of the Fairbanks district in 1919 was $778,087, the value in 1918 was $848,989. In 1919, as in the past, the mineral production of the district was chiefly placer gold. The value of the placer gold produced in 1919 was $730,000 as compared with $800,000 in 1918. About 53 placer mines, employing 350 men, were operated in the district during the summer of 1919, and 24 mines, employing 86 men, during the previous winter. Of the total mines operated in the summer about half were small, employing only 2 to 4 men each. Eighteen of the summer mines are on Goldstream Creek and its tributaries, and the value of their total output of gold was about $275,000. The largest single operations were those of the dredging company, which employed two gold dredges on Fairbanks Creek. Seven relatively large plants were operated on Cleary Creek, and a few on Dome, Vault, and other streams. About 28 deep placer mines were worked in 1919 by shafts and drifts, and by the use of steam for thawing. Many of these, however, were small, employing only 2 to 4 men. This type of mining is on the wane, owing principally to the high cost of fuel. With the use of Nenana coal, which has now been made available to Fairbanks by the completion of the railroad, it should be revived. The most economical form of mining, however, is mining by dredges and steam scrapers. It is shown elsewhere in this volume (p. 11) that the Fairbanks district contains large reserves of gold placers. It should be noted, however, that it will take some time for the placer miners to adapt their plants, now equipped to burn wood, to the use of the Nenana lignitic coal.

The aggregate value of the mineral output of the Fairbanks district to the close of 1919 was $72,044,767. Much the larger part of this amount represents the value of the placer gold, the production of which is shown by years in the subjoined table. In addition to the actual production of the district, about $1,000,000 worth of gold mined in tributary areas passes through Fairbanks each year.

Placer gold and silver produced in the Fairbanks district, 1903–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1903	1,935.00	$40,000	348	$188
1904	29,025.00	600,000	5,225	2,821
1905	290,250.00	6,000,000	52,245	28,212
1906	435,375.00	9,000,000	78,367	42,318
1907	387,000.00	8,000,000	69,660	37,616
1908	445,050.00	9,200,000	79,909	43,151
1909	466,818.75	9,650,000	84,027	45,375
1910	295,087.50	6,100,000	53,116	28,683
1911	217,687.50	4,500,000	52,245	27,690
1912	200,756.25	4,150,000	48,182	29,632
1913	159,637.50	3,300,000	20,274	12,245
1914	120,937.50	2,500,000	29,024	16,050
1915	118,518.75	2,450,000	28,444	14,421
1916	87,075.00	1,800,000	11,058	7,276
1917	63,371.25	1,310,000	8,379	6,904
1918	38,700.00	800,000	5,708	5,708
1919	35,313.75	730,000	55,197	5,820
	3,392,538.75	70,130,000	631,408	354,111

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

Approximate distribution of gold produced in Fairbanks district, 1903–1919.

Cleary Creek and tributaries	$23,060,000
Goldstream Creek and tributaries	14,355,000
Ester Creek and tributaries	11,330,000
Dome Creek and tributaries	8,080,000
Fairbanks Creek and tributaries	7,700,000
Vault Creek and tributaries	2,665,000
Little Eldorado Creek	2,255,000
All other creeks	685,000
	70,130,000

The first lode mining was done at Fairbanks in 1910 and, as shown in the subjoined table, the industry reached its maximum output in 1915. Since then the relative decline in the value of gold and the high cost of fuel have discouraged this type of mining. Many small lodes in the Fairbanks district will be developed when industrial conditions improve. The records show that the value of the average recovery per ton from the gold ore that has been milled has been about $35. This shows that only the highest grades of ore could be profitably exploited under existing costs of mining and milling. During 1919 lode mining and prospecting have almost ceased, the only operations being those of a few owners who continued a little development with the plan of blocking out ore to be mined when costs are decreased. Incidental to this, a little ore is recovered and milled. Developments of this type were made at half a dozen quartz properties, including the Smith & McGlone, Bondholder, Saint Paul, Gilmore, and Crites & Feldman. The mining of tungsten and antimony ores has been discontinued, owing to the decrease in the price of those metals after the war.

Lode gold and silver produced in the Fairbanks district, 1910–1919.

Year.	Crude ore (short tons).	Gold.		Silver.	
		Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1910	148	841.19	$17,389	106	$57
1911	875	3,103.02	64,145	582	308
1912	4,708	9,416.54	194,657	1,578	971
1913	12,237	16,904.98	349,457	4,124	2,491
1914	6,526	10,904.75	225,421	2,209	1,222
1915	5,845	10,534.91	217,776	1,796	910
1916	1,111	1,904.81	39,376	140	92
1917	1,200	2,311.38	47,781	2,217	1,826
1918	1,035	1,294.04	26,750	616	616
1919	1,384	2,026.57	41,893	378	424
	35,069	59,242.19	1,224,645	13,746	8,917

HOT SPRINGS DISTRICT.

There were no important mining advances in the Hot Springs district in 1919. Only 12 mines were operated in the summer and 3 during the winter. The mines on Patterson Creek made the largest gold output; those of American Creek made the second largest output. Incidental to gold mining about 30 tons of concentrates containing about 36,000 pounds of metallic tin, worth $23,590, were recovered from the Hot Springs placers. Since 1910 these mines have produced about 262 tons of stream tin, containing about 312,260 pounds of metallic tin, valued at $155,490.

Placer gold and silver produced in the Hot Springs district, 1902–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1902–3	12,717.79	$262,900	1,818	$964
1904	7,038.56	145,500	1,007	584
1905	5,805.00	120,000	831	507
1906	8,707.50	180,000	1,245	843
1907	8,465.63	175,000	1,210	798
1908	7,256.25	150,000	1,038	550
1909	15,721.88	325,000	2,248	1,169
1910	15,721.88	325,000	2,248	1,169
1911	37,974.37	785,000	5,430	2,932
1912	19,350.00	400,000	3,267	2,009
1913	19,350.00	400,000	3,267	1,973
1914	36,281.25	750,000	6,125	3,387
1915	29,508.75	610,000	4,982	2,526
1916	38,700.00	800,000	6,534	4,299
1917	21,768.75	450,000	3,675	3,028
1918	7,256.25	150,000	1,225	1,225
1919	4,837.50	100,000	817	915
	296,461.36	6,128,400	46,967	28,878

TOLOVANA DISTRICT.

About 18 placer mines were operated in the Tolovana district during the summer of 1919 and 7 during the previous winter. Most of the gold recovered in 1919, as in previous years, was taken from the deep mines of Livengood Creek. The immediately available water supply of the Tolovana district is scant, and except in seasons of unusual rainfall the water is likely to be insufficient to sluice up the dumps on Livengood Creek. Such were the conditions in 1918 and 1919.

Though deep mining has dominated in the Tolovana district in the past, the miners there are giving increasing attention to the shallow placers. During the summer of 1919 the miners of the Tolovana district showed considerable interest in the report that placer gold had been found in the Mike Hess and Beaver Creek basins.

Placer gold and silver produced in the Tolovana district, 1915–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1915	3,870.00	$80,000	321	$163
1916	33,862.50	700,000	2,813	1,851
1917	55,631.25	1,150,000	8,430	6,946
1918	42,328.12	875,000	4,060	4,060
1919	25,396.88	525,000	2,141	2,454
	161,088.75	3,330,000	17,815	15,474

RAMPART DISTRICT.

In the Rampart district 7 mines, employing 21 men in the summer of 1919, and 2 mines, employing 5 men in the previous winter, were operated. The largest mines were on Hunter Creek, where two small hydraulicking plants were operated. With the rest of Alaska, the Rampart district suffered from the scarcity of labor. Cassiterite is found in the concentrates of ores taken from some of the mines, but none of it is being saved.

Placer gold and silver produced in the Rampart district, 1896–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1896–1903	29,799.00	$616,000	4,440	$2,664
1904	4,353.75	90,000	649	376
1905	3,870.00	80,000	576	351
1906	5,805.00	120,000	865	588
1907	6,046.87	125,000	901	595
1908	3,628.12	75,000	540	286
1909	4,837.50	100,000	721	375
1910	2,080.12	43,000	310	167
1911	1,548.00	32,000	231	125
1912	1,548.00	32,000	274	169
1913	1,548.00	32,000	274	165
1914	1,451.25	30,000	257	142
1915	1,693.13	35,000	300	152
1916	1,935.00	40,000	343	226
1917	1,596.37	33,000	280	231
1918	1,161.00	24,000	206	206
1919	1,451.25	30,000	90	101
	74,352.36	1,537,000	11,257	6,919

RICHARDSON DISTRICT.[2]

Though the region tributary to the town of Richardson, which is on the Fairbanks-Valdez road, has no large mines, it contains much auriferous gravel, and in the aggregate a considerable number of prospectors there support themselves by placer mining. During the last two years some systematic prospecting, part of it done with the use of a churn drill, has been carried on in this district under the leadership of Frank Lawson. The results have encouraged the con-

[2] Called the Salchaket-Tenderfoot district in previous reports.

tinuation of the work. It is estimated that during 1919 some gold was mined on 11 different claims in this district, employing about 20 men.

Placer gold and silver produced in Richardson district, 1905–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1905	(a)	(a)	(a)	(a)
1906	4,837.50	$100,000	989	$673
1907	18,140.62	375,000	3,707	2,447
1908	18,140.62	375,000	3,707	1,965
1909	7,256.25	150,000	1,483	771
1910	4,837.50	100,000	989	534
1911	4,837.50	100,000	989	524
1912	4,837.50	100,000	989	608
1913	4,837.50	100,000	989	597
1914	4,837.50	100,000	989	547
1915	4,595.62	95,000	939	476
1916	3,870.00	80,000	790	520
1917	1,289.37	25,000	245	202
1918	290.25	6,000	59	59
1919	483.75	10,000	99	111
	83,091.48	1,716,000	16,963	10,034

a Prospects.

CHISANA DISTRICT.

The Chisana district, which lies in the headwater region of the Tanana River, is one of the most inaccessible in Alaska. Mining here has been on the wane since 1915, though the gold output in 1919 was somewhat greater than that in 1918. The largest part of the gold produced in 1919 was won by rewashing the old tailings of Bonanza Creek.

Placer gold and silver produced in the Chisana district, 1913–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1913	1,935.00	$40,000	465	$280
1914	12,093.75	250,000	2,910	1,609
1915	7,740.00	160,000	1,862	944
1916	1,935.00	40,000	465	306
1917	1,935.00	40,000	420	346
1918	725.63	15,000	160	160
1919	1,306.12	27,000	314	352
	27,670.50	572,000	6,596	3,997

KANTISHNA DISTRICT.

Placer mining was continued in a small way in the Kantishna district during 1919, about 12 mines having been operated. The most important advances reported were those made in lode mining. In 1918 a galena-bearing vein was discovered on the Alice claim, on the ridge between Friday and Eureka creeks. This was opened up in 1919 by a shaft about 70 feet deep. The vein was followed by a drift, whose length was not reported. The owner reports that the vein ranges in width from 1 to 2 feet and averages about 18 inches. The galena ore contains a high percentage of silver and some gold and copper. The vein traverses schist bedrock and has a calcite gangue. A number of galena and gold prospects in this district have been described by Capps,[3] and development work appears to have been done on some of them in 1919.

The Kantishna district is now difficult of access and is in need of wagon-road connection with the Alaska Railroad. At present supplies for the district are taken up Kantishna and Bearpaw rivers in small launches to the settlement of Diamond. Thence they are sledded to the mines in winter. Several hundred tons of silver ore is said to have been sledded to Bearpaw River from the Alice claim during the winter of 1919, at a cost, including sacking, of $35 a ton. On top of this comes an additional cost of $60 a ton for freight to the States. To meet these high freight charges the ore shipped was carefully picked with the hope that its average value would exceed $150 a ton.

Placer gold and silver produced in the Kantishna district, 1903–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1903–1906	8,465.62	$175,000	1,325	$795
1907	725.62	15,000	114	75
1908	725.62	15,000	114	60
1909	241.87	5,000	38	20
1910	483.75	10,000	76	41
1911	1,451.25	30,000	227	120
1912	1,451.25	30,000	227	140
1913	1,451.25	30,000	227	137
1914	967.50	20,000	152	84
1915	967.50	20,000	152	77
1916	1,451.25	30,000	227	149
1917	725.63	15,000	120	99
1918	1,451.25	30,000	227	227
1919	725.63	15,000	114	128
	21,284.99	440,000	3,340	2,152

BONNIFIELD DISTRICT.

In the Bonnifield placer district mining was continued in a small way by six operators. The district contains great bodies of auriferous gravel that carry too low a content of gold to warrant their development except in a large way. When the industrial conditions improve an increase in placer mining may be expected.

[3] Capps, S. R., The Kantishna region, Alaska: U. S. Geol. Survey Bull. 687, pp. 95–106, 1919.

Placer gold and silver produced in the Bonnifield district, 1903–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1903–1906	1,451.25	$30,000	227	$136
1907	241.87	5,000	38	25
1908	241.87	5,000	38	20
1909	2,418.75	50,000	379	197
1910	483.75	10,000	76	41
1911	967.50	20,000	152	81
1912	967.50	20,000	152	93
1913	967.50	20,000	152	92
1914	1,451.25	30,000	227	126
1915	967.50	20,000	152	77
1916	483.75	10,000	76	50
1917	580.50	12,000	98	81
1918	580.50	12,000	91	91
1919	483.75	10,000	75	84
	12,287.24	254,000	1,933	1,194

NENANA COAL FIELD.[4]

The completion of the Alaska Railroad from Fairbanks to the Nenana coal field, except for a bridge at Tanana River, stimulated mining. The Lynn mine was first opened up at Mile 387 on a bed of lignite 4 to 4½ feet thick. This coal proved to be of inferior quality, and work was abandoned after 2,000 tons had been mined.

A lignite of much better grade was found at the Burns mine, Mile 362, where three beds have been developed by entries aggregating 1,000 feet in length. These beds have been traced on the surface for about 2,000 feet. They are somewhat faulted but not enough to affect seriously the cost of mining. About 7,300 tons of coal were taken from this mine in 1919. This coal was used by the Alaska Engineering Commission and by the town of Nenana. The Bureau of Mines has issued the following statement[5] on the steaming value of the Nenana coal:

The Fairbanks station of the Bureau of Mines has recently completed two series of tests designed to determine, first, the comparative steaming value of Alaska lignite and spruce wood, and, second, the resistance of lignite to weathering when stored in piles in the open. The tests were made under the direction of John A. Davis, superintendent of the station, who was assisted by Paul Hopkins and John Gross. These investigations are of special interest to Alaska, since much has been written about the large lignite fields of the Nenana district and their possible value as a fuel supply.

The steaming tests were run to determine the relative value of lignite and spruce wood in the small boilers commonly used in the mining camps of Alaska. Spruce wood has been used for steaming purposes almost exclusively in the past, but the price has risen from $7 to $20 per cord in the last 15 years and other sources of fuel are sought. The lignite used in the tests was not of the highest quality, since it was obtained near the surface. Both the wood and the lignite were carefully weighed, sampled, and analyzed, so that the results of the tests could be accurately compared.

[4] The Nenana coal field lies within the Bonnifield placer district.

[5] Bur. Mines Monthly Rept. nvestigations, February, 1920.

The boiler used was one of a battery of two horizontal water-tube boilers, each rated at 125 brake-horsepower. Two grades of lignite, one from the Lynn mine and one from the Burns mine, and one grade of wood were tested.

The results showed that, under the conditions of these tests, when compared pound for pound the value of spruce wood lay between the values of the two samples of lignite. The relative water evaporations per pound of fuel were: Lynn lignite, 3.06; Burns lignite, 3.99; spruce wood, 3.68 per pound. However, in comparing a cord of wood with a ton of lignite, it was shown that a cord of wood is equivalent to more than a ton of lignite from either mine.

In the weathering tests several hundred pounds of Nenana lignite were used. It was first carefully sampled for analysis and then sized through a series of rings from three-eighths to 2 inches in diameter; 80 per cent of the sample was retained on a 1-inch ring. The lignite was then spread in shallow trays and placed on the roof of the station, where it was allowed to remain, fully exposed to the weather, for 14 months. At the end of a week it was noticeably weathered on the surface, and at the end of a month it had broken up into small pieces.

At the end of the test period it was found that the surface portion, immediately exposed to the atmosphere, was entirely disintegrated, while that farthest from the surface was only partly disintegrated, although very fragile. Over 50 per cent would then pass through a three-eighth inch ring and 85 per cent passed a three-fourth inch ring. The average loss in weight through weathering was 6.08 per cent (mostly moisture). The weathering at the end of 14 months, however, seemed only slightly more than that at the end of 1 month. In large piles only the surface, to a depth of 4 to 6 inches, would weather badly, and the material beneath would be so protected as to suffer little change. These tests show that the behavior of these lignites is substantially the same as that of North Dakota lignite.

Early in 1920 permits were granted to mine coal at two other places in the Nenana field. One is on the west side of Nenana River, on Lignite Creek; the other on the east side, close to the canyon. Development work on these claims is under way.

CIRCLE DISTRICT.

The output of the gold placers of the Circle district in 1919 was the smallest since 1894. About 18 mines, employing about 30 men, were operated in the winter of 1918–19, and 26 mines and one dredge, employing 77 men, in the summer of 1919. The largest operations included the dredge on Mastodon Creek and hydraulic mines on Mastodon and Eagle creeks. The smallness of the output was due to shortage of water and late thawing, to curtailment of operations because of high costs, and to the deaths of several large operators of the district in the wreck of the *Sophia*. No new discoveries were reported and no new projects were undertaken.

Placer gold and silver produced in the Circle district, 1894–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1894	483.75	$10,000	123	$77
1895	7,256.25	150,000	1,886	1,226
1896	33,862.50	700,000	8,794	6,080
1897	24,187.50	500,000	6,289	3,773
1898	19,350.00	400,000	5,031	2,968
1899	12,093.75	250,000	3,144	1,886
1900	12,093.75	250,000	3,144	1,886
1901	9,675.00	200,000	2,512	1,507
1902	9,675.00	200,000	2,512	1,331
1903	9,675.00	200,000	3,144	1,698
1904	9,675.00	200,000	3,144	1,823
1905	9,675.00	200,000	3,144	1,918
1906	14,512.50	300,000	3,773	2,565
1907	9,675.00	200,000	3,144	2,075
1908	8,465.63	175,000	2,212	1,166
1909	10,884.37	225,000	2,830	1,472
1910	10,884.37	225,000	2,830	1,528
1911	16,931.25	350,000	4,402	2,333
1912	15,721.87	325,000	2,439	1,500
1913	8,465.63	175,000	1,314	794
1914	10,884.37	225,000	1,689	934
1915	11,126.25	230,000	1,727	875
1916	14,512.50	300,000	2,252	1,482
1917	9,675.00	200,000	1,561	1,285
1918	8,465.63	175,000	1,798	1,798
1919	6,530.63	135,000	1,260	1,411
	314,437.50	6,500,000	76,098	47,391

FORTYMILE DISTRICT.

Placer mining in the Fortymile district, as in all the other isolated districts of Alaska, declined in 1919, when the gold output was smaller than in any previous year. Some productive work was done at about 20 mines, but most of these were small. The largest output was made from Jack Wade Creek and Walkers Fork. A hydraulic plant on Dome Creek that had been in process of installation since 1917 was completed but was operated only a short time. This plant is intended to exploit bench gravels. Another company has been exploring the placers of Dennison Fork and the adjacent region with a view of installing large plants. The Fortymile district contains much auriferous gravel whose gold content is great enough to justify mining when costs are reduced. A good wagon road into the district from Yukon River is very much needed.

Placer gold and silver produced in the Fortymile district, 1886–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1886–1903	193,500.00	$4,000,000	30,553	$22,915
1904	14,851.12	307,000	2,345	1,360
1905	12,384.00	256,000	1,955	1,193
1906	9,868.50	204,000	1,558	1,059
1907	6,772.50	140,000	1,069	706
1908	6,772.50	140,000	1,069	567
1909	10,884.37	225,000	1,719	894
1910	9,675.00	200,000	1,528	825
1911	9,575.00	200,000	1,528	810
1912	10,303.87	213,000	1,627	1,000
1913	4,837.50	100,000	764	461
1914	2,418.75	50,000	382	211
1915	2,418.75	50,000	382	194
1916	2,418.75	50,000	382	251
1917	3,870.00	80,000	624	513
1918	3,628.12	75,000	573	573
1919	1,983.37	41,000	313	350
	306,262.10	6,331,000	48,371	33,882

EAGLE DISTRICT.

The output of placer gold in the Eagle district in 1919 was about the same as in 1918. Most of it was mined on tributaries of Seventymile River and American Creek, where 14 mines were operated, employing 30 men. No new developments or discoveries were reported.

Placer gold and silver produced in the Eagle and Seventymile districts, 1908–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1908	483.75	$10,000	76	$40
1909	1,209.37	25,000	191	99
1910	483.75	10,000	76	41
1911	580.50	12,000	92	49
1912	967.50	20,000	164	100
1913	2,418.75	50,000	382	231
1914	2,418.75	50,000	382	211
1915	1,935.00	40,000	305	155
1916	822.37	17,000	130	86
1917	628.88	13,000	96	75
1918	1,209.37	25,000	191	191
1919	969.50	20,000	152	170
	14,127.49	292,000	2,237	1,448

CHANDALAR DISTRICT.

Little information has been received concerning mining in the Chandalar district. The placers were apparently worked on about the customary scale, two summer mines and one winter mine employing eight and five men, respectively.

Placer gold and silver produced in the Chandalar district, 1906–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1906–1912	2,902.50	$60,000	416	$241
1913	266.06	5,500	38	23
1914	241.87	5,000	35	19
1915	241.87	5,000	35	18
1916	435.37	9,000	62	41
1917	725.63	15,000	104	86
1918	628.88	13,000	96	96
1919	453.75	10,000	79	88
	5,895.93	122,500	865	612

KOYUKUK DISTRICT.

In the Koyukuk district, in spite of its extreme isolation, considerable placer mining was done in 1919. It is estimated that 15 mines, employing 60 men, were operated during the summer of 1919, and 3 mines, employing 10 men, during the previous winter. The largest operations were those on Nolan Creek. Gold placers were discovered on Hogatza River, in the Koyukuk district, in 1919, but the developments are not yet sufficient to determine their value. Placers are also reported to have been discovered in the basin of Birch Creek, a tributary of Wild River, and also in the Koyukuk district, though the reports have not been verified. These placers are in inaccessible regions and would have to be very rich to justify their development under present conditions. The reports, however, indicate that not all the Alaska prospectors have become discouraged.

Placer gold and silver produced in the Koyukuk district, 1900–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1900–1909	106,454.02	$2,200,600	15,242	$8,993
1910	7,740.00	160,000	1,108	598
1911	6,772.50	140,000	970	514
1912	9,675.00	200,000	1,385	852
1913	19,350.00	400,000	2,770	1,673
1914	12,577.50	260,000	1,800	995
1915	13,303.12	275,000	1,902	964
1916	14,996.25	310,000	2,147	1,413
1917	12,093.75	250,000	1,700	1,401
1918	7,256.25	150,000	860	860
1919	5,321.25	110,000	760	851
	215,539.64	4,455,600	30,644	19,114

INDIAN RIVER AND GOLD HILL DISTRICTS.

Mining was continued in a very small way in the Indian River and Gold Hill districts of the Middle Yukon Valley during 1919. It is estimated that only five placer mines were operated.

Placer gold and silver produced in the Indian River and Gold Hill districts, 1911–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1911	483.75	$10,000	69	$37
1912	1,185.19	24,500	170	105
1913	1,548.00	32,000	221	133
1914	1,209.37	25,000	173	96
1915	725.63	15,000	104	53
1916	483.75	10,000	69	45
1917	241.88	5,000	27	22
1918	193.50	4,000	29	29
1919	338.62	7,000	52	58
	6,409.69	132,500	914	578

RUBY DISTRICT.

Placer mining in the Ruby district declined greatly in 1919 as compared with previous years. About 22 mines, employing 80 men, were operated during the summer of 1919, and only 2 during the previous winter. A new gold-bearing channel was discovered on Flat Creek and was profitably developed. Some new gold discoveries were also made on Poorman Creek. There were also large mining operations on Greenstone Creek.

Placer gold and silver produced in the Ruby district, 1907–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1907–8	48.38	$1,000	7	$4
1909				
1910				
1911				
1912	8,465.63	175,000	1,157	712
1913	37,974.37	785,000	5,188	3,134
1914	48,375.00	1,000,000	6,609	3,655
1915	33,862.50	700,000	4,626	2,345
1916	41,118.75	850,000	5,618	3,697
1917	42,811.88	885,000	6,073	5,046
1918	19,350.00	400,000	3,000	3,000
1919	7,981.88	165,000	1,255	1,406
	239,988.39	4,961,000	33,533	22,999

INNOKO AND TOLSTOI DISTRICTS.

Placer mining was continued in the Innoko and Tolstoi districts on about the same scale as during previous years. A total of 17 mines, employing 68 men, were operated in the summer of 1919, and 12, employing 15 men, in the previous winter. The largest plants were on Ophir and Gaines creeks. Considerable prospecting of auriferous lodes was done during the year. Some ore was recovered with the view of making shipments for mill tests.

Placer gold and silver produced in the Innoko and Tolstoi districts, 1907–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1907	628.87	$13,000	67	$44
1908	3,483.00	72,000	370	196
1909	16,447.50	340,000	1,746	908
1910	15,721.87	325,000	1,669	901
1911	12,093.75	250,000	1,284	681
1912	12,093.75	250,000	1,284	681
1913	13,545.00	280,000	1,438	869
1914	9,675.00	200,000	1,027	568
1915	9,191.25	190,000	976	495
1916	10,642.50	220,000	1,130	744
1917	8,465.63	175,000	1,113	917
1918	5,805.00	120,000	608	608
1919	6,772.50	140,000	717	803
	124,565.62	2,575,000	13,429	8,415

IDITAROD DISTRICT.

The operation of two gold dredges in the Iditarod district was continued in 1919, but as compared with 1918 other forms of placer mining decreased. It is estimated that a total of 12 mines, employing 70 men, were operated in the summer of 1919, and 3 mines, employing 20 men, in the previous winter.

Placer gold and silver produced in the Iditarod district, 1910–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1910	24,187.50	$500,000	4,254	$2,297
1911	120,937.50	2,500,000	21,270	11,273
1912	169,312.50	3,500,000	29,778	18,313
1913	89,977.50	1,860,000	9,551	5,769
1914	99,652.50	2,060,000	10,578	5,849
1915	99,168.75	2,050,000	10,526	5,337
1916	94,331.25	1,950,000	10,013	6,589
1917	72,562.50	1,500,000	11,050	9,105
1918	59,985.00	1,240,000	9,000	9,000
1919	35,071.88	725,000	5,300	5,937
	865,186.88	17,885,000	121,320	79,469

MARSHALL DISTRICT.

Productive mining in the Marshall district was nearly all confined to Willow Creek. About eight mines were operated in the district during the summer of 1919, employing some 56 men.

Placer gold and silver produced in the Marshall district, 1914–1919.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
1914	725.62	$15,000	94	$52
1915	1,209.37	25,000	156	79
1916	13,061.25	270,000	1,686	1,109
1917	20,559.37	425,000	3,300	2,719
1918	7,256.25	150,000	940	940
1919	4,837.50	100,000	624	699
	47,649.36	985,000	6,800	5,598

KUSKOKWIM REGION.

Mining interest in the Kuskokwim Valley during 1919 centered in the McGrath (Mount McKinley) district. Here the principal events were the successful operation during the entire season of the gold dredge installed on Candle Creek in 1918, and the discovery and development of a number of lodes carrying gold, silver, and some copper. The most promising of the lodes discovered are on Nixon Fork, 10 to 20 miles from Kuskokwim River. These lodes appear to lie in a zone of mineralization along a contact of limestone and intrusive granite. The most important developments are on the Crystal lode, said to be 3 to 5 feet in width and to carry considerable gold and some silver and copper. In the fall of 1919 preparations were made to open up this lode and make a shipment in the summer of 1920 of a thousand tons of ore for a smelter test. Other promising auriferous lodes have been found and prospected. A specimen sent to the Geological Survey by Dr. W. F. Green from the Whelen claim, contained copper and a little nickel. Another specimen, from Roundabout Mountain, also sent by Dr. Green, contained pyrite and chalcopyrite and a trace of nickel. The evidence in hand indicates that a part of this district is well mineralized, and this augurs well for the finding of commercial ore bodies.

Mining was continued in the Aniak-Tuluksak district, including Georgetown, in the Kuskokwim district during 1919, but on a reduced scale as compared with previous years. Some dredging ground on Marvel Creek, in this district, was prospected. Placer mining in the Goodnews Bay district, which is described elsewhere in this volume, was also continued on a reduced scale.

The value of the total gold produced in the Kuskokwim Valley in 1919 was about $350,000. The value in 1918 was $100,000. The substantial increase in 1919 is to be credited to the McGrath district. In 1919 about 20 placer mines, employing about 100 men, were in operation in all the Kuskokwim districts. Work was continued at the Parks quicksilver mine on the lower Kuskokwim. A retorting plant was shipped in during the summer of 1919 and installed about the end of the year. About 30 men were employed at this mine.

The Kuskokwim Valley, because of lack of steamers, is rather difficult of access. Small ocean vessels can ascend the Kuskokwim as far as Bethel, and the river is navigable by smaller craft for some 600 miles above that place. As mining increases better service will no doubt be established, but the only communication with Seattle in 1919 was afforded by small gas boats and schooners. Some five boats were used on this run, the largest of which had a capacity of about 1,000 tons. The passage from Seattle takes about 30 days. Passenger rates from Seattle to Bethel in 1920 were $125 and freight rates were about $30 a ton. Freight is carried from Bethel up the Kuskokwim to McGrath and other places by a river steamer. This boat makes two or three trips a season and can carry about 300 tons of freight. The up-river journey from Bethel to McGrath takes about 10 days. In 1919 about 3,000 tons of freight was carried to Bethel from Seattle, of which about 800 tons was sent up the river as far as McGrath. McGrath can be reached by overland horse trail from Iditarod and Ruby. The lower Kuskokwim Valley can be reached by way of the mail route that crosses the Portage trail from lower Yukon River.

SEWARD PENINSULA.

The value of the mineral output of Seward Peninsula in 1919 was about $1,423,449, compared with $1,195,172 in 1918. Of the output in 1919, $1,360,000 represents the value of the placer gold and $63,449 the value of the miscellaneous products, including tin, lode gold, silver, and platinum. The value of the placer gold produced in 1918 was $1,108,000, so that there was a substantial increase.

In all 24 gold dredges were operated in Seward Peninsula during 1919, distributed as follows: Nine in the Nome district, eight in the Council district, four in the Solomon district, and one each in the Kougarok, Fairhaven, and Port Clarence districts. Three dredges used the so-called cold-water method of thawing the gravels. In addition to the dredges, about 75 open-cut mines and 13 deep placer mines were operated on Seward Peninsula in 1919. About 555 men were employed in placer mining and about 60 of these were employed in deep mining during the winter. Some 32 ounces of platinum was won from the gold placers of the Dime Creek region, in the southeastern part of Seward Peninsula. There were some small developments on auriferous quartz and galena deposits of Seward Peninsula in 1919.

The York district, of Seward Peninsula, continues to be the center of the tin-mining industry of Alaska. Here two dredges and one small open-cut mine were operated in 1919 on placer tin, employing some 25 men, and about 56 tons of stream tin was recovered by these operations. (See p. 229.) Developments were also continued at the Lost River tin-lode mine, in the same district, where about 25 men were employed. A more detailed statement of the mining developments in the Seward Peninsula is given in another part of this report.

KOBUK RIVER.

About $25,000 worth of gold was taken from the gold placers of the Kobuk district in 1919, as compared with $15,000 in 1918. Seventeen mines were operated, employing about 40 men. Most of the gold was taken from Klery and Dahl creeks. It is reported that James Cross and Harry Brown discovered gold in the Ambler Valley of the Kobuk region. The gold is said to be bright and rather coarse and to include flat nuggets. It is reported that at least $1,000 was taken out during the summer of 1919.

ADMINISTRATIVE REPORT.

By Alfred H. Brooks and George C. Martin.

INTRODUCTION.

During 1919 twelve parties were engaged in surveys and investigations in Alaska. The length of the field season ranged from 1 to 12 months, being determined by the character of the work and by the climatic conditions prevailing in different parts of the Territory. The parties included 8 geologists, 3 topographers, 1 engineer, and 12 packers, cooks, and other auxiliaries. Eight of the parties were engaged in geologic surveys, three in topographic surveys, and one in stream gaging. The areas covered by reconnaissance geologic surveys on a scale of 1:250,000 (4 miles to an inch) amount to 3,300 square miles. Much of the time of the geologists was devoted to the investigation of special problems relating to the occurrence of minerals, the results of which can not be expressed in terms of area. About 2,300 square miles was covered by reconnaissance topographic surveys on a scale of 1:250,000 (4 miles to an inch). Stream gaging was continued in southeastern Alaska, in cooperation with the Forest Service.

Of the parties whose work may be classified geographically, two parties worked in southeastern Alaska, three in the Cook Inlet-Susitna region, and one each in the Yukon, Copper River, and Kuskokwim regions and in Seward Peninsula.

The funds available for field and office work relating to the field season of 1919 included an appropriation of $75,000 for the fiscal year ending June 30, 1920, and the unexpended balance of the appropriation for the year ending June 30, 1919, of which about $16,700 was used in equipping parties for the season's field work. The following tables show the allotments, for both field and office work, of the total funds classified by regions, by kinds of surveys, and by kinds of expenditures. In the first table the general office expenses are apportioned to the several allotments, account being taken of variations in character of work. The results are expressed in round numbers. Salaries of the permanent staff, other fixed charges, and the total allotments for the work of the office at Anchorage are included up to the end of the fiscal year 1920, but expenses other than these include only the cost of field and office work during 1919. The "general investigations" comprise among other things the cost of collecting mineral statistics, and of office work relating to the field investigations of previous seasons. A balance of about $10,400 from the appropriation for the year ending June 30, 1920, is available for equipping the field parties in 1920.

Approximate general distribution of appropriations for investigations in Alaska, field season of 1919.

	1918–19	1920
Southeastern Alaska	$500	$13,200
Copper River region		1,800
Cook Inlet and Susitna basin	13,200	22,900
Yukon basin		2,300
Kuskokwim region	3,000	8,700
General investigations		15,700
To be allotted to field work, 1920		10,400
	16,700	75,000

Approximate allotments to different kinds of surveys and investigations, field season of 1919.

	1918–19	1920
Reconnaissance geologic surveys	$8,600	$17,600
Special geologic investigations		9,900
Reconnaissance topographic surveys	8,100	9,800
Investigation of water resources		4,200
Collection of mineral statistics		1,900
Miscellaneous, including administration, inspection, clerical salaries, office supplies and equipment, and map compilation		21,200
To be allotted to field work, 1920		10,400
	16,700	75,000

Allotments for salaries and field expenses, field season of 1919.

	1918–19	1920
Scientific and technical salaries		$33,458
Field expenses	$16,700	15,421
Clerical and administrative salaries and miscellaneous expenses		15,721
To be allotted to field work, 1920		10,400
	16,700	75,000

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

Progress of surveys in Alaska, 1898–1919.

Year.	Appropriation.	Areas covered by geologic surveys.			Areas covered by topographic surveys.[a]					Water resources investigations.	
		Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000).	Detailed (scale 1:62,500).	Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000; 200-foot contours).	Detailed (scale 1:62,500; 25, 50, or 100 foot contours).	Lines of levels.	Bench marks set.	Gaging stations maintained part of year.	Stream-volume measurements.
		Sq. m.	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Sq. m.*	*Miles.*			
1898	$46,189	9,500			12,840	2,070					
1899	25,000	6,000			8,690						
1900	60,000	3,300	6,700		630	11,150					
1901	60,000	6,200	5,800		10,200	5,450					
1902	60,000	6,950	10,050		8,330	11,970	96				
1903	60,000	5,000	8,000	96		15,000					
1904	60,000	4,050	3,500		800	6,480	480	86	19		
1905	80,000	4,000	4,100	536		4,880	787	202	28		
1906	80,000	5,000	4,000	421		13,500	40			14	286
1907	80,000	2,600	1,400	442		6,120	501	95	16	48	457
1908	80,000	2,000	2,850	604		3,980	427	76	9	53	556
1909	90,000	6,100	5,500	450	6,190	5,170	444			81	703
1910	90,000		8,635	321		13,815	36			69	429
1911	100,000	8,000	10,550	496		14,460	246			68	309
1912	90,000		2,000	525			298			69	381
1913	100,000	3,500	2,950	180	3,400	2,535	287				
1914	100,000	1,000	7,700	325	600	10,300	10				
1915	100,000		10,700	200		10,400	12	3	2	9	
1916	100,000		5,100	636		9,700	67			20	
1917	100,000		1,750	275		1,050				19	
1918	77,000		3,500			1,200					
1919	75,000		2,700			2,300				19	
		73,200	107,485	5,507	51,680	151,530	3,731	462	74		
Percentage of total area of Alaska		12.48	18.33	0.94	8.81	25.83	0.64				

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

George C. Martin directed the work of the division of Alaskan mineral resources until May 4, when Alfred H. Brooks, having received his discharge from the Army, resumed his former duties. Much of Mr. Brooks's time between May 4 and his departure for Alaska in August was devoted to duties other than those relating to Alaska. Mr. Brooks, in company with Mr. John Hallowell, Assistant to the Secretary of the Interior, sailed from Seattle for Alaska on August 15, and devoted the following six weeks to a study of the region adjacent to the Government railroad, making also brief visits to the Matanuska coal field and the Fairbanks district. He returned from the interior by wagon road to Chitina and thence by railway to Cordova. During this part of the journey a side trip was made to the Kennecott-Bonanza mine.

Of the total of 88 days given to Alaska office work between May 4 and December 31, Mr. Brooks devoted 12 days to critical reading of manuscript, 9 to preparation of the annual press bulletin, 3 to field plans, and 18 days to geologic studies. The rest of the time was devoted to routine and administrative duties. Mr. Martin, in addition to doing a large amount of administrative work, spent much time in preparing this volume and in compiling and coordinating the mineral statistics. He also prepared a summary report on the Alaska oil fields and continued his studies on the Mesozoic geology of Alaska. His field work is referred to below.

Miss Lucy Graves, chief clerk of the division, has assisted the geologist in charge in various phases of administrative duties. She has charge of clerical work and the files and makes administrative examination of all accounts and vouchers. Much of the work of compiling the statistics of the mineral production of Alaska has been done by Mr. T. R. Burch.

GEOGRAPHIC SUMMARY.

SOUTHEASTERN ALASKA.

The investigation of the water resources of southeastern Alaska, begun in 1915 under a cooperative agreement with the Forest Service, was continued throughout 1919. G. H. Canfield, who had charge of this work, maintained automatic gages throughout the year. In addition to these gages, others were installed in cooperation with individuals and corporations. The results are briefly summarized in another part of this report. This work could not have been carried on without the cordial cooperation of the Forest Service, many members of which have given substantial aid. Particular acknowledgment should be made to C. H. Florey, forest supervisor at Ketchikan.

A reconnaissance of the geology and mineral deposits of parts of the Glacier Bay and Lynn Canal regions was made by J. B. Mertie, jr. Field work was begun on July 23 and continued until September 18. An area of about 200 square miles was mapped in reconnaissance. Mr. Mertie also visited the productive mines of the Juneau and Ketchikan districts.

COPPER RIVER REGION.

The completion of the report on the Kotsina-Kuskulana district, which was suspended by the assignment of Mr. Moffit to work for the War Department during the war, required the gathering of a small amount of additional field data in order to bring it up to date. Mr. Moffit spent September in this work.

COOK INLET AND SUSITNA REGIONS.

Because of the importance of the region tributary to the Government railroad and the growing demand for information concerning it, a special effort is being made to complete the mapping of that region. The surveys and investigations in the Cook Inlet and Susitna regions in 1919 included a topographic and geologic reconnaissance survey of areas between Talkeetna River and Broad Pass and in the upper Kantishna region, as well as detailed investigations at the coal mines in the Matanuska Valley.

A party in charge of S. R. Capps, assisted by S. H. Cathcart, made reconnaissance surveys on the scale of 1 : 180,000 of an area of about 300 square miles in the high mountains on the headwaters of the Kantishna and of the upper tributaries of the Susitna. T. P. Pendleton, attached to this party, made topographic surveys of the same area. The party began field work on the north side of the Alaska Range June 28 and finished August 27, crossing the Alaska Range and returning to the coast by way of Susitna River.

A topographic reconnaissance survey of an area adjacent to the Government railroad between Talkeetna River and Broad Pass was made by J. R. Eakin from June 22 to September 12. An area of about 600 square miles was mapped on a scale of 1 : 180,000. R. M. Overbeck completed geologic surveys of the same area.

YUKON REGION.

The placer mines of the Eagle and Circle districts were visited by G. C. Martin from August 16 to September 13 for the purpose of obtaining information concerning recent mining conditions and developments.

GOODNEWS BAY.

Topographic and geologic reconnaissance surveys of an area in the vicinity of Goodnews Bay and the lower Kuskokwim were made by a party in charge of R. H. Sargent. Mr. Sargent mapped topographically an area of 1,400 square miles on the scale of 1 : 180,000. G. L. Harrington, who accompanied Mr. Sargent's party, made a reconnaissance geologic map of an area of about 2,000 square miles. Field work began July 4 and ended August 17.

SEWARD PENINSULA.

After the end of his field work in the Kuskokwim region, G. L. Harrington made investigations of general mining developments in Seward Peninsula. He was engaged in this work till October.

ALASKA OFFICE.

The branch office of the Geological Survey at Anchorage, in charge of Theodore Chapin, was maintained throughout the year. The main purpose in opening this office is to provide the means of close cooperation between the Geological Survey and those in charge of the operation of the Government coal mines in the Matanuska Valley. It is also the purpose of the resident geologist to do everything possible to aid the mining industry in the region tributary to the Government railroad, to keep in close touch with all local developments in mining and prospecting, and to furnish whatever aid may be possible by giving information, advice, and publications to all who are engaged in mining and prospecting.

COLLECTION OF STATISTICS.

The collection of statistics of production of metals in Alaska, begun by the Alaska division in 1905, was continued as usual. Preliminary estimates of mineral production for the previous year were published on January 1.

PUBLICATIONS.

During 1919 the Survey published six bulletins and one professional paper relating to Alaska. In addition, two bulletins were in press and 13 reports, including this volume, were in preparation at the end of the year. Eight topographic maps were published, and nine were in preparation at the end of the year.

REPORTS ISSUED.

Professional Paper 109. The Canning River region, northern Alaska, by E. deK. Leffingwell.

Bulletin 668. The Nelchina-Susitna region, Alaska, by Theodore Chapin.

Bulletin 664. The Nenana coal field, Alaska, by G. C. Martin.

Bulletin 683. The Anvik-Andreafski region, Alaska, by G. L. Harrington.

Bulletin 687. The Katishna region, Alaska, by S. R. Capps.

Bulletin 692. Mineral resources of Alaska, 1917, by G. C. Martin and others.

Bulletin 699. The Porcupine district, Alaska, by H. M. Eakin.

REPORTS IN PRESS.

Bulletin 682. The marble resources of southeastern Alaska, by E. F. Burchard. (Published in November, 1920.)

Bulletin 712. Mineral resources of Alaska, 1918, by G. C. Martin and others. (Published in October, 1920.)

Bulletin 719. Preliminary report on petroleum in Alaska, by G. C. Martin.

REPORTS IN PREPARATION.

Chromite of Kenai Peninsula, Alaska, by A. C. Gill.

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

The Mesozoic stratigraphy of Alaska, by G. C. Martin.

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

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

The Ruby-Kuskokwim region, Alaska, by J. B. Mertie, jr., and G. L. Harrington.

The Cretaceous and Tertiary floras of Alaska, by Arthur Hollick.

The Juneau district, Alaska, by A. C. Spencer and H. M. Eakin.

The Ketchikan district, Alaska, by Theodore Chapin.

York tin deposits, Alaska, by Edward Steidtmann and S. H. Cathcart.

Geology and mineral resources of region tributary to Alaska Railroad, by S. R. Capps.

TOPOGRAPHIC MAPS ISSUED.

Canning River region, by E. deK. Leffingwell; scale, 1:250,000; sketch contours. (Plate I, Professional Paper 109.)

North Arctic coast, by E. deK. Leffingwell; scale, 1:500,000; no contours. (Plate III, Professional Paper 109.)

Coast line between Challenge Entrance and Thetis Island, by E. deK. Leffingwell; scale, 1:125,000; no fixed contour interval. (Plate IV, Professional Paper 109.)

Coast line between Martin Point and Challenge Entrance, by E. deK. Leffingwell; scale, 1:125,000; no fixed contour interval. (Plate V, Professional Paper 109.)

Nelchina-Susitna region, by J. W. Bagley; scale, 1:250,000; contour interval, 200 feet. (Plate I, Bulletin 668.)

Anvik-Andreafski region, by R. H. Sargent; scale, 1:150,000; contour interval, 100 feet. (Plate I, Bulletin 683.)

Marshall mining district, by R. H. Sargent; scale, 1:125,000; contour interval, 100 feet. (Plate II, Bulletin 683.)

Kantishna region, by C. E. Giffin; scale, 1:250,000; contour interval, 200 feet. (Plate I, Bulletin 687.)

TOPOGRAPHIC MAPS READY FOR ENGRAVING.

Kotsina-Kuskulana district, by D. C. Witherspoon; scale, 1:62,500; contour interval, 100 feet.

Lower Kuskokwim region, by A. G. Maddren; scale, 1:500,000; contour interval, 400 feet.

Ruby district, by C. E. Giffin and R. H. Sargent; scale, 1:250,000; contour interval, 200 feet.

TOPOGRAPHIC MAPS IN PREPARATION.

Innoko-Iditarod region, by R. H. Sargent and C. E. Giffin; scale, 1:250,000; contour interval, 200 feet.

Port Wells region, by J. W. Bagley; scale, 1:250,000; contour interval, 200 feet.

Jack Bay district, by J. W. Bagley; scale, 1:62,500; contour interval, 50 feet.

Fidalgo-Gravina district, by D. C. Witherspoon; scale, 1:250,000; contour interval 200 feet.

Susitna-Chulitna district, by D. C. Witherspoon; scale, 1:250,000; contour interval, 200 feet.

Seward-Fairbanks route; compiled; scale, 1:250,000; contour interval, 200 feet.