INVESTIGATIONS OF THE MINERAL DEPOSITS OF SEWARD PENINSULA.[a]

By Philip S. Smith.

INTRODUCTION.

It is intended in this paper to summarize the results of the geologic investigations which have been carried on in Seward Peninsula since the close of 1906. As an account of the earlier developments has been given in former progress reports,[b] a repetition of the facts there set forth is unnecessary and undesirable.

PRODUCTION.

In Seward Peninsula the past year has been marked by increased activity in prospecting for both placers and lodes, but so far no strikes of rich bonanzas such as characterized the winter of 1905–6 have been made. An estimate, compiled from various sources, of the amount of gold produced by the entire peninsula for the year 1907 shows the value of the output to be about $6,750,000. The production of gold in Seward Peninsula from 1897, the first year in which any notable amount of gold was won, down to the present time is shown in fig. 3. It will be noticed that in 1907 the production showed a decrease of about $750,000 over that of the preceding year. The high total in 1906 was due to the discovery and development of the phenomenally rich placers of the ancient beach about 3 miles north of Nome. Although extensions of this beach have been uncovered during the last year, nowhere else has the beach proved as

[a] In collecting data for many portions of this report the writer was assisted by G. I. Finlay and Frank J. Katz during the field season of 1907.

[b] Brooks, A. H., Placer mining in Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 19–24. Moffit, F. H., Gold mining in Seward Peninsula: Bull. No. 284, 1906, pp. 132–141; The Nome region: Bull. No. 314, 1907, pp. 126–144. Smith, P. S., Gold fields of Solomon and Niukluk River basins: Bull. No. 314, 1907, pp. 146–156; Geology and mineral resources of Iron Creek: Bull. No. 314, 1907, pp. 157–163. Brooks, A. H., The Kougarok region: Bull. No. 314, 1907, pp. 164–179.

rich as in the portion first discovered, between Snake and Nome rivers. But, as the mining of placers goes on with much rapidity, the explored ground on this portion of the beach has been more or less exhausted. As an instance of this may be cited the richest of all the third-beach mines, which early in the summer finished hoisting the last of its gravel. Just as the modern beach was soon exhausted, so this more ancient one has yielded up its treasure for nearly 3 or 4 miles of its length. With the exhaustion of the present beach new placer fields of even greater value were discovered, but no such good fortune has followed the yearly depletion of the store of gold in the ancient beach. It is the normal history of a placer camp to undergo great fluctuations in production, so that the falling off in 1907 does not, in all probability, mark the decline of the Seward Peninsula camps.

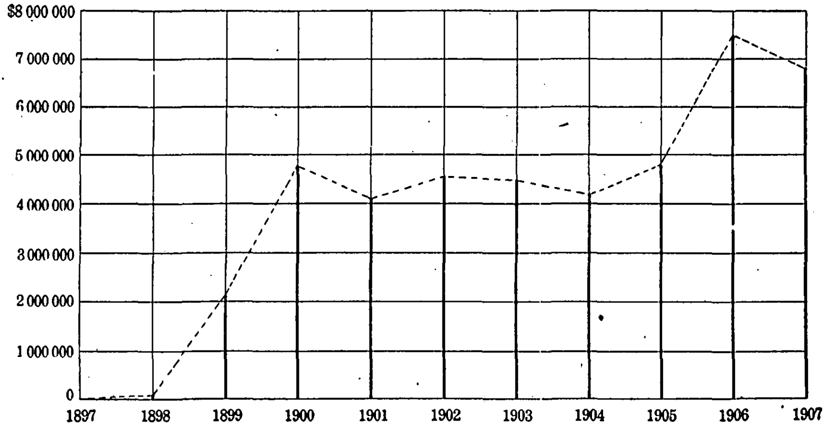


FIG. 3.—Gold production of Seward Peninsula, 1897–1907.

Although the decrease in gold is attributable mainly to the exhaustion of some of the rich bonanzas of the preceding year, there are several minor factors which may have also had some effect in reducing the output of the district. One of these minor causes was the labor trouble, which culminated in a strike during a portion of the winter of 1906–7. Previously it had been the custom to make winter wages one-half the summer rate, which is $5 a day and board. This scale was adopted because in the winter the country was oversupplied with labor. Such a condition is practically inevitable because in the winter all the shallow workings, which are active during the summer, of necessity are closed, only drift mines being operated. Thus the number of men who can be employed in the winter is only a small fraction of the number needed in summer. The surplus workmen must seek other regions, go prospecting on their own account, or accept the wages that are offered. The first two choices are not open to all, for they require a certain amount of capital and therefore many are compelled to accept the third. Under such conditions those needing labor can dictate the terms of employment.

During the winter of 1906–7, however, the men tried to force the adoption of a higher scale of wages, amounting to a raise of about 50 cents a day on the old winter rate, and, failing to have the demand recognized, quit work. This strike lasted in an acute stage for about a month. During this time the mine operators adopted one of two policies. The larger operators, anxious not to lose a day of valuable time from hoisting pay gravels, acceded to a raise in wages. Many of the smaller operators, who were either finishing up the last of their hoisting or whose lack of funds prevented their granting the higher scale, closed down. Personal communication with many of the smaller operators, however, led to the conclusion that the closing of their mines did not materially alter their production, but simply postponed their hoisting to a little later in the season and made them rush work a little more vigorously during the shorter time in which they had to operate. It is therefore the opinion of the writer that although the effect of the strike was depressing on the total production, the result was not so serious as many promoters would have the public believe.

Although it is conceded that the strike may have somewhat decreased the production of gold in 1907, it is believed that the effect may not have been entirely insalutary. This statement does not rest on the probable solution of the labor problem involved. The most beneficial result of the strike was that when several of the mines were closed and the laborers had to shift for themselves, many of the more energetic turned their attention to prospecting. Such prospecting must inevitably result in much good, for the future of Seward Peninsula depends not so much on the complete economical working out of the known deposits as on the systematic search for new fields and the extension of the known placer grounds.

Prospecting at the present time is much hampered in Seward Peninsula by the fact that nearly every available bit of ground has been staked. Even though the person desiring to locate knows that the annual assessment work has not been done, he is confident, from the bitter experience of many others, that successful location of pay gravel on the ground in question will inevitably lead to legal complications. For this reason prospecting by individuals is discouraged. The new law laying the burden of proof of assessment work on the holder if he does not record his work is variously viewed by different prospectors. There is, however, a feeling that a method of proving assessment work even more radical than by the word of witnesses is required to meet the best interests of prospectors.

CRITICISM OF POPULAR THEORIES.

Certain facts have been pointed out in previous reports which if heeded by prospectors would cause them to conduct their search with more promise of success than the hit-or-miss style so often adopted. Nevertheless there are numerous popular misconceptions which seem to have taken root in the minds of some inexperienced miners, and which are bound to have a retarding effect on the development of the district. The three most pronounced of these misconceptions are the theory that a second bed rock may be found below the first, the theory that the ledges are not wholly in place, and the theory that there is a uniformity of elevation of possible ancient beach lines in areas outside of the now partly explored Nome tundra.

ABSENCE OF MORE THAN ONE BED ROCK.

In regard to the first fallacy, it is necessary to understand clearly what is meant by the term bed rock. According to the loose usage prevalent among prospectors, bed rock is any layer of clay, sand, or other material on which gold is found. Such, however, is not the accepted scientific meaning of the term, by which bed rock is defined as the consolidated hard rock,[a] such, for instance, as the schist or limestone of Seward Peninsula. If used with this distinction it may be stated that there is no chance of finding a second bed rock below the first. It is evident, therefore, that drilling or exploration for placers beneath the hard schist bed rock is not advisable.

In making this statement the writer is well aware that certain peculiarities have been encountered which at first sight might suggest to the inexperienced that unconsolidated gravels do occur beneath the schist. One such peculiarity is afforded by the Golden Gate well at Nome, in which schist nearly 100 feet thick was encountered at a depth of 40 feet, and below it quicksand was struck. Various explanations have been suggested to account for this occurrence. Somewhat similar conditions were observed at the Daisy mine, near Nome. At this place a hole (A, fig. 4) was sunk 22 feet to what was supposed to be bed rock of schist, into which the hole penetrated for 8 feet. The hole was then abandoned and a new one started at B. In this hole pay was struck, and drifting on it traced the pay streak over in the direction of A. When the claim was carefully surveyed it was found that the drift from B was 67 feet below the bottom of hole A and directly under it. The explana-

[a] According to the Standard Dictionary, bed rock is "the solid rock underlying the looser material of the earth's surface."

tion of the section is suggested in fig. 4 by dotted lines. It is believed that the schist of hole A, which was thought to be bed rock, was merely a piece of slide and that the real bed rock was the schist encountered in hole B underlying the pay. The conclusion that the schist encountered in the first hole is not in place is unavoidable, for there is no known or conceivable process in nature which could produce a schist from gravels and not profoundly modify the underlying gravels as well. Schists are formed by one of two main processes, which may be summarized briefly as contact metamorphism and dynamic metamorphism. The first method of schist formation is due to contact with igneous rocks; but the blocks of schist found in the midst of gravels could not have been produced in this manner, for, as is well known to every miner, there are no igneous rocks cutting the gravels near the places where the schist blocks occur. In the production of schists by dynamic action the

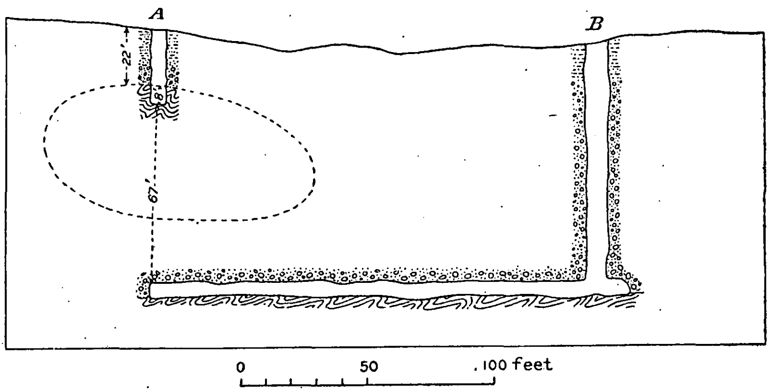


FIG. 4.—Diagrammatic cross section at the Daisy mine, near Nome.

mass of original material is moved and deformed. This process may take place deep under the surface as a result of the increased temperature produced by deep burial. But if such is the case the underlying gravels must have been subjected to just as much metamorphism as the layer which is supposed to have been changed into a schist. Another way in which schists may be formed by dynamic metamorphism is by the folding and deformation of rocks when subjected to mountain-building pressures. Such a process could not have affected this region after the underlying gravels were deposited, for the planes of original sedimentation, which are clearly visible in the gravels, have not been much disturbed.

It seems, therefore, that there is no reasonable way in which schist may be formed in the midst of a gravel deposit. It seems also evident that where the so-called " bed rock " is simply a stratum of clay or sand on which values may or may not be found, there is indisputably an underlying bed rock in place which may or may not have served as a surface on which placer gold has been concentrated. In this sense, therefore, pay horizons below the clay false bed rock, such as occur at the level of the old second beach, may be sought. There is absolutely no possibility of finding any gravel deposits beneath the bed rock, if this term is used in its technical sense, and exploration seeking to pierce this bed rock is inviting financial disaster.

LEDGES IN PLACE.

This brings us to the second popular fallacy already noted, that the ledges of the district are not in place. Without resorting to the verbal evasion possible, for the word ledge, according to all geologists, means "rock in place," it may be definitely stated that the rocks which outcrop here and there throughout the country are in place. Although the upper few feet of various outcrops are much riven by the frost, and although the normal downhill creep of material through gravitative action has caused a slight migration of material away from the actual outcrop, yet these processes have had so slight an effect on the region that their results are negligible.

The reason why the idea of the dislocated character of the ledges has taken root in the popular mind perhaps lies in the fact that apparently different kinds of rocks occur along the same line of strike. This condition is explained in two ways. In the first place, the most noticeable structure seen in the rocks—namely, cleavage—is not an original structure, but is secondary, and therefore does not indicate the true direction in which the rocks trend. It is consequently to be expected that on the strike of the cleavage different rocks should be encountered successively. The second explanation for the variety of rocks along the strike is that the region is very markedly deformed. This deformation consists both of folding and faulting. In papers now in preparation Moffit[a] describes some of the foldings observed in the Nome and Grand Central region, and the writer[b] notes instances of deformation in the Solomon and Casadepaga districts. In these papers it is shown that intense folding has taken place, coupled with faulting of both the normal and reversed types. The faulting seems to have occurred at two distinct periods, one probably coincident with the metamorphism of the district and another after the formation of the latest quartz veins. Because of these dislocations and crumplings of the crust the geology is very complex and the orderly sequence observed in less deformed regions is wanting.

It is impossible to evade the conclusion that the ledges are in reality in place. Although the geologic structure of Seward Peninsula is

[a] Moffit, F. H., Hess, F. L., and Smith, P. S., Geology of the Nome and Grand Central quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

[b] Smith, P. S., Geology of the Solomon and Casedepaga quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

much complicated by mountain-building deformation, there is nowhere in the district evidence that the blocks of this portion of the earth's crust have suffered any serious lateral movements since the beginning of the cycle of disintegration and decomposition which has resulted in the formation of the Seward Peninsula placers. Oscillations, it is true, have occurred and are occurring, but there has been no widespread landslide action since the recent gravels were accumulated. In fact, if the paleontologic evidence afforded by shells from the Nome tundra is accepted, there can be no reason for supposing any considerable movement to have taken place since Pliocene time.

In this connection it may be of importance to the prospectors for quartz to note that the region is considerably disturbed, so that in mining faults will be encountered which will add to the cost and difficulty of winning the ore. On the other hand, it is believed that the same kinds of rocks may be found in place beneath the cover of moss, slide, and vegetation as those from which the placer gold was derived. The discussion of quartz prospects and of the occurrence of veins from an economic standpoint, however, is given farther on in this paper.

ELEVATION OF ANCIENT BEACHES.

The third erroneous idea which has crept into popular fancy has reference to the places where prospecting for beach deposits may be carried on and especially to the elevation of these ancient beaches above sea level. The misconception has resulted from the fact that the known rich beach back of Nome has maintained a pretty constant elevation for a distance of 5 miles. It is therefore argued by many that the beach at Solomon or somewhere else ought to be sought for at this same elevation. Such a conclusion seems unjustifiable when the various incidents in the history of the beaches are considered. It is difficult to conceive how any process of uplift could have been absolutely uniform over any considerable distance, for the mechanical difficulties of lifting evenly a structure consisting of diverse units of different sizes and weights and balance would be practically insurmountable. Instead of supposing that every portion of the old beach must now be at precisely the same height above sea level, therefore, it is far more reasonable to imagine that only a few points would be at any given elevation and that the majority would be higher or lower. To pass to concrete examples of the present day, one has only to note the elevation shown at Cape York and Nome and the depressed character of the country near Port Clarence to see that all parts of the peninsula have not been affected in the same way at the same time.

To summarize, it is believed that when the third beach was formed at Nome there was a continuous beach around Seward Peninsula just as there is today; that in the intricate history which has taken place since the third beach at Nome was formed some portions of the peninsula have been uplifted higher than others; and, furthermore, that certain portions of the beach have been cut away entirely during the subsequent depression of the region, or that certain portions were preserved beneath the sea where the depression was rapid enough. In view of these facts, it is felt that only by the closest scrutiny of the surface features and of all the available physiographic evidence can the level of the third beach be predicted within reasonable limits.

Prospectors are fast learning that the mere presence of beach material is not sufficient ground for expecting pay, and that there are two essential conditions for forming rich beach deposits. These are (1) a large amount of land waste which has been sorted by wave and water action, so that concentration and reconcentration have been effective, and (2) proximity to mineralized areas from which the valuable metals of the placer may have been derived.

PLACER DEPOSITS.

INTRODUCTION.

The general tendency at the present time in placer work is to reduce the cost of operations by installing mechanical devices for handling the gravels. The miners of the Candle, Council, Kougarok, Nome, Solomon, and Bluff regions have taken advantage of the water resources to such an extent that but little additional water can be obtained, except at a prohibitive price. The conversion of water power into electric power is one of the possibilities of the future. Already on Solomon River a short ditch is in process of construction to furnish water power for generating electricity to run two dredges. A project for damming Salmon Lake and utilizing the head thus formed for the generation of electricity has been discussed for two years or more, but owing to legal complications nothing has been done on the actual construction.

NOME AND GRAND CENTRAL REGIONS.

BEACHES.

As a result of extensive prospecting, it has been found that there is considerable beach wash north of Cape Nome; but it has also been shown that pay gravels are practically wanting. If this is a fact, and there is every reason to believe that it is, the beaches of the more recent past must have looped from the seaward face of the cape; and probably the headland of Cape Nome was a portion of the mainland, at the time of the formation of the third beach, rather than an island. During the last year several paying properties have been located in the neighborhood of Cunningham Creek, and as the height of the pay above sea level is approximately that of the well-known third beach farther west, they are supposed to mark the eastern continuation of that beach. If this is the case, the beach makes a marked swing to the southeast from the point where it reaches the surface on McDonald Creek. This extension of the beach, although rich, is not nearly as rich as the portion earlier discovered between Nome and Snake rivers. Perhaps one reason for this decrease in gold content is that much of the waste of which the beach is formed is derived from the granitic mass of Cape Nome. It has previously been stated that in the Nome-Snake river portion the waste has been derived largely from a region contiguous to a limestone-schist contact. Such is not the case to the east. This relation may be only fortuitous, but it gives a suggestion which may be worth consideration.

The thickness of the overburden along the beach east of Nome River is variable, but is generally in the neighborhood of 100 to 120 feet. This requires a considerable plant, but the difficulties in the way of transportation are not very great. The gold from this portion of the beach seems to be of the same character and appearance as that obtained farther west. In some places it occurs on a false bed rock. The gravels are coarser than those from the third beach between Holyoke and Bourbon creeks, as would be expected if a large part of the waste had been derived from the Cape Nome headland. The larger amount of garnets in the gravels is due to the derivation of the material from the granites and from the large bodies of greenstone which predominate in the Osborn and St. Michael creek country. This beach is probably cut out by the valley of Hastings Creek and the rich placers of the lower portion of this stream may be due to partial reconcentration from the former beach.

West of Snake River the third beach is believed to have been located in the vicinity of Sunset Creek, and considerable gold has been won from this place during the last year. No new features were brought out in this locality beyond the continuation of the old beach to a region in which its presence has been for some time suspected. The western continuation shows that the beach must have extended at one time across Snake River and was subsequently cut through by that stream as it wore down its valley. The gold in this portion of the beach was scattered to some extent by the stream, as it re-sorted the older beach gravels. The rich spots, however, in the lower portion of Snake River, doubtless acquired their original concentration at the time when the Snake River valley was filled with gravels on which the sea was working.

There are some who believe that another beach has been located inland from the third beach, but it has not been possible for the

Survey party to go into the question in sufficient detail to make a statement. It is known, however, that beach material is found at a higher elevation than that of the third beach, so that it is not at all improbable that the sea has stood at a relatively higher level at a time geologically not very remote. This is demonstrated by the fact that marine gravels cover the pay gravels of the third beach.

Work on the third beach has gone on with as much vigor as formerly. Probably half of the entire production from the Nome district comes from this beach. A railroad runs nearly the entire length of the beach, from Sunset Creek to McDonald Creek, so that supplies may be easily transported. A few new pieces of ground have been opened up, but in the main it is evident that the earlier-discovered portion of the beach is nearing exhaustion.

On the second beach but little work has been done during the last year. Between the second and third beaches, however, another beach has been discovered, and this is locally known as the "intermediate" beach. Several large hoisting plants have been erected to handle the gravel. A peculiar thing about this beach, if statements made by presumably reliable men may be trusted, is that it occurs at an elevation of 22 feet above the sea. Such a height would make it lower than the second beach, which lies seaward of it. It would indicate, therefore, a depression of the land subsequent to the formation of the intermediate beach, whereby new deposits were laid down. A rapid uplift must then have occurred, so that the sea took a stand seaward of the second beach, and renewed its attack on the coast.

It was reported that in one of the mines on the intermediate beach a bar had been found which showed the layers of sand and gravel dipping off in both directions—toward and away from the sea. Although this property was examined with considerable care, no evidence to substantiate the report was observed. The facts indicated changeable conditions, but nothing which could be rightfully interpreted as an offshore bar. At this place the bed rock consists of black, graphitic, somewhat quartzitic schist breaking into small rectangular blocks. The pay gravel is made up of but poorly rounded black schist fragments mixed with a good deal of mud. The gravels are very dirty. Above, in the south end of the drift, there is a sand layer which rises very steeply toward the north. In the north end there is a thin layer of muck between the pay gravels and an overlying bed made up of large bowlders. The bowlders are well rounded and some of them are 2 feet in length.

The presence of layers of muck and vegetation in the midst of gravel and slide has been noted in many other places. Thus on the bench west of the middle portion of Dry Creek a drill hole showed the following section:

Section of drill hole west of Dry Creek.

	Feet.
Tundra vegetation and muck	4–5
Subangular fragmental material	30
Tundra vegetation and peat	4
Subangular fragmental material	50
Gravels and creek wash.	

The same thing is also seen on Otter Creek south of the rise in the bed rock.

On the intermediate beach near Center Creek a number of shells have been found. Some are intact, but many of them have been broken into small bits. From their resemblance to certain living forms, it has been suggested by Dall that they lived in water not colder than that on the southern side of the Aleutian Islands at the present day. This gives an interesting insight into the temperature conditions which prevailed while a portion of the coastal-plain gravels of this part of the Nome region were being formed, and serves as a valuable check on the imaginings of those who account for the gold of the tundra as the product of glaciation.

STREAM AND BENCH PLACERS.

The placers that occur in portions of the district outside the coastal-plain province have produced during the last year probably less than one-third of the gold that has been won from the Nome and Grand Central regions. Although forming such minor contributors, these placers, which do not owe their gold concentration to marine action, have yielded during 1907 considerably over a million dollars. The output from this source is obtained from a great number of streams, but the greater proportion comes from Dexter Hill and its environs. During the last year much gold has been recovered from Glacier Creek and its tributaries, from Anvil Creek, especially in its headwater portions, from the upper portions of Dexter Creek and its tributaries, and from the upper branches of Dry Creek.

A region which has sprung into some prominence during the last year, although it has been a producer for a long time, is the Buster Creek country. The completion of a ditch into Buster Creek has given water power under a sufficient head to permit profitable handling of the gravels. During the season of 1907 four outfits have been at work on this creek.

COUNCIL DISTRICT.

The Council district is second only to the Nome-Grand Central region in its gold production. Ophir Creek is the principal center of mining, and on the main stream thirteen different outfits have been at work during the past season. The methods used on the creek are varied. Four properties are being worked by means of hydraulic elevators; two by dredges; two by scrapers, one using both horse and steam scrapers and the other only horse scrapers; one by a steam shovel; one by a derrick and cars; and three by shoveling into boxes.

On the lower portion of Dutch Creek, a tributary of Ophir Creek, one group of claims is being worked by hand labor. None of the tributaries of Ophir Creek above Dutch Creek as far as Crooked Creek are being developed. On Crooked Creek, however, three outfits have been at work during the last season. The gravels are shoveled by hand into the boxes. On Albion Gulch, a tributary of Crooked Creek, two mining camps have been established. One of these is particularly interesting as it is the only hillside placer so far reported in Seward Peninsula. At this place there is a good head of water and the deposit is worked by hydraulicking. The other property is developed by ordinary hand methods.

Near the mouth of Melsing Creek a new steam scraping plant has been recently installed. At least a month was spent in getting the equipment into running order, so that an important part of the season was lost. It is hoped that another year will see the plant operating full time and yielding satisfactory returns. Between the scraper and the mouth of Basin Creek two outfits have been shoveling into boxes. Three or four men have been employed at each place, but no extensive work has been accomplished. At the mouth of Basin Creek a claim is being worked by horse scrapers. The pay gravels are practically at the level of the creek, so there is some trouble in handling the seepage water. Above Basin Creek no prospecting or mining has been done on Melsing Creek or any of its tributaries.

On the tributaries of the Niukluk below Council only a little desultory work has been done during 1907. Above Council two claims have been worked on the central portion of Warm Creek, the gold being won in both by shoveling into sluice boxes. Near Camp Creek some hydraulicking has been done, but the returns from the property are not available. At the mouth of Elkhorn Creek some work was in progress during the earlier part of the season, but later the party removed to Ophir Creek.

The most interesting exploration work that has been done in the vicinity of Council was the testing of the Niukluk flat gravels by drill holes. Near Council there are numerous exposures of bed rock along the river, and in many places ledges came so near the surface that it was originally believed that the gravels which formed the broad flats southwest of the river were only a thin veneer. During the last summer, however, explorations carried on between Fox and Bear creeks, 2 or 3 miles from the Niukluk have shown gravels 250 feet thick in places. Such a depth would carry the bottom of the hole 50 or 60 feet below sea level. It is not believed that this low area was formed by marine erosion, as the narrowness of the cut in bed rock suggests stream work rather than ocean work. As has been pointed out, bed rock outcrops above the level of the Niukluk at Council and also above the level of Fox River at the point where the road from Council to East Fork approaches that stream; yet between these two points the bed rock is at least 200 feet lower.

Local downwarp seems inadequate to explain this feature, for it would be expected that some indications of the depression would appear in the surface forms, if warping took place after the overlying gravels had been deposited. Such surface indications are wanting. It seems more probable, from the slight evidence at our command, that the region is a stream valley and that the low areas revealed by drilling probably mark an old channel. Subsequent to the formation of the channel depression took place, whereby filling of the more ancient valley was effected. At the close of this stage the land probably stood at a lower elevation than it does at present and the surface of the flat, southwest of Council, was the flood plain of the old Niukluk River. A later episode, marked by the physiography of the region, was a slight uplift whereby the rivers were allowed to incise their courses 20 to 40 feet below the old flood plain. The duration of the different stages is of importance, for if the channel which has been disclosed by the drill hole was made in a short time the distribution of the gold and the width of the profitable ground would be different from those features produced in a region which had been stable for a long time. The facts known are still too meager to permit final interpretation, but the occurrence of bed rock so near the surface in certain places in the flat suggests a canyon character for the old valley rather than a more mature form.

Further light on this question is afforded by the record of a shaft 102 feet deep which was sunk near Mystery Creek about halfway between its junction with the Niukluk and the point where it leaves the hills. A short distance above this shaft bed rock is practically at the surface in the creek, being covered only by a thin mantle of gravels, not more than 4 feet deep. The gravels cut by the shaft were but slightly waterworn, and yet small shells in a perfect state of preservation were found. Unfortunately the shells were not kept and it is not known whether they were fresh-water or marine forms.

It is evident that from the very fragmentary facts now known about this region it is unsafe and unwarranted to draw far-reaching conclusions, yet a setting forth of the known conditions and surmises may be of assistance in solving some of the problems. Residents in the district, knowing the fabulous riches of the beaches at Nome, are anxious to prove marine occupation of the Niukluk flats. The whole question, however, is one which depends not on salt water or fresh water, but on the work accomplished. No matter what the water was that occupied the area—river, estuary, lake, or bay—if no concentration of the gravels occurred, no gold placers could be formed.

From the topography of the country surrounding the flats it has seemed that the possible connection with the ocean would be so narrow that water sorting would be reduced to a minimum. To consider a concrete example, let us take the shaft near Mystery Creek. This shaft must have reached within 25 or 50 feet of sea level; in other words, if the popular idea that the flats near Council were occupied by the sea is correct, the region could not have been depressed more than 25 or 50 feet below its present position. Suppose all the unconsolidated superficial material which now forms the flats of the Niukluk Basin were removed and the region sunk 50 feet; it must be evident that the connection of this basin with the ocean south of Steamboat Creek would be so narrow that the conditions would be similar to those at Imuruk Basin. Anyone familiar with that basin knows that although it is an arm of the sea and its water is salt, no considerable beach concentration is taking place.

SOLOMON AND CASADEPAGA REGIONS.

BEACHES.

Prospectors aware of the similarity between the coastal plains at Nome and Solomon have begun to turn their attention to the latter district, and already scores of holes have been sunk to explore the tundra gravels. Up to the close of the summer of 1907, although beach material was encountered in many places, no pay had been located. The facts gleaned from the Nome tundra have been so driven into the minds of prospectors that they are inclined to give too wide application to the details. As has been mentioned in a previous paragraph, the hope of finding pay beaches at the same elevation throughout Seward Peninsula is fallacious.

The greatest amount of exploration has been carried on west of Spruce Creek, and during the last year over a dozen parties have been engaged in the search. A few sections may be of interest as showing the different kinds of material encountered in shafts 2 miles inland from the shore, just west of Spruce Creek. Of these shafts the second is 100 yards south of the first, the third 100 yards south of the second, and the fourth 75 yards southeast of the third.

Sections of shafts west of Spruce Creek.

1.

	Depth.	Thickness.
	Feet.	*Feet.*
Blue clay with large amount of ice	15	15
Slide rock consisting mainly of chlorite schist	30	15
Clean river sands, becoming coarser toward bottom	48	18
Yellow and red gravels	50	2
Fine dark sand	54	4
Black clay with some slide	58	4
Fine light-colored sand	62	4
Black peaty material containing some fragments of wood which look like spruce	64	2
Fine sand and black mud	67	3
Black clay containing well-rounded pebbles 1 inch in diameter	70	3
Fine iron-stained beach sand with schist and black quartz pebbles	73	3
Bed rock; black schist.		

2.

Blue clay with much ice	8	8
Reddish, fairly rounded gravels like the material between 30 and 48 feet, hole 1	20	12
Alternate layers of black mud and beach sand, not very gritty	40	20
Light-colored yellowish sand	41½	1½
Decomposed peaty material with some wood fragments	42	½
Black sand, mud, and quartz pebbles	50	8
Schist bed rock.		

3.

Blue clay with much ice	8	8
Slide with some water-made pebbles	20	12
Black, dirty, fine-grained sand	26	6
Clay with some reddish-yellow gravels	29	3
Light-colored beach sand	32	3
Black peaty material with some quartz pebbles	35	3
Gravels of black angular schist with some well-rounded quartz pebbles	43	8
Bed rock; black schist.		

4.

Blue clay with much ice	8	8
Black, somewhat angular fragments with some well-rounded pebbles	23½	15½
Yellowish sand with very fine small pebbles; looks like sea sand	27½	4
Decomposed peaty material with strong, offensive odor	30½	3
Black, dirty wash with some very well rounded beach pebbles. One of the pebbles was 8 inches in longest dimension	38½	8
Bed rock; black schist with some limy layers.		

The most interesting features brought out by a study of the foregoing sections are the thickness of the gravels and the presence of certain comparable beds. There is a marked seaward thinning of the deposits; thus in the first section the depth to bed rock is 73 feet, whereas in the last it is only 38½ feet. Not only is this true of the section as a whole, but also of some of the individual layers; for example, the blue clay and ice, which is 15 feet thick in the first section, is only 8 feet thick in the last. Certain members, however, show no constant variation in thickness.

One of the most marked beds, which seems to be rather constant throughout the area explored by the four shafts, is the layer of black peaty material. This bed occurs pretty constantly at an elevation of

10 feet above bed rock, and although there is some variation in thickness, the average is between 2 and 3 feet. It is uncertain what origin is to be assigned to this layer of vegetation. It may represent a land surface which has been submerged or it may be the accumulation of mud and marsh vegetation in a salt-water lagoon. The presence of spruce fragments is not conclusive, for logs may have been washed into ancient lagoons just as they are into those of the present day, or, on the other hand, the spruce may have grown on land near the point where the fragments are found. A careful study of the vegetable remains might shed much light on this point. Although no definite conclusion has been reached, it is tentatively suggested that the theory of tidal-marsh origin has many points in its favor.

CREEK AND BENCH PLACERS.

The Solomon and Casadepaga region produced a small percentage of the total placer output of Seward Peninsula for 1907. The greater part has been taken from Solomon River and its tributaries, only a small portion coming from the Casadepaga drainage. At the dredge near Oro Fino work has gone on even more actively than formerly, and even when almost all other work in the district had ceased owing to the cold, it was able to continue production. The lengthening of the season by even a day or two means a considerable increase in profit. The main new development at the dredge was a project for the generation of electricity by water power. This project was commenced only in the latter part of the season, but it is hoped that another year will see the entire plant run by electricity. The owners report that during the last year a large amount of a heavy iron mineral has been caught in the boxes which adds considerably to the work of cleaning up. This material on examination proved to be magnetic iron oxide, or magnetite. Much of it is in pieces an inch or so in length. No locality from which magnetite of such size could be derived is known in the area drained by Solomon River. The theoretical consideration of these fragments might have important practical value in giving an insight into the way in which the gravels were accumulated.

On Shovel Creek much work has been in progress during the season of 1907 as far as the mouth of Mystery Creek. In this area some technical problems have received a novel treatment, but no important scientific facts have been gleaned. Four or five parties have been at work on Mystery Creek below Problem Gulch. A new ditch line from Bonanza and California creeks which is nearing completion will soon reach this area, so that a more abundant water supply at a considerable elevation will be available. Above Mystery Creek no mining has been done on the main stream. On West Creek seven or eight parties have been mining the creek and low bench gravels. The most productive work, however, has been near the mouth of the creek. At this place a bucket dredge running on a track has been working double shift a large part of the summer. The section of the gravels shows a thickness of about 6 feet. The upper portion is rather fine creek wash consisting mainly of schist fragments. The lower part is as a rule coarser, and though many of the fragments are well rounded by water, numerous large, angular blocks 2 or 3 feet long are encountered. On Kasson Creek a continuation of earlier work has been in progress near the mouth of the stream. The limestone bed rock of this portion of the stream is much fissured, and this condition, added to the entire disappearance of the water, makes the winning of the gold a difficult problem.

Above Shovel Creek on Solomon River two outfits have been at work near the mouth of Penny Creek, but on Penny Creek itself little work has been done except at the junction with Minnesota Creek. One prospector has been located on the very summit of the saddle between Minnesota and Kasson creeks. Above Penny Creek the next group of mining operations have been on the Solomon River benches near the mouth of Quartz Creek. Between this place and Big Hurrah Creek some mining was in progress during the middle of the season, but work here began late and closed early. On Big Hurrah Creek mining was carried on most actively near the mouth, but work extended all the way up to Tributary Creek. Above that point, however, no productive work was accomplished. The elevators at the mouth of this creek did not commence work until late in July, and owing to the short season the production was relatively small.

Between Big Hurrah Creek and East Fork a little work has been done on some of the small side streams from the east and also just below East Fork. On East Fork and its tributaries no mining has been done during the last year. Above East Fork, near the mouth of Jones Creek, an elevator has been in successful operation. Near Winnebago Creek horse scrapers have been in use. On Butte Creek there has been a little mining, especially on South Fork. At this place the geology is very complex. A heavy white limestone which forms the divide between Winnebago Creek and South Fork is folded down so that for a considerable distance above the productive ground the stream runs practically on the contact between it and the underlying chloritic schist. Some quartz has been observed apparently filling nearly vertical gash veins near the contact, but these veins show no evidence of metallic mineralization.

Near the mouths of Johns and Coal creeks on the Solomon River flood plain some mining has been carried on recently, but on a small scale. On Coal Creek and its tributaries no mining has been done except on Fox Creek. Here, however, only one man has been at work, so the returns were small. The pay gravels were located upstream from the limestone which occupies the middle part of the creek's course. Between Coal Creek and the head of Solomon River work during the last year has been mainly of the assessment type, and the production is consequently negligible.

In the Casadepaga drainage area but little real mining work has been done recently. A mile or so above the mouth of Bonanza Creek, on the main river, one man has been mining gravels a few feet above the water. Most of the gold is coarse, but the returns are not adequate. On Dawson Creek, near the mouth, are some bench gravels which have been mined off and on during the summer. On Big Four Creek, about three-fourths of a mile above its mouth, one man has been doing a little work on the stream gravels. Difficulty has been experienced at this place on account of the depth of the gravels and the impossibility of taking care of the seepage water. No other work has been done on Big Four Creek, although in previous years several outfits have been located on the main stream and its tributaries. The region would appear favorable for further prospecting, as the complex deformation and dislocation that the rocks have undergone would undoubtedly allow easy passage for mineralizing solutions. Also, if there is truth in the idea that the contact between the heavy limestones and the schists is a zone of mineralization, there are, particularly in the Birch Creek country, many places where this contact can be followed for long distances. Not only does heavy limestone appear here, but also the continuation of the black, graphitic, quartzitic slate belt which has been described as present in the vicinity of the Big Hurrah mine.

Between Big Four and Penelope creeks three or four small outfits have been mining some of the low bench gravels of the main stream, but the production from this source is small. On Penelope Creek some active work has been in progress and the season has been satisfactory. Mining on this stream has centered on a group of claims about a mile above the mouth. At this place, to the west of the stream, a shaft has been sunk for 93 feet through creek wash and gravels. The low channel thus disclosed would seem to mark the deeper valley of Penelope Creek, which conformed with the previous deeper valley of the Casadepaga. The bed rock of this creek is almost exclusively schist.

Nearly opposite Penelope Creek Goose Creek joins the Casadepaga. An interesting experiment in the utilization of water power for scrapers is in progress on claims near the lower part of this creek. As this system undoubtedly furnishes power at a low cost its introduction may follow in other districts. The gradient of the stream is, however, so low that the tailings must be rehandled. The gold is mostly fine and much worn. At present the creek gravels only are being worked, but some of the lower benches which have been examined yield fair prospects. Work is going on at but one other camp on Goose Creek, located 4 or 5 miles above the mouth of the stream. Only a small crew has been employed. On Quartz Creek, the largest tributary of Goose Creek, a party has been at work about half a mile above the mouth. Here the bed rock is schist, but upstream a belt of limestone, rather flat lying, occupies the creek bed for nearly half a mile. Much of the gold is rather coarse, some pieces worth from $5 to $8 being found. The depth to bed rock changes rather abruptly; in some places it is only 3 feet below the surface, but in others it is 10 feet. At the place where bed rock lies nearest to the surface, no gravels intervene between it and the muck and vegetation, but where the bed rock is deeper there is a considerable body of gravel. It is stated, however, that the gold values are just as good on the higher bed rock as on the deeper. The gold has penetrated far into bed rock along the crannies and fissures, so that in many places it is necessary to take up 2 feet of the rock in order to win the pay. Some work has also been done on the first tributary of Quartz Creek from the east. The course of this creek has been largely determined by the contact between a heavy limestone and chloritic schist. There are many limestone caverns here which make the economical washing of the gravels a serious problem. The gold from the side stream is coarse and fairly sharp, and fragments of quartz are attached to many of the nuggets.

The next upstream tributary of the Casadepaga on which mining work has been done is Canyon Creek. The present stream flows in a comparatively recent valley incised 10 feet or so in older creek gravels. Practically no values are carried by the modern gravels. The best pay occurs in the benches, especially those north of the stream. These gravels are rusty and overlain directly by the muck and vegetation of the tundra. The bench gravels seem to be more thoroughly rounded than those of the present creek. The gold is bright and not much worn and on the whole medium coarse. The bulk of the gold is in flat pieces, from a fraction of a cent up to 50 cents in value. Nuggets worth up to $2 have been found, but they are rather uncommon. Some of the large pieces show quartz attached to the gold. The bed rock throughout the productive portion of the creek is almost exclusively chloritic schist. In the schist are numerous quartz veins, which probably belong to the earlier series. Work on the group of claims has been carried on by pick and shovel methods, but late in the season a hydraulic elevator was installed, and it is hoped that another season will record large returns from these properties.

On Banner Creek, a tributary of the Casadepaga from the east above Canyon Creek, some mining has been in progress about a mile above its mouth. This portion of the stream flows over the contact between a limestone and a schist. The placer is a creek placer. Only two men have been employed and they have worked but a portion of the season. On Lower Willow Creek several camps have been established, but not much production is to be credited to this creek. Besides two or three creek claims 3 to 4 miles above the mouth some work has also been done on the benches, which are most notably developed north of the stream. No work has been done on the upper portion of Lower Willow Creek.

At the junction of Ruby Creek and the Casadepaga a party of four have been hydraulicking the gravels with water brought by a ditch from the upper part of Ruby Creek. The gold at this place is almost entirely bright gold. This is the usual character of the Casadepaga gold because of the revival of dissection by uplift. The uplift has, as a rule, affected the smaller side streams less, and consequently much of the gold they carry is rusty. This is believed to be the real reason for the difference between the Ruby Creek and Casadepaga gold, instead of the one suggested by many prospectors, that they are two different "runs." Although remnants of previous mining may be noted throughout the length of Ruby Creek, the gold output for the last season has been derived entirely from the lower two claims. No mining has been done on the Casadepaga above Ruby Creek during 1907. A party, it is true, has been engaged in prospecting the higher benches on the northern slope of the valley, opposite Monument Creek, but the work was simply that of testing the ground.

Development in the entire Casadepaga region has been much hampered by the lack of adequate transportation facilities. It was believed that with the completion of the railroad to Penelope Creek in 1906 this difficulty would be removed. The season of 1907, however, has shown that such is not the case. Until late in the summer no trains were run across the Ruby divide, and then they were run only once or twice a week. Early in September train service beyond East Fork on Solomon River was discontinued. Even in this short season the charges ($50 a ton for freight and $5 apiece for passengers) for the 30-mile run to Penelope were so high and the protection given goods in transit and while waiting delivery was so inadequate that few miners could make use of the railroad. During the last year no additional track has been laid.

OTHER PORTIONS OF SEWARD PENINSULA.

It has been noted that no geologists of the Survey visited the Kotzebue Sound, Bluff, Kougarok, or Port Clarence districts during the last season. For this reason the report on these districts is wanting in details.

KOTZEBUE SOUND.

During the year 1906–7 about 9 per cent of the production of Seward Peninsula came from the region around Kotzebue Sound, known as the Fairhaven precinct. In this area there are three mining centers—one in the vicinity of Candle, one in the basins of the streams having their mouths near Deering, and the third on Bear Creek. Two large ditches and one smaller one have been completed this year, one for each of the mining centers, so that the problem of water supply has been more or less satisfactorily solved. An account of these and several smaller ditches may be found in a paper by F. F. Henshaw elsewhere in this volume.

At Candle there has been a continuation of the work of previous seasons, and prospecting has been carried on more extensively on some of the bench deposits. The gravels on the benches vary much in thickness and in elevation above the present stream. Some of the benches on which pay is reported are said to be about 50 feet above the river and to carry gravels from 15 to 30 feet thick. The opening up of these deeper gravels will undoubtedly have a beneficial effect on the district, for it will permit winter work. At the present time only a few men can be given permanent employment. The opening of the Candle ditch will also help the country, for in the past the lack of a water supply under sufficient head has been a serious detriment.

In the Inmachuk basin there has been a decided increase in the amount of winter mining. Where the summer season is as short as it is in the Kotzebue Sound region, it is of great importance for the miners to be able to work during the winter. In shallow creek diggings such work is impossible; but in many places the gravels are from 20 to 40 feet thick and lend themselves to advantageous development during the winter. No new mining developments, with the exception of ditch building, have occurred in the Inmachuk basin within the last year.

Bear Creek, the third mining center in the Kotzebue Sound region, is east of the range between Kiwalik and Buckland rivers. Bear Creek itself is a tributary to the West Fork of the Buckland. It lies about 40 miles from Candle. The productive ground is confined to a few claims and only a small force of men has been employed in the district. The production for this year has been rather small, because much of the season has been spent in ditch building. It is believed, however, that in another year the production of Seward Peninsula will receive an appreciable increase from this district. The isolation of this camp, however, makes the cost of supplies so high that it will not be able, for some time, to compete with more favorably situated fields.

BLUFF.

Considerable excitement has been awakened during the last year by the finding of an ancient beach deposit below sea level near Bluff. This strike has been looked on as a most unusual and inexplicable occurrence, not so much on account of the finding of pay, but because the deposit occurs below sea level. To one who has studied the Nome beaches, such a fact ought not to be surprising. The beaches already known bear witness to the oscillations that the region has undergone. Moreover, drill records which have been made at the mouth of Snake River show bed rock in places several scores of feet below the present sea level, with beach material above. The deep gravel-filled valleys of Nome and Snake rivers also show that the land once stood relatively higher with respect to the sea than it does at present. If such things are known to have taken place in the past in the Nome region, there is no reason why they should not also have occurred in other places.

To return to the Bluff region, there are certain facts that should be borne in mind by prospectors. The fact that, at Bluff, a certain beach occurs below sea level is by no means proof that it connects with a beach below sea level somewhere else. This point has been emphasized in other portions of this report (see pp. 212–213), but it is of such importance that it should be reiterated. At the present time there is no conclusive reason for connecting the newly discovered beach at Bluff with any of the beaches at Nome. Careful and systematic tracing by studying surface forms and by unraveling the details of the past history of Seward Peninsula is the only way in which the various beaches can be projected and correlated one with another.

The result of the uncovering of this new beach has been a notable increase in the production during the last year, so that probably almost as much gold has been taken from this small area as from the whole Fairhaven district.

Although more or less worn, the gold seems to be mainly of local origin. In this connection the presence of mineralized zones, as has been pointed out on page 239, is of importance.

KOUGAROK REGION.

The Kougarok was visited and described by Brooks[a] in 1906, and but few additional notes are available. Mining during the last year has been on practically the same scale as formerly. The completion of the Seward Peninsula Railway from Nome to Lanes Landing or

[a] Brooks, A. H., The Kougarok region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 164–181.

Shelton, in the late fall of 1906, has been of much benefit to the district, for it has provided quick and relatively low-priced transportation to a district which was practically inaccessible except by small boats in summer or by sleds during the winter.

Mr. F. F. Henshaw, who spent considerable time during the last year in the Kougarok district, has kindly furnished notes on the mining operations.[a] On Coffee Creek five or six men have been employed. On Dahl Creek some work was done before July 10 and after August 20, but probably not more than ten men have been mining during the season. The next productive stream is Windy Creek, where four men have been ground sluicing. Still farther upstream, in the vicinity of Left Fork, a small tributary of the Kougarok, three men have been doing a little prospecting. On North Fork there has been no productive work except below the mouth of Eureka Creek, where two men have been shoveling into boxes and ground sluicing. Still farther upstream three men have been at work on a bench of Kougarok River just below Arizona Creek. Practically only prospecting work has been done on Henry Creek during the last year, two men being employed. Just below Henry Creek, at the mouth of a small tributary from the east, two men have been mining. On Taylor Creek an outfit of two men has been shoveling into boxes at the mouth of Solomon Creek, about 6 miles east of the junction of Taylor Creek and the Kougarok. Two men have been mining on Macklin Creek. On the main river two outfits of four and six men each have been mining creek gravels near the mouth of Macklin Creek. Four others at the same locality have been shoveling in bench gravels that occur at a small elevation above the river. Probably six or seven men have been prospecting or washing gravels on a small scale above the mouth of Macklin Creek. In this portion of the river only two of the side streams have yielded pay. These tributaries are both small. On the lower, Trinity Creek, which enters 2 miles above Macklin Creek, two men have been working the creek gravels. On Mascot Gulch, which is about 2 miles above Trinity Creek, a party of two men has been working whenever water was available.

Although lying outside the Kougarok drainage basin, the tributaries of the Noxapaga heading in the Kougarok divide have generally been considered as belonging to this district. In 1907 the only two streams from which any production was reported were Garfield and Boulder creeks. On the former five men have been employed and the reports are encouraging. On the latter four men have been mining, but no returns are available.

From the foregoing statements it would appear that about seventy men have been mining in this region during the last year. None of

[a] The ditch-building operations are described in Mr. Henshaw's paper on the water supply of the Nome and Kougarok regions, elsewhere in this volume.

the operators have done any extensive work, the mining being generally carried on by pick and shovel methods, so it is doubtful whether more than 50,000 yards of dirt have been handled. In the above enumeration no account of the men engaged in ditch building has been taken. Over a hundred men have been employed in this work, but they have contributed nothing to the gold output.

PORT CLARENCE REGION.

The Port Clarence region has not been visited by members of the Geological Survey for a number of years and but few new notes about it have been collected from mining men. For several years the region received but scant attention from the outside. Now, however, it has shown increasing activity and mining promises to be pushed more energetically. To the north of Grantley Harbor and Port Clarence there are two areas in which most of the mining is being done. One of these is near Sunset Creek and the other is in the American Creek basin. On Sunset Creek a ditch line over 30 miles in length has just been completed, so that in August, 1907, the water was available for mining. Owing to the late turning on of the water, much of the season was lost for productive mining. The gravels at this place are between 6 and 8 feet deep, and it is planned to handle them with a hydraulic elevator. It is expected that the work will be vigorously pressed in the future.

In the American Creek district the most active mining work has been on Windy Creek at the mouth of Budd Creek, but only one crew of five or six men has been employed. The completion in the late fall of a large ditch will probably give a great impetus to mining in 1908 in this region. The ground to be worked with water from the ditch is about a mile downstream from the junction of Budd and Windy creeks.

South of Port Clarence the main productive area is in the Bluestone basin. Heretofore work has been greatly impeded by the lack of sufficient water, but this deficiency is being remedied by ditch construction. Gold Run is the most important tributary of the Bluestone, and it is from this creek that most of the gold obtained in 1907 has come. There have been about eight different outfits in the Bluestone country, ranging from camps of fifteen men down to individual prospectors.

LODE MINING.

During the year 1906–7 there has been increased activity in prospecting for lode mines, and on the whole the work has given a healthy stimulus to the district. Nowhere, however, except at the Big Hurrah mine, has the work progressed beyond the prospect stage, so that the output of the peninsula has not been materially affected.[a] The holders of many of the veins, however, have placed an unreasonably high value on their properties and this discourages investment by outside capital. A few thousand dollars is ample reward for the pluck and luck which locates a promising ledge, but several hundred thousand dollars should be the prize reserved for the man who makes a producing mine from the unproved project. A realization of this fact is important if outside capital is to be invested, for business men will not accede to the fabulous valuations set on the undeveloped properties scattered through Seward Peninsula.

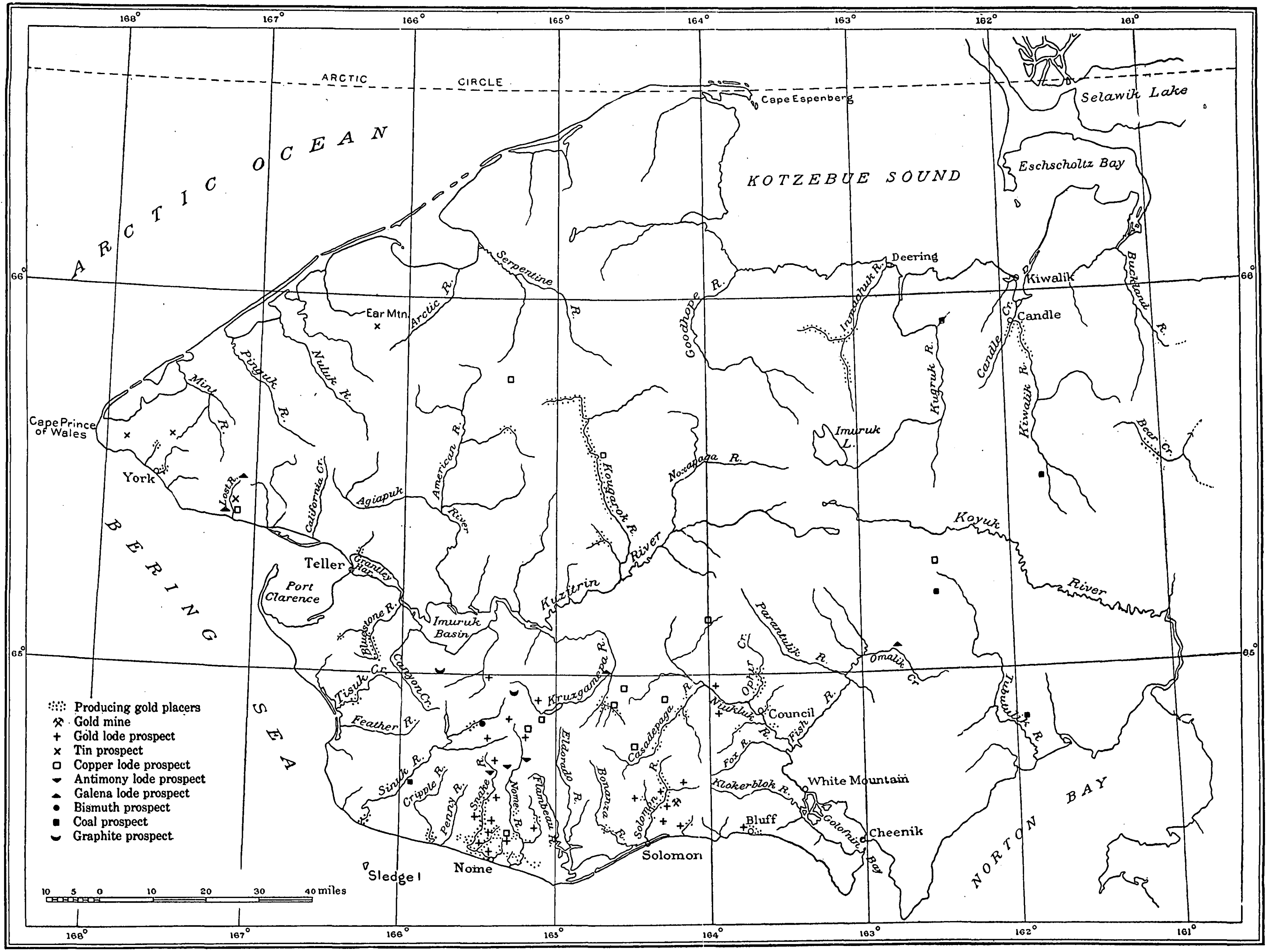
GOLD.

GENERAL CONDITIONS.

The fact that mineralization is widespread in this portion of Alaska is being more and more conclusively proved each succeeding year as prospectors turn their attention to the search for veins. The lode deposits that are attracting most attention at the present time in Seward Peninsula are those in which gold is the main or most important metallic mineral. This is necessarily true, for all the other metals require more elaborate plants and the products must be disposed of in a constantly fluctuating market. The other metals are sought, but only those which promise to return some values in gold are likely to be of immediate importance. Thus, although antimony is found in some of the lodes, copper in others, and bismuth in still others, the owners are counting on defraying some of the expense incident to mining by the returns from the accessory gold content.

There are two main types of veins. In one the filling is mainly quartz with the values carried as free gold; in the other the filling is mainly quartz, but the gold occurs chemically combined with sulphur or some other element. Although the question has not been thoroughly studied it is believed that the veins in which free gold is the principal valuable mineral have been formed later than the larger part of the metamorphism and are therefore not very badly sheared or altered. From a geologic standpoint the places where veins occur may be summarized as follows: In the black quartzose slates, near the contact between two different lithologic types, and in the chloritic schists. The importance of these geologic conditions in the production of mineralized veins, measured by the facts at present known, is indicated by the order in which the different kinds are named. The veins in the black slates are generally destitute of sulphide mineralization, but many of those of the other two classes carry sulphides. Some of the contact deposits occur near the contact of heavy limestone and chloritic schist and others near the contact of heavy lime-

[a] In this paper the tin developments are not considered, as they are treated in detail by Adolph Knopf in the succeeding paper in this volume.



MAP OF SEWARD PENINSULA, SHOWING DISTRIBUTION OF MINERAL RESOURCES.

stone and greenstone or feldspathic schist. No productive veins have thus far been found in the greenstones and attendant schists or in the granites, although these rocks are distributed more or less widely through Seward Peninsula.

It may be of interest to mention the various places where lodes have been reported. It has not been possible for members of the Survey to visit all the different properties enumerated, so the list probably includes veins which have not the possibility of an economic future. It has been the object, however, to exclude as far as possible those locations in which no serious prospecting and development work have been done. The map (Pl. V) indicates the location of the various prospects described on the following pages.

It is realized that overemphasis may have been placed on some properties which have been producing but little, and that not enough space may have been given to others which because of their remoteness or for some other reason have not come to the writer's attention, yet it is believed that the following notes may serve as a summary of operations up to the close of 1907. To those outside the district these notes will indicate the tendency and scope of present work, and to those within its limits they will record what has been done and point out certain needs for further systematic development.

NOME AND GRAND CENTRAL REGIONS.

The Snake River basin seems to be one of the more heavily mineralized areas in the Nome region. This is interesting in connection with the fact that the richest portion of the ancient beaches occurs in the part of the tundra nearest the former mouths of this stream and its tributaries. In many places, however, the bed rock itself on which the beach material is deposited shows evidences of mineralization; thus between Holyoke and Saturday creeks veins which are reported to assay well have been found intersecting the schists.

As it is believed that the mere statement of localities where veins have been prospected in the Snake River region may be of some value to prospectors, it is proposed to note briefly some of the reported lodes, taking the main river and each of its tributaries in succession from mouth to head.

On Dry Creek most of the exploration for lodes has been near the upper part. Near East Gulch there is a contact of the heavy limestones and the schists and at this place a shallow hole has been sunk on a calcite vein. The evidences of mineralization are very slight, consisting only of a small amount of iron decomposition products. A vein has also been encountered in sinking an 80-foot shaft in placer ground in the upper portion of Dry Creek, and another prospector near the same place reports ore carrying from $5 to $15 a ton in gold.

Veins are also reported on Bear Creek, a stream whose course is determined by the limestone-schist contact.

On the west side of Anvil Creek, at an elevation between 300 and 400 feet, there is a quartz lode on which a small amount of work has been done. The country rock is a black, somewhat quartzitic schist which is much wrinkled. The folding that has taken place seems to have formed open spaces in which the quartz has been deposited. The quartz is very lean and no metallic minerals are visible. Three-fourths of a mile to the north there is another quartz vein which has been opened by an adit about 15 feet long. The general trend of the vein is north and south, with a westerly dip, but it is so brecciated that its true structure could not be determined with precision. In places the quartz shows well-terminated crystals an inch or so in diameter, and the vein is believed to belong to the later series. Although the quartz is considerably stained with iron there is no other sign of mineralization, and as no work had been done on the property for some time it seems probable that the returns from the work already done were not sufficient to warrant further outlay. A short distance above Perkinsville on Anvil Creek there are numerous quartz stringers from an inch to 8 or 10 inches in width. These occur in a black, finely fissile chlorite schist and although some of them cut across the schistosity, in general they appear to lie parallel to it. The stringers are somewhat bent and folded with the schist, and like it they stand nearly vertical and are badly fractured and minutely dislocated. The veins carry some iron pyrite scattered throughout in small stringers and vugs. Assays show a small gold tenor. In form the quartz veins are generally lens shaped and most of them are not more than 100 feet in major dimension.

The Anvil-Glacier divide shows numerous veins, some of which have given promising assays. Near the point where the road crosses this divide a shaft has been sunk for almost 100 feet in a schist which is intersected by a network of quartz veins. Some selected fragments of the quartz show free gold. North of this shaft on the same divide are numerous calcite veins, but so far no ore body has been found in veins of this type. The quartz veins in this neighborhood, however, carry a small gold content. One such vein occurring near a schist-limestone contact, according to Moffit,[a] has a thickness of 1 to 2½ feet and can be traced for a distance of about 100 feet.

Near the mouth of Snow Gulch on Glacier Creek there are numerous quartz veins, picked specimens from which yielded, according to Moffit,[b] $9 a ton in gold. The schist in the immediate neighborhood of these veins is in places heavily impregnated with pyrite and probably carries gold also.

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[a] Moffit, F. H., Geology of the Nome and Grand Central quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

[b] Op. cit.

This belt of mineralization extends over toward Rock Creek and shows the same features of heavy disseminated mineralization. Near the wagon road leading to Rock Creek there is a shaft said to be 70 feet deep which has been sunk on a series of intersecting quartz veins. At this place, in addition to the ordinary iron pyrite, some arsenical pyrites have been found and also an intimate mechanical mixture of copper and antimony sulphides.

Above Rock Creek on Snake River the next veins which have been prospected occur near the mouth of Boulder Creek. At this place there are a number of small veins, the largest of which, according to Moffit,[a] is not over 5 inches thick. These all carry some gold, although the assay returns indicate too low a tenor to be profitable under present conditions. Near Goodluck Gulch also there are numerous quartz stringers showing mineralization—mostly iron pyrite or its decomposition products. The quartz shows much crushing. On Pioneer Gulch there is some mineralization which has led to considerable prospecting during the last summer. The quartz at this place is reported to carry considerable free gold, but the stringers are very narrow and would be difficult to mine.

Above Boulder Creek three leads have been found, but the most important is the one near the head of Goldbottom Creek. The vein at this place has been known for some time, as the ground was staked four or five years ago, but only within the last two years have exploration and development been active. The vein is located near the contact of the heavy limestone which forms the larger part of Mount Distin with the underlying schist to the west. It is reported that the vein has been traced for a distance of a mile and that everywhere it is parallel to the limestone-schist contact. Such a character would suggest a gentle dip, which would make the cost of operating rather high. At the present time the ore is treated in a 3-stamp mill the power for which is afforded by water delivered by a ditch about a mile in length. It is understood, however, that a gasoline plant is to be installed so that work may be kept up continuously throughout the year. This prospect was not visited by any member of the Survey during 1907, but from apparently reliable information it is believed that this group of veins belong to the class of contact deposits which are so common throughout a large part of Seward Peninsula, but which so far have not yielded much return.

On Nome River and its tributaries but few veins carrying gold as the main metallic mineral have been uncovered. On Osborn Creek a quartz vein which occurs near the contact of a greenstone and mica schist has been slightly developed. Assays of this ore are reported to show a great variation in gold content, from $4 to over $40 a ton. Associated with the gold is a little copper sulphide, which on weath-

[a] Op. cit.

ering imparts the characteristic copper-carbonate stain to portions of the vein. On Banner Creek a vein, said to be 8 feet wide, with both walls well defined, is reported, but was not visited by any member of the Survey. Several small limestone bands cross Banner Creek and the lode may occur near the contact of the schists and limestones, but this fact could not be ascertained. The ore is reported to show a small amount of free gold in the quartz. Near Mormon station, on the Seward Peninsula Railway below Dorothy Creek, a vein has been found more or less impregnated with iron pyrites and a little copper pyrite.

In the Kigluaik Mountains and in the plateau region to the south there has been some prospecting for quartz lodes. On Stewart River a quartz lead which is said to be 4 feet wide has been located and a tunnel has been started, but as yet nothing is known definitely of the property. Some prospecting has been done on Buffalo Creek and on the upper portion of Hudson Creek, but no permanent force has been at work, so the returns presumably were not satisfactory. On Cobblestone River on the north side of the mountains some free-milling quartz has been discovered, but its value was not learned. On the first tributary from the east to Grand Central River above Nugget Creek two men have been at work uncovering a ledge of auriferous pyrite. This lead is reported to be a series of quartz stringers, some of them 3 feet in width, which conform more or less closely to the cleavage of the black graphitic schists that form the country rock at that place. The quartz contains a considerable sprinkling of pyrite and the outcrop is heavily iron stained.

SOLOMON AND CASADEPAGA REGIONS.

In the Solomon region is located the Big Hurrah quartz mine, which is the only producing lode mine in the entire peninsula. This mine has been described in some detail by Collier.[a] It has been in almost constant operation since its discovery in 1900, and although the ore is known to be of low grade, its total production is important. There are several veins at this place, but the middle one has been most extensively worked. At the present time the shaft is down more than 250 feet and several hundred feet of drift are turned off. The veins occur in a black, hard, somewhat graphitic, quartzitic rock which breaks into more or less rectangular fragments. This rock occurs in a rather narrow belt, a mile or so wide, extending from Uncle Sam Mountain to the head of Solomon River. The country rock is much fractured and is thoroughly intersected by quartz veins or stringers from a fraction of an inch up to several feet in width. The veins have all been more or less crushed and crumpled, but they

[a] Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., The gold placers of parts of Seward Peninsula: Bull. U. S. Geol. Survey No. 328, 1908, pp. 228–231.

have not been so greatly deformed as to lose their continuity. The amount of deformation which they have suffered suggests that they belong to the later series of quartz veins, which were formed either coincidently with or later than the second period of metamorphism that the region has undergone.

A striking feature of the quartz in the Big Hurrah mine is the absence of much sulphide mineralization. To one familiar with many of the gold lodes in the States, the almost entire lack of iron stains on the quartz and the absence of any undecomposed sulphides in the rocks is very noticeable. It seems, therefore, that the gold must occur in the quartz mainly in a native state rather than mechanically mixed with pyrite or other metallic compounds. If this is true it has an important bearing on the successful search for gold lodes in the district, for the prospector, instead of being able to approximate the value of a ledge by sight alone, must have recourse to competent assays to determine the gold content. It is known that much of the quartz which is said to run $10 to $14 a ton in gold looks like a hard, dense, unmineralized rock which would generally be passed by as "bull quartz." The lode prospector should be advised to sample carefully all strong quartz leads and have the samples accurately assayed, rather than simply to neglect the lead because it looks lean and unlike the auriferous quartz found in many known productive camps. By no means would he always be repaid for his trouble, for undoubtedly many of the leads are barren, but he might discover lodes that would be overlooked in the more crude prospecting. In a quartz lode of low tenor, where the gold is in finely disseminated particles, it would be practically impossible to gain reliable information from roughly crushing the ore and panning.

The main developments at the Big Hurrah mine have been by means of an incline shaft which has a general though not constant slope of about 60°. The strike of the veins is northwesterly and the dip is to the southwest. The upper portion of the vein has also been worked in part by adits run in from the outcropping of the vein on Little Hurrah Creek. North of the main lead there is another vein which occurs about 50 feet below in the foot wall. This vein, unlike the two farther south, has a northwesterly dip, although the strike is essentially the same as the others. It is the belief of the mine operators that this northern vein is a continuation of one of the others, the structure being therefore anticlinal. From the evidence of the structure as shown in the rocks of the neighborhood, as well as from the amount and character of deformation of the veins, it is suggested that such an interpretation is not the correct one, but further developments alone can definitely determine the true structure.

The ore as a rule is in bunches of quartz some of which show a considerable segregation of gold, but the best grade of ore is in what is called locally "ribbon rock." The ribbon character is due to bands of quartz separated from each other by small partings or horses of dark graphitic schist, of varying width but all relatively narrow. The ore breaks down rather readily, as both the hanging and foot walls are generally determined by fault planes which show slickensiding. The faults, however, do not continue uninterruptedly throughout the mine. The movement was along a number of fault planes which were essentially parallel. The time of mineralization seems to have been later than the main folding and deformation of the region but earlier than the slight faulting which is marked by the dislocations already noted. It may therefore be associated with the later stage of mountain building which gave rise to the east-west structural trend now visible in the Kigluaik and Bendeleben mountains.

The Big Hurrah mine is well equipped for carrying on all the necessary mining and concentration processes. The main hoisting plant has consisted of steam-power hoists but the use of oil or gasoline in the future is contemplated, as the efficiency in ratio to the expense is higher. There is a compressor capable of running a few drills, but most of the ore is stoped by hand work. After arriving at the collar of the shaft the ore is trammed by hand through a covered way somewhat over a hundred yards in length to the stamp mill, where it is stored until needed. The stamp mill consists of four batteries of five stamps each. The location is well chosen for economically conducting the various processes, as the level of the track from the shaft is well toward the top of the mill. The batteries are of the usual California type, with automatic feed. After crushing, the ore passes over plates and the major part of the gold is won in the upper few feet. The pulp passing over the plates is led to tables for concentration. Two of the tables are of the Frue type, but the other two are of local construction. The tailings from the tables are carried out to a settling pond formed by diking a flat below the stamp mill. After the plates have been cleaned the amalgam and heavy concentrates from the stamps are put into an amalgamating barrel and slowly rotated with steel balls for twelve hours and then retorted and sold to the bank. The concentrates from the tables are sacked and shipped to outside smelters for treatment. The force employed for both the mine and the mill is about forty men.

In the belt of black graphitic quartzitic schist already noted as occurring in the Solomon and Casadepaga regions there is widespread evidence of mineralization, though save in the immediate neighborhood of the Big Hurrah mine no considerable prospecting has been done. At the small, dry gulch leading from Uncle Sam Mountain there is a prospect pit which has been abandoned for some time. It is sunk on the black quartzitic schist, which is very much sheared and folded; in fact, many of the small quartz veins form a complete S. The quartz of the veins has a peculiar appearance, owing to the presence of a halo of milky crushed quartz around a central more glassy portion. Some of the quartz is heavily iron stained, but as a rule no sulphide minerals are evident. Even on top of Uncle Sam Mountain prospectors have been looking for veins, for there are two abandoned pits slightly to the west of the highest point. In these holes a somewhat mineralized black slaty schist intersected by numerous quartz veins is exposed.

In the lower portion of Linda Vista Creek, a tributary of Big Hurrah Creek, there is a vertical quartz vein which strikes toward the northwest. It is 7 or 8 feet wide and has been faulted twice. Much of the rock near it is considerably crushed. The main evidences of metallic mineralization consist in the large number of limonite stains which cover the quartz. Somewhat north of this vein there is another hole in which an 18-inch quartz vein is exposed. This vein strikes in the same direction as the other, but dips only about 60° SW.

About a mile north of the mouth of Little Hurrah Creek a good deal of prospecting has been done in the past, although work has now been entirely abandoned and the pits are filled with water. This property also occurs in the area of black quartzitic schists, which here strike northwest and dip at a low angle to the northeast. Two inclines with a slope of about 30° have been driven, but the character of the veins could not be determined, owing to the water. Near the inclines there has been about 300 feet of open cutting, but in the exposed area only narrow quartz veins which pinch out within a short distance are visible. The quartz, like so much of the quartz in the black quartzitic slate area, shows but sparing amounts of metallic minerals. Evidences of faulting are common.

On the first tributary to Solomon River from the west below East Fork an adit has been driven on a vein occurring in the black graphitic slates. This vein is located along a fault which has an indeterminate throw, and is distinctly later than the fault. The amount of mineralization is not very great, although in places the rocks are considerably iron stained. The adit is only 20 feet long and the mineralization becomes progressively less toward the breast, and the amount of drag indicated by the wall rocks also diminishes. No work has been done at this place for some time.

Mineralization is also commonly associated with the contact of the limestone and the schists. In many places this mineralization consists only of the introduction of quartz, but in some places sulphides have also been formed. The heavy limestones of the Solomon and Casadepaga regions form a belt along almost the entire western margin of the quadrangles;[a] thence, with some dislocation,

[a] As mapped by the Geological Survey.

swing eastward to form the group of hills of which Mount Dixon is the highest point; and thence, continuing still farther east, form the bare limestone ridges so prominent in the No Man Creek region. There are, however, many other places where limestones occur and in some of these more isolated limestone areas the contacts with the schist show mineralization. At Spruce Creek, near the contact of a much folded limestone and schist, some work has been done in the past on veins which are reported to carry values in free gold. No recent prospecting has been done at this place. On the north side of the divide at the head of Trilby Creek, a tributary of Big Hurrah Creek, there is a quartz stringer which seems to strike north and south, but has been only slightly developed.

At some other places the veins apparently occur near the contact of igneous and sedimentary rocks. Thus at the contact of chloritic schists and greenstones on the high hill at the head of Butte Creek the schists are somewhat impregnated with sulphides, most of which are altered to limonite in the surface exposures. Also at the junction of French Creek and East Fork there is a heavy float of vein quartz showing a small amount of metallic sulphides. Some of the quartz fragments are 3 feet in longer dimension and the float can be traced almost continuously for nearly a quarter of a mile. This locality is near the contact of a limestone and greenstone, where there has been some dislocation.

Still other veins occur in the chloritic schist areas away from any contacts with other rocks. Such a series of veins has been opened on West Creek 2 miles above the mouth. Some work is done here every year and there are 600 or 700 feet of underground workings, but the mine has not yet shipped any ore. The development has been on a north-south vein, which was opened by an adit that drifted along the vein for over 350 feet. In this drift both walls were decomposed chloritic schist which in places showed marked slickensiding. Another adit about 300 feet long has been driven on a vein farther west which shows the same general character as the first. A crosscut following a small cross stringer has been run from the eastern drift. The quartz from all the veins is practically the same in character. It is white and somewhat shattered, but is apparently not sheared nor folded and presumably belongs to the later set of veins. In addition to the quartz the veins carry abundant chlorite and a small amount of pyrite and marcasite. The later metallic minerals occur in small stringers and vugs. The wall rocks are also said to be gold bearing and the foot-wall schist is reported to carry from $8 to $10 a ton in gold, but no assays of the rock have been made by the Survey.

OTHER DISTRICTS.

Near Bluff there has been a more considerable development of a group of properties, with the aim of definitely determining the character and distribution of the ore, than at any other place in the southern and eastern parts of Seward Peninsula. Although this group of claims was not visited during the past year by any member of the Survey, the statements here made are regarded as reliable. In occurrence the ore seems to be closely associated with a limestone-schist contact, with the limestone lying definitely above the schist. In these veins quartz is the most important gangue mineral. The lodes are all located rather near the sea, so that the question of freightage is not serious and supplies can be obtained much more economically than in the camps farther inland. Although these leads have been known for five or six years, the last summer has been more productive of economic results than any previous year. At one claim a shaft about 50 feet deep has been sunk and a short drift about 15 feet in length has been turned off. On the adjoining claim the zone of the mineralization is so wide that two shafts, one on the hanging wall and one on the foot wall, have been sunk. One of these is reported to be 100 feet deep; the other is slightly less than half that length. On the next claim also two shafts have been sunk to a depth of approximately 50 feet. Two shorter shafts have been put down on the next claim, and one shaft about 75 feet deep has been sunk near the end line of the next claim beyond.

The ore from these properties is crushed in an arrastre which is operated by a horse, but it is intended to erect a stamp mill later. No just estimate of the production from this group could be obtained. The properties are particularly interesting as suggesting a possible origin of the gold which has made certain of the creek and beach gravels near Bluff so rich.

Farther east, in the neighborhood of Golofnin, a lode which is reported to give assay returns of $2 to $17 a ton in gold has been discovered, but details regarding the occurrence are wanting.

In the neighborhood of Council several veins were mentioned by the writer [a] in 1907 as having been located and as appearing promising for further exploration. No mining has been done during the last season on the lode southeast of Post Creek other than the annual assessment work. Nor has any development work been carried on near the head of Camp Creek, where another vein was reported last year. The lode near the head of Crooked Creek was prospected to some extent during the winter of 1906–7, but the excavations showed the vein to be constantly decreasing in size until it finally pinched

[a] Smith, P. S., Gold fields of the Solomon and Niukluk river basins: Bull. U. S. Geol. Survey No. 314, 1907, p. 155.

out. Fortunately, however, a hillside placer, formed undoubtedly from the disintegration of this vein, was found farther downhill, so that the owners have more than made up for the loss of the lode.

COPPER.

NOME AND GRAND CENTRAL REGIONS.

At the present time there are only two localities within the Nome and Grand Central regions where lodes carrying copper are being prospected. One of these lodes, on Dexter Creek, is valuable mainly for its gold content, although it is reported that assays showing as much as 4 per cent of copper have been obtained. The second prospect is the larger and is being more actively explored. This lead occurs near the head of Nome River on the high ridge between Copper and Dickens[a] creeks, at an elevation of about 1,250 feet. The deposit is developed by a vertical shaft 10 feet deep and an incline shaft on a low slope was driven on the ore. It was intended to keep three men working on the property continuously during the winter and in this way to systematically explore the ground.

The geologic structure of the area immediately adjacent to the mine is somewhat complex. A narrow belt of heavy white limestone occurs at this place and it is in this limestone that the shaft has been sunk and the veins have been found. Below the limestone on the west there are several shallow prospect pits that show schist fragments and outcrops. The schists exposed under the limestone are of two types; one is a silvery-gray schist with an abundance of small muscovite flakes and much chlorite, the bulk of the rock being quartz; the other is a dark-greenish schist with numerous crystals of feldspar and with some amphibole. It has not been possible as yet to examine these rocks microscopically; but from the evidence acquired by the study of many rocks of nearly identical appearance from near-by areas, it is believed that the silvery schist is of sedimentary origin and that the green schist is derived from an igneous rock. Such an igneous rock would probably be akin to the greenstones, which in Seward Peninsula are allied to the quartz diorites.

Above the limestone there is a strongly developed ledge of typical greenish feldspathic schist which is presumably of igneous origin. The direction of the cleavage, the most dominant structure in the feldspathic schist, is N. 30° W., which is the general trend of the ridge. The dip of all the rocks is northeasterly and as a rule is rather

[a] This creek has recently been given the name Dome Creek by the miners of the vicinity. This seems undesirable, for the creek was originally known as Dickens Creek, claims were staked in this name, and the name was published by the Geological Survey in 1900. It is also undesirable because there are at present five Dome Creeks in Seward Peninsula—one a tributary to Tisuk River, one to American River, one to Taylor Creek, one to Kiwalik River, and one forming part of Iron Creek.

flat. The presence of schists of supposed igneous origin, however, suggests that they may cut the sedimentary rocks and so cause complications in the development of the property. It has been determined in other portions of the Grand Central region that the greenstones are later than any of the sedimentary schists; if, therefore, the feldspathic schists have been derived from these greenstones, they must be the latest hard rocks in the district.

The character of the vein and the distribution of the metals in it are peculiar. All over the surface are numerous blocks of limestone stained with a little malachite, but in the upper portion the vein shows mainly galena. Specimens from this upper portion show numerous drusy cavities and the appearance is that of a replaced limestone. In every fragment several small quartz veins are visible. The ore is almost entirely galena with only a small amount of copper carbonate and practically no copper sulphide. An assay of picked specimens made by the owners is reported to have yielded 15 per cent of copper and 20 per cent of lead, with a rather high silver and low gold content.

In the breast there seems to be a nearly vertical fissure which shows for some distance in the inclined shaft. From this fissure a good deal of bornite, practically unmixed with any other minerals except galena, has been won. This vein seems to pinch out 2 feet or so below the roof and the bornite is absent from the rest of the underground workings. Near the floor of the incline there is a quartzitic rock which looks much like a replaced limestone. This quartzite contains a band about 8 inches thick of copper sulphides and carbonates mixed with quartz. The sulphides are mainly chalcopyrite, and both the carbonates, azurite and malachite, are present. In addition to the main stringers already described, some ore is scattered throughout the breast, but it is too disseminated to allow profitable extraction.

The sulphides in the lower part of the mineralized belt occur nearly parallel with the stratification of the limestone. Nowhere in the underground workings was schist seen, but from the evidence already cited it seeems probable that the contact of the schist would be found a short distance below the floor of the incline. If this is the case and if the underlying schist is igneous in origin, the variation in the ore away from the contact might be explained. It is difficult, however, to believe that the ore was brought in by the igneous action which was responsible for the formation of the feldspathic schists, for the latter, where seen, were not mineralized. Unless, therefore, the distribution of ore may be explained by assuming that the limestone acted as a precipitant for the ore-bearing solutions or gases, while the schist did not, the absence of mineralization in the feldspathic schists is a vital objection to the theory.

About a mile north of the shaft is an exposure of a granite intrusive. Although it is possible that this rock may have had some effect on the deposition of the ore, none of the granite is found near the mine and it is believed that it has no intimate connection with the ore. In the absence of extensive openings that would permit careful study of the details it is believed that the ore was introduced later than the igneous activity connected with the greenstone-feldspathic schist intrusion and was coincident with the replacement of the limestone by silica.

A third of a mile above the mouth of Copper Creek, near the limestone-schist contact, an adit has been run in for 20 or 25 feet on some stringers of copper ore. Work at this point has been abandoned. This property belongs to the same company that owns the prospect on the hill above, and it is believed by the owners that the veins in the two places are the same; but the ground has not been studied in sufficient detail to make such a correlation more than a surmise. Both these properties are favorably located for shipping ore and receiving supplies, as they are less than a mile from the railroad. Already 5 or 6 tons of roughly sorted ore have been shipped for mill tests, but the returns are not yet available.

IRON CREEK REGION.

Between Iron Creek and the broad flat drained by tributaries of the Kruzgamepa and of the Niukluk there is a ridge of heavy white limestone underlain by chloritic and feldspathic schists. From the scattered evidence collected in a hurried examination, it appears that the limestone is very considerably folded but that the major structure is nearly flat. The limestone would appear to be a continuation of the limestone already described as forming the western margin of the Solomon and Casadepaga quadrangles. In those areas the contact with the underlying schist seems to have been a zone of mineralization. In general the mineralization is sparsely disseminated, but in places there are stringers of ore which tempt prospecting.

The greatest amount of prospecting for copper in this contact zone has been at the headwaters of Sherrette Creek, a tributary of the Kruzgamepa. At one place about 4 miles east of the mouth of Iron Creek an inclined shaft has been sunk on a mineralized zone 5 feet in width. The foot wall is a silvery-gray chloritic schist destitute of feldspars. The hanging wall is ill defined, and the width of the ore would have to be drawn on a commercial basis. The foot wall is so poorly exposed that its character may be due to alterations effected by the mineralizing solutions, but it is believed that it is not a schist derived from an igneous rock.

The ore so far disclosed consists chiefly of malachite, but there are also some copper sulphides, mainly chalcopyrite with only a subordinate amount of bornite. The stringers are very narrow and no commercial ore has yet been discovered. All over the hill, however, may be found fragments showing copper stains. This has given rise to the popular belief that the belt of mineralization is very wide. If, however, the interpretation that the ore occurs near the schist-limestone contact is correct and if this contact forms a more or less flat surface, with local wrinklings here and there, it seems more likely that the width of the mineralized area is not very great and therefore that the chance of finding valuable lodes is not promising except in those places where the mineralization, instead of being disseminated over a large area, has been more restricted.

All the float or ledges on the higher ground north of Iron Creek which show copper carbonate stains carry that mineral in the form of malachite. Lower down the slopes, near the upper branches of Left Fork, a tributary of Iron Creek, there is a copper lead where malachite is almost wanting and where the copper carbonate occurs in the form of azurite. The reason for this difference in character is not known. At this place only a small amount of exploration has been done and the ore so far developed is not found in commercial quantities.

OTHER COPPER PROSPECTS.

In the Solomon and Casadepaga regions, as has already been pointed out (p. 237), there is generally some mineralization near the contact of the heavy limestone and the underlying schists. The greatest amount of copper-stained float is found near this contact on Mount Dixon and in the Moonlight Creek divide. At the latter place a shallow prospect pit has been sunk and the larger stringers staked, but on Mount Dixon no exploration has been done. Near the gold prospect west of Spruce Creek, described on page 238, there is also an interesting group of quartz veins showing some copper stains. These veins occur near the contact of limestone and schist at an elevation of about 700 feet. At the contact is found a siliceous rock looking like a replaced limestone. This is cut by nearly unmetamorphosed quartz veins which show finely terminated quartz crystals. These late veins show but slight traces of mineralization other than the quartz; the copper sulphide and carbonates occur in the lower quartzitic layer.

In the Kougarok region a few copper properties have been located. Moffit[a] describes one of these as follows:

It is located near the head of South Fork of Serpentine River, between Quartz and Bismarck creeks. The copper occurs as carbonates, chiefly malachite with some azurite, with quartz, at a contact of limestone overlying gray mica schist. A shaft 25 feet deep has been sunk above the vein, which dips to the northwest. * * * An incline 20 feet long was also driven in the vein, whose thickness is said to be from 6 to 21 inches, and 10 to 12 tons of ore were taken out.

This prospect has not been visited recently by any members of the Survey. It is not yet on a producing basis. Near the mouth of Taylor Creek, also in the Kougarok district, a copper lode has been reported. The information concerning it is meager, but from some hand specimens which were seen it appears to occur in a much metamorphosed limestone. The copper is disseminated through this rock and occurs mainly in the form of sulphides. The specimens do not indicate a vein of any continuity, but development work has uncovered only the surficial portions.

East of the Kougarok no copper lodes are reported between the river and the vicinity of Mount Bendeleben, where there is a lead concerning which any authentic information is wanting. Still farther east, on the upper branches of Koyuk River, a copper lode has been staked and a small amount of development work was done in the fall of 1906 and the spring of 1907. The hanging wall is reported to be a heavy white limestone and the foot wall a dark-greenish feldspathic schist and greenstone. Although the lode is reported to be very wide, the similarity to the leads that have been studied by members of the Survey in other parts of Seward Peninsula suggests that the zone of mineralization may be flat lying and thus give the appearance of greater width than it really has. Assays made on picked specimens show that there is a high percentage of silver in the ore; thus a return of 17.5 ounces of silver was obtained from ore running 3.4 per cent of copper. The gold content is very low. The location of the lode is unfavorable, for it is very difficult of access and this will undoubtedly hamper developments.

ANTIMONY PROSPECTS.

In 1905 a vein of stibnite was located by float on the divide west of Manila Creek, and some work was carried on in 1906. The condition at this place at the close of 1906 has been described by Moffit.[b] Since that time there has been a fairly steady development of the property. The main work accomplished has been the driving of a crosscut adit which successfully located the vein. This adit was 315 feet long and the vein where intersected was 3 feet wide. It is reported, however,

[a] Moffit F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 139.

[b] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, p. 139.

that the amount of antimony was materially less than in the surface exposures, but that the gold tenor had fortunately increased. The quartz is described as being white and compact, with but a small amount of metallic minerals visible. Now it is proposed to erect a stamp mill near the mine and to recover the gold values on the plates. The residue from the stamp will be concentrated on tables; but it is not intended to market the antimony ore at present. Transportation of concentrates from the mine to the smelter at Tacoma costs about $12.50 per ton, and this high rate has led the owners to hold the concentrates in reserve until they feel justified in erecting a plant of their own to treat the antimony. In the present depressed state of the antimony market such a charge for transportation would be a serious handicap to the successful operation of the property. If the decrease in the amount of antimony present in the ore is as marked in the next lower level as it has been from the surface to the adit level the value of the mine is likely to be determined by the gold content of the ore, with very subordinate values in antimony.

The Manila Creek property is the only one in the district that has shipped any antimony ore, but there are several places in the same general region where stibnite has been found. On the east side of Nome River, near the head of the Osborn Creek drainage basin, three prospectors at the close of the season found promising indications of an antimony lode. The lead is reported to be rather flat lying and is much contorted, the ore occurring in lenses and kidneys. A piece of ore 6 inches wide, 8 inches thick, and a foot long from this vein was examined and found to consist of almost pure stibnite. The ore, in addition to antimony, carries more or less gold. Near the gold lode on Goldbottom Creek also some auriferous antimony ore has been reported, but the prospect was not visited by members of the Survey. On Last Chance Creek a vein which is said to be 5 feet wide has been discovered, but exploration has not proceeded far enough to show the value of the property. Picked samples, however, are reported to yield high assays in both gold and antimony. Near the mouth of Goldbottom Creek on Snake River some stibnite has been found and it was proposed to ship some of the ore, but it is not known whether this was done or not.

GALENA PROSPECTS.

In Seward Peninsula the greatest deposits of galena so far reported are in the region north of Port Clarence and in the hills east of the Fish River basin. The Port Clarence region is described by Knopf on pages 268–271 of this volume. Not much additional information over that published by Mendenhall [a] in 1901 is at hand regarding the region

[a] Mendenhall, W. C., Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900, a special publication of the U. S. Geol. Survey, 1901, pp. 213–214.

east of Fish River. It is known, however, that during the past year mining and exploration were more actively pursued in the Omalik country than previously. The ore body at this place has been opened up by a shaft, and a crosscut adit has also been driven to connect with the shaft in depth. The ore occurs in a massive, coarsely crystalline limestone. The property is said to have an efficient equipment for development work, but is hampered by the high cost of labor and of transporting supplies.

A third locality for galena, near the mouth of Iron Creek on Kruzgamepa River, was brought to the attention of the Survey in the fall of 1907. Three pits have been sunk on the southern side of the river. The easternmost one shows schist very much decomposed and somewhat out of place, with bowlders of yellowish-brown iron-stained limestone above. Twenty-five paces west of this pit there are a series of angular greenstone blocks which seem to be nearly in place and are probably frost-riven fragments from a ledge occupying essentially the position of the greenstone float. A second pit nearer the mouth of Iron Creek shows some galena with a few copper stains. No productive ore is exposed. The third hole, which is nearest the mouth of Iron Creek, is driven in limestone, and there is no schist exposed. In the cut was a lenticular body of galena about 4 feet thick. Most of this has been mined out, but no ore has been shipped. The strike of the limestone in the pit is N. 35° W. and the dip is rather steep to the northeast.

Across the Kruzgamepa and directly opposite these pits is another vein, openings on which show lenses of high-grade galena. This pit is in limestone, but apparently cutting across the bedding of the limestone is a band of feldspathic schist. The galena does not seem to conform to the general strike and dip of the limestone, but the rocks are considerably decomposed and only the surface has been exposed in the excavations, so that accurate determination of the structural features was not possible. The structure is very complex, for within a distance of less than 150 paces the dip of the rocks changes twice from easterly to westerly. It seems clear, however, that the galena at this place occurs as a replacement deposit in limestone near the contact between a schist derived from an igneous rock and a limestone. Owing to the nearness of the exposures on the opposite sides of the Kruzgamepa, it is suggested that the deposits on the south side may be of similar origin. If this is so the decomposed schist lying under the limestone may have been derived from an igneous rock, and the greenstone float noted between the first and second pits on the south side of the river may be in place and the equivalent of the more sheared feldspathic schists which on the north side are observed cutting the limestone. It should be noted that in addition to the galena there is also a little chalcopyrite scattered through the ore.

LODE DEPOSITS OF THE RARER METALS.

BISMUTH.

Near the fork of Charley Creek, a tributary of Sinuk River, bismuth-bearing quartz has been known for some time and was recently described by Moffit.[a] This lode occurs near a limestone-schist contact. During the last season work has been carried on to some extent and the property is being developed by a tunnel. Bismuth is also reported in the Kigluaik Mountains, but no details of the location or occurrence were obtainable.

MERCURY.

Although no well-authenticated find of mercury ores in place has been made in Seward Peninsula, the following quotation from Moffit[b] suggests that the presence of cinnabar is not improbable:

> An interesting fact in connection with the melting of Daniels Creek gold is its loss of weight due to the volatilization of cinnabar caught in the sluice boxes with the gold. The cinnabar occurs in the creek gravels.

MOLYBDENUM.

A small amount of molybdenum, unfortunately not in economic quantities, is reported by Moffit[c] as associated with gold in quartz veins on the divide between Anvil and Glacier creeks. These veins carrying molybdenum occur near the contact of limestones and schists.

TUNGSTEN.

Although no lodes of tungsten have been discovered in Seward Peninsula outside of the area described by Knopf (see p. 262), the presence of much placer scheelite, a lime tungstate, suggests that lodes may be searched for in other portions of the peninsula with some assurance of success. Placer-gold miners in the central part of the Snake River basin often find a considerable amount of scheelite in the concentrates from the sluice boxes. It is a whitish, non-metallic-looking mineral particularly characterized by its very high specific gravity. It is found only in small quantities and is used in making filaments for certain kinds of electric lights and in the manufacture of very tough steel. The value fluctuates within wide limits

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[a] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, p. 138.

[b] Moffit, F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 139.

[c] Moffit, F. H., Hess, F. L., and Smith, P. S., Geology of the Nome and Grand Central quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

owing to the varying conditions of the market, but it may be approximately placed between $400 and $800 a ton.

Float scheelite has also been reported in the Council district, but in amounts so small that the promise of locating the ledges from which it was derived is remote. In the Solomon region, especially near West Creek, a heavy nonmetallic-looking mineral was reported, but the material from this locality examined by the writer proved to be barite. This is also a heavy white mineral, but not of any considerable economic value.

HINTS TO MINERS.

In closing this portion of the report, a general word of advice concerning methods of work may not be unacceptable to those unfamiliar with lode mining. It has been noticed that in many places after an ore stringer has been located on a hillside, there has been a disposition to leave the vein and to start a crosscut adit at a lower level to intersect the ore body in depth. Such a scheme seems too hazardous and too expensive to be attempted in a region where the general character of the veins is no better known than it is in Seward Peninsula. If the vein is caught in the adit all is well and good and the crosscut undoubtedly gives an easy and economical method of handling the ore above that level. But the intersection of the vein in the crosscut is more or less problematical, especially in a region of disturbed rocks. To intersect a vertical vein by means of a crosscut 500 feet below the outcrop where the slope of the surface is 30° requires 850 feet of dead work which gives but meager information concerning the value of the property. On the other hand, if a system of sinking on the vein itself were adopted, an incline or shaft 100 feet in depth would not only block out considerable ore, but would afford much information concerning the character of the vein. Such a system of "gophering" might have to be entirely abandoned for the subsequent economical development of hoisting and breaking down the ore. It would have, however, the advantage of practically doing away with dead work, and would undoubtedly prove the true value of the mine better than a more elaborate scheme based on the assumption that the work done was of permanent character. If the ore body proves to be of value the miner can afford to neglect in large measure the early charges for prospecting, whereas if the surface showings do not continue or if the vein becomes impoverished in depth the sooner he realizes the fact the better.

For the present, therefore, it is believed advisable for the developments to follow the ore even though it may lead in tortuous courses. Such a plan should be pursued until the values of the prospects have been firmly established and the course and character of the veins accurately determined.

NONMETALLIFEROUS PRODUCTS.

Earlier in this paper it has been pointed out that the high cost of essentials has prevented the development of all save the richest deposits, or those which produce an easily converted commodity. For this reason the nonmetalliferous deposits have received but scanty attention. It is true that so important a resource as water has been well utilized. Not only is it developed for mechanical purposes, but even the springs which afford drinking water have been commercially controlled for local use.

FUELS.

Owing to the absence of all forests near many of the most productive camps, the question of fuel is of the highest importance. Lignitic coal has been reported in several places on Seward Peninsula, but in only one of these is it produced on a commercial basis. This mine, near the junction of Chicago Creek and the Kugruk, has been described by Moffit.[a] It is still producing coal and is undoubtedly a great boon to the prospectors in the Inmachuk-Kiwalik country. The coal, however, is not of so good a quality as that from Washington and British Columbia, but the greatly reduced transportation charges make it locally important. For shipments to regions more than a few score miles from the mine, however, the low heat-giving capacity and the high cost of transportation will not permit competition with the Wellington and other outside coals.

Coal is also known in the Sinuk Valley, but the area of the coal rocks can not be over a square mile[b] and the coal is of a poor quality. In the eastern part of the peninsula prospectors report considerable float of lignitic coal on the headwaters of the Tubutulik, but the ledge has not been opened up. Concerning this region Mendenhall[c] says: "No direct evidence of the presence of this mineral [coal] was secured on the Koyuk, but along the river bank, associated with the sandstone [Tertiary?] outcrops, on the Tubutulik, are numbers of small pieces of bright, compact coal, seemingly of good quality." All the coal so far found in Seward Peninsula is lignite, and there is slight probability that other kinds of higher grade will be discovered.

An attempt has been made near Nome to use for fuel the peat and vegetable material which forms the upper 6 to 12 inches of the tundra. The experiment as yet has not been sufficiently thorough to determine its value. It is probable, however, that the peat is too

[a] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula: Bull. U. S. Geol. Survey No. 247, 1905, p. 67.

[b] Collier, A. J., MS. notes.

[c] Mendenhall, W. C., Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900, a special publication of the U. S. Geol. Survey, 1901, p. 214.

full of rock material and ice to be valuable except in the more inaccessible regions. In special areas, where the peat has accumulated without the admixture of much foreign material, it may be of local importance to prospectors. The long period required to dry the peat and its low fuel value will always be drawbacks to its extensive use.

GRAPHITE.

On the southern face of the Kigluaik Mountains the presence of graphite has been known for some time. The occurrence is interesting, for, as has been pointed out by Moffit,[a] there are three distinctly different associations of this mineral. Aside from the scientific interest attaching to this locality, it is of no present importance. On the north side of the mountains, however, not far from Imuruk Basin (locally called Salt Lake), there is another occurrence of graphite which has been recently exploited. At this place a series of very graphitic layers is interlaminated with more quartzose schists. Much of the graphite is obtained in blocks 2 feet in length and a foot in thickness, practically unmixed with foreign material. It is claimed that with rough hand sorting a very high grade ore can be obtained from the group of claims. The owners have already transported several tons of the ore to tide water and expect to ship it for sale in the States. The price of graphite is usually about 4 cents a pound, although there is considerable fluctuation, as the market is small. It would be well, however, to sample the properties on a thoroughly commercial basis before calculating the value, for much of even the high-grade Ceylon graphite contains 10 to 15 per cent of impurities.

MICA.

Mica is another of the nonmetalliferous products that has invited some attention in this region. In the Kigluaik and Bendeleben mountains there are a series of granite and pegmatite dikes which cut the later basic intrusives of the Kigluaik group. As is characteristic of many pegmatites from other parts of the world, the crystals of the component minerals are extremely large. Under such conditions some of the micas are large enough to have commercial value. At the present time the only place in Seward Peninsula where mica has been exploited is in the Bendeleben Mountains. Specimens of the product from this place show that the mica is of light color and that from selected pieces plates 5 or 6 inches square could be obtained. The inability to utilize the by-products and the high cost of mining and transportation will prevent the development of the properties in the near future.

[a] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 139-140.

THE SEWARD PENINSULA TIN DEPOSITS.

By ADOLPH KNOPF.

INTRODUCTION.

The known Alaskan tin deposits that are of a character sufficiently encouraging to warrant prospecting are limited to the extreme western part of Seward Peninsula, and are embraced in an area of about 400 square miles. Four localities are at present being prospected. These are Ear Mountain, Buck Creek, Cape Mountain, and Lost River, named in order from north to south. Ear Mountain is isolated from the other three localities, which are grouped together in what is known as the York region.

The York tin deposits were examined by Collier in 1903[a] and 1904,[b] and by Hess in 1905.[c] No member of the Geological Survey visited the region in 1906. Numerous reports indicated that extensive development work was in progress. Owing to this fact and to the fact that the earlier examinations had been limited on account of lack of time, it was deemed advisable to make a more detailed investigation of the tin deposits in 1907. With this purpose in view the writer was instructed to examine all known occurrences of tin in Seward Peninsula and to give special attention to the origin of the ores and the commercial importance of the field. A summary of results is herewith presented, wherein it is shown that the mode of the origin of the ores has a direct bearing on the economic importance of certain types of tin deposit that are now being prospected. A more detailed report, embracing the scientific results of the investigation, is in course of preparation.

The various localities will be described in geographic order, as already enumerated.

[a] Collier, A. J., Tin deposits of the York region, Alaska: Bull. U. S. Geol. Survey No. 225, 1904.

[b] Collier A. J., Recent development of Alaskan tin deposits: Bull. U. S. Geol. Survey No. 259, 1905, pp. 120-127.

[c] Hess, F. L., The York tin region: Bull. U. S. Geol. Survey No. 284, 1906, pp. 145-157.

EAR MOUNTAIN.

Ear Mountain is located in the northwestern part of Seward Peninsula, in latitude 66° north, longitude 166° west. It is 50 miles north of Teller and 15 miles south of Shishmaref Inlet. The mountain has long, smooth profiles on the northern and eastern sides, but on the southern and western sides rises abruptly from the tundra-covered plateau which lies at an elevation of 1,000 feet. It is flat topped and attains a maximum elevation of 2,308 feet.

The only cassiterite obtained by the writer from Ear Mountain was stream tin from Eldorado Creek on the northeastern side of the mountain. No tin ore in place could be seen. Attention has lately been directed to some occurrences of yellow copper pyrites and galena along the contact of the granite of Ear Mountain and the rocks that have been intruded by it.

GENERAL GEOLOGY.

The core of Ear Mountain consists of a large intrusive mass of coarse-grained granite. Radiating from this main body of granite are numerous tongues of fine-grained white granite which have been injected into the surrounding sedimentary rocks. These are prevailingly of a limy character, comprising crinkled limestone and lime-mica schists, gashed with numerous quartz stringers. On the south side of the mountain the rocks are more siliceous and include quartzites and black siliceous schists. The youngest rocks of the region are a system of quartz porphyry dikes cutting both the limestones and the granites. The two most prominent of these dikes have a thickness of 15 feet and can be traced for several thousand feet. They strike N. 30° E. and north and south, according to the compass.

The granite of Ear Mountain consists of well-formed feldspars and dark, smoky quartz crystals embedded in a finer matrix of feldspar, quartz, and black mica. The smoky quartz crystals are a characteristic feature of the granite, and have not infrequently been mistaken by the prospector for cassiterite, especially when the color is more intense. In addition to the minerals named, black tourmaline occurs very abundantly. It is, however, usually connected with narrow seams that traverse the granite. These seams consist of quartz and tourmaline and are adjoined by a band of altered granite 2 or 3 inches broad. This alteration has been produced by the introduction of numerous tourmaline needles which have grown at the expense of the earlier-formed feldspar. The quartz-tourmaline seams, on account of their resistance to atmospheric attack, weather out in relief. Several such seams can be seen running up and down the "Ears"—the granite monoliths responsible for the name of the mountain.

The offshoots from the main granite body are finer-grained and lighter-colored granites. They contain, besides quartz and feldspar, white mica and, in many places, numerous small three-sided prisms of tourmaline.

MINERAL OCCURRENCES.

The granite has exerted considerable influence on the sedimentary rocks that surround it, and the line of contact is marked by a belt of rocks of distinct character. Numerous minerals, such as garnet, vesuvianite, and tourmaline, make their appearance in this contact zone. They are due in part to a recrystallization of the material of the sedimentary rocks under the influence of the heat furnished by the granite and in part to an accession of new material by emanations from the granite during its period of cooling. In addition to the tourmaline, axinite, and other contact-metamorphic minerals, the contact rocks are flecked at certain localities with galena, chalcopyrite, and a lustrous coaly black mineral, an iron borate—a mineral new to science and as yet unnamed. It is this type of rock which has raised hopes that copper and lead deposits of economic value exist at Ear Mountain. Tin-bearing rock also is believed by the prospectors to occur along the contacts.

The practical importance of understanding how these deposits were formed arises from the fact that (1) the size and persistence of the deposits and (2) their probable value are dependent on the mode of origin.

Under the first heading attention may be drawn to certain structural features of the granite boss of Ear Mountain—features which occur also at Cape Mountain and at Brooks Mountain. It can be shown from various lines of evidence that any such granite mass as that of Ear Mountain must have cooled under a considerable blanket of protecting rocks. The surface of the granite against these overlying rocks is not necessarily smooth, but may be gently undulating, or may even contain sharp ridges, such as, for instance, have been revealed by the extensive mining operations in Cornwall. The troughs or depressions between these granite ridges will be occupied by the overlying rocks, which will thus appear immersed beneath the general surface of the granite. At Ear Mountain erosion has proceeded far enough to strip off much of the protective capping of sedimentary rocks which formerly arched over the granite, though on the highest peak—the south peak—the granite is still covered under a thickness of 100 feet of schists. (See fig. 5.) This erosion has revealed the fact that the former surface of the granite boss was slightly uneven. The limestones and schists resting in these inequalities now occur as isolated patches surrounded on all sides by granite. The section across Ear Mountain at Eunson's shaft (fig. 6) will illustrate this feature. These rocks may show local indications of ore, but the ore rock, being of contact-metamorphic origin, will have a small areal extent, will have no great depth, and will give out when the underlying surface of the granite is reached. The prospector, therefore, should use considerable caution before attempting any exploitation of ore bodies occurring in such patches of rock lying upon the surface of the granite.

Along the periphery of the granite the ore deposits of contact-metamorphic origin are more likely to have permanence in depth. What

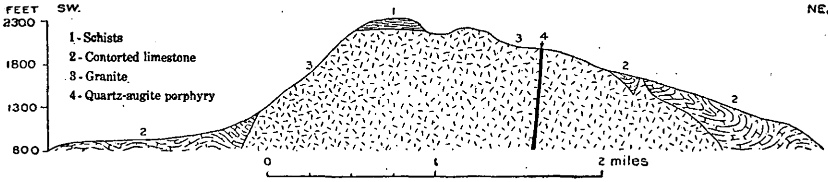

FIG. 5.—Section across Ear Mountain, Seward Peninsula.

is known of contact-metamorphic deposits in other parts of the world, however, is not of a character to encourage extravagant hopes for the similar occurrences found at Ear Mountain. They are usually of low grade and irregular in form. Such deposits are mined in southeastern Alaska for their copper contents, but conditions must be exceptionally favorable to make them of commercial value.

On the northeastern side of the mountain, near Vatney's cabin, the contact metamorphism has been more pronounced than usual. Some metamorphosed limestone in proximity to a granite dike was being

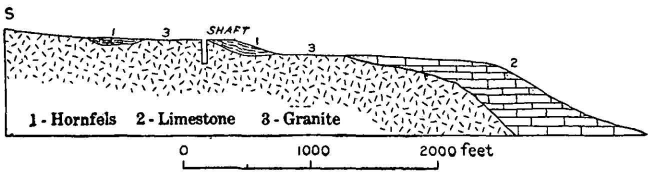

FIG. 6.—Sketch section at Eunson's shaft, Ear Mountain, showing patches of hornfels resting upon granite.

prospected for tin ore. It contains small bunches of a reddish-brown mineral showing crystal faces, which, when carefully examined, are seen to be diamond shaped. This is typical of garnet. When only the apex of the garnet crystal is visible it bears an exceedingly deceptive resemblance to the four-sided pyramid characteristic of cassiterite.

The quartz-tourmaline seams that cut the granite have already been described. At various places on Ear Mountain interlacing networks of such seams occur, and an extensive tourmalinization of the adjoining granite has taken place. Masses of quartz-tourmaline rock have been produced, little resembling the original granite. Such occurrences have been opened up by shallow prospect pits at a number of points. It is quite possible that some deposits of this character may carry low-grade values of tin, but those opened thus far lend small encouragement to this idea. The principal basis of faith, as it exists in the locality, is the presence of abundant tourmaline. It is rather generally held throughout this part of Seward Peninsula that tourmaline is an infallible indication of tin ore. It is true that cassiterite is usually accompanied by tourmaline, but it is emphatically not true that tourmaline is usually accompanied by cassiterite. Tourmaline is of world-wide distribution, and extensive occurrences are known which contain no traces of tin. It would, therefore, appear advisable to proceed cautiously on the tourmaline prospects of Ear Mountain.

The quartz porphyry dikes merit detailed description, inasmuch as they have been actively prospected for tin ore. They consist of dense-textured rock of dark-blue or green color in which are set numerous large crystals of white feldspar and smoky quartz. In addition to these, but occurring in lesser abundance, are augite of a peculiar brownish color and lustrous crystals of black mica. Many of the augites attain unusually large dimensions—as much as 2 inches or more—and are commonly regarded as "tin crystals" by the local prospectors.[a] The presence of these augite crystals, thus mistaken for cassiterite, has led to considerable prospecting of the quartz porphyry dikes. No cassiterite was visible in the specimens submitted to the writer, and he could detect only the minutest grains in the thin sections studied under the microscope. Moreover, chemical analysis of "ore" samples, made in the laboratory of the Survey, showed the presence of traces of tin only, amounting to a few hundredths of 1 per cent.

On the northeast side of Ear Mountain an augite-quartz porphyry dike has been opened by a shaft and explored by a drift 112 feet long. Nothing but hard barren rock was encountered. Work was suspended, and at the time of visit the shaft was flooded with water. Farther southwest, on the extension of the same dike, a number of open cuts have been made on account of the prevalence of numerous large augite crystals embedded in the dike rock.

A shaft known as Eunson's shaft was sunk near the point where a quartz porphyry dike striking north and south crosses the granite-limestone contact. The shaft was reported to be 30 feet deep, but at the time of visit was flooded with water and partly caved in. On the dump a variety of rock is represented. Contact-metamorphosed limestone, granite, granite porphyry, quartz porphyry, and various

[a] Augite is approximately half as heavy as cassiterite and is easily distinguished from that mineral by the fact that it is rather readily fusible before the blowpipe. Cassiterite is entirely infusible.

altered modifications of the quartz porphyry appear. The quartz porphyry is partly tourmalinized and contains small patches of purple fluorite. Arsenopyrite is rather abundant. The tin ore reported from this locality probably came from highly altered portions of the quartz porphyry dike.

BUCK CREEK.

GENERAL GEOLOGY.

The bed rock of the Buck Creek area consists of slates, many of which are poorly fissile and resemble shales. Some greenstones are associated with the slates, but can rarely be found in place. A prominent exposure of greenstone, however, forms a low ridge just north of Buck Creek. The slates dip prevailingly at low angles. The slaty cleavage is developed in an irregular and variable degree in different parts of the area. Much of the rock is shaly looking, but at other points, such as at the head of Sutter Creek, the slates are thinly fissile and the cleavage is at right angles to the sedimentary banding.

Two quartz porphyry dikes cut the slates at the head of Buck Creek. The characteristic feature of these dikes, especially of the one running northward from Potato Mountain, is the number of large, fine glassy quartz crystals set in a light-gray groundmass. The margins of the dikes have been strongly chilled and show a bluish-black rock containing small crystals of quartz and feldspar. Where the dikes are thin they consist entirely of this kind of rock. As is usual in this part of Seward Peninsula, these quartz porphyry dikes have been prospected for tin, and a number of cuts have been opened on them. One of these cuts shows a dike 10 feet wide, somewhat impregnated with pyrite, especially in the vicinity of seams. A small amount of tourmaline in radial groups and a little white mica also appear. Some specimens containing cassiterite have been obtained, but they appear to be of extremely rare occurrence.

The largest porphyry dike, which has a maximum thickness of 50 feet, trends N. 35° W. (magnetic) across the country. It has been faulted approximately 400 feet along the north-south line. The line of this fault is marked by a great quartz vein, 15 feet or more in thickness, which can be traced for considerably more than a mile. The vein contains a vast number of slate fragments, and each of them has acted as a nucleus around which quartz crystals commenced to grow. Failure of the crystals to coalesce in their outer extremities has produced a vuggy vein structure lined with innumerable hexagonal pyramids of quartz. No minerals, with the exception of some botryoidal limonite incrusting the quartz crystals, have been observed in the vein, so that it is without economic importance.

DEVELOPMENTS.

On the ridge of hills at the head of Buck Creek a prospect hole at an altitude of 1,140 feet discloses a fine showing of tin quartz. The claim, known as the "Eureka," is situated on the summit of the ridge. The hole is 10 feet deep, and exposes a face of 7 feet of quartz, carrying a considerable percentage of cassiterite. The quartz is milk white and of greasy luster, and the cassiterite occurs disseminated through it in crystalline aggregates, intimately intergrown with arsenopyrite and small needles of blue tourmaline. Developments on this property are at present inadequate to give either dip or strike of the ore body with any degree of certainty. The depth attained is not great enough to expose solid bed rock. The wall rock is still in a highly shattered condition, due to the heave of the frost. About 60 feet from the prospect hole croppings show that the country rock (slate) is lying nearly horizontal.

At numerous points on the same ridge of hills open cuts have been made exposing networks of quartz stringers in the slates. Some carry cassiterite and some merely show small rosettes of blue tourmaline. At the head of Peluk Creek a shaft 20 feet deep was sunk on stringers in the slate. The quartz on the dump shows abundant pyrite and here and there some cassiterite.

In the vicinity of this last-mentioned occurrence float tin ore has been picked up in which the cassiterite occurs in a totally different mineral association. It is found in a green rock, composed largely of radiating groups of actinolite. Under the microscope some finely granular calcite is found to be associated with the actinolite. Arsenopyrite, in amounts greatly exceeding the cassiterite, is very abundant. A number of open cuts have been made in the effort to locate the bed-rock source of this tin ore. At the time of visit the owner had just succeeded in uncovering the edge of the deposit in place, so that no facts are available as to its probable value. It is apparently lying flat and seems to represent a stratum of limestone interbedded between impervious slates and now highly altered by the action of tin-bearing solutions.

CAPE MOUNTAIN.

Cape Mountain forms the promontory fronting Bering Strait at the westernmost extremity of the American continent. On the eastern flank of the mountain are a few scattered houses, which form the settlement known as "Tin City." Tin City is 110 miles by steamer route from Nome, with which it is now connected by telephone.

GENERAL GEOLOGY.

Cape Mountain consists of a granite mass which has invaded a series of crystalline limestones of Carboniferous age. The limestones are lying nearly flat, but with a slight easterly dip. They extend eastward nearly to the mouth of Baituk Creek, where they are faulted against the York slate of undetermined age. At the cape the limestones dip in toward the granite. Some siliceous schists are associated with the limestones. Their main development is in the capping forming the summit of Cape Mountain, where they are 300 feet thick. Some narrow dikes of basalt cut the granite as exposed in mining operations.

The granite of Cape Mountain is a coarse-grained gray rock, strongly porphyritic, containing numerous large crystals of feldspar. The essential minerals making up the granite are, in addition to the feldspar, quartz and black mica. Along the contact with the limestone the feldspars are aligned with their longer axes parallel. More commonly, however, the granite becomes fine grained along its margin, and fluorite, tourmaline, and white mica appear. A number of dikes, standing nearly vertical, cut the rocks surrounding and overlying the granite. In addition, horizontal sheets of granite have been forced in between the limestone beds. These features tend to increase the irregular character of the contact surface between the limestones and the granite. Some limestone masses were broken off from the roof which covered the granite at the time of its intrusion and partly sank into the molten rock. An isolated limestone patch which had this origin rests in the granite near the head of Lagoon Creek. Attention is drawn to these foundered blocks of limestone, because, if any ore occurs along their contacts, it can have only a meager distribution. The principal effect of the intrusion of the granite on the surrounding limestone has been to coarsen its grain and to produce a coarse white marble, extending at a maximum 200 or 300 feet from the contact. Proximity to the granite contact is indicated in many places by the peculiar rough appearance of the limestone, due to the development of small patches of lime-silicate minerals, ordinarily invisible to the eye. These weather out in relief and give the limestone a characteristic "shaggy" appearance near the granite. Contact metamorphism is relatively rare, and is confined mainly to the limestone adjoining the dikes.

ORE DEPOSITS.

Tin ore occurs in three ways at Cape Mountain—(1) in tourmalinized granite dikes and peripheral portions of the main granite mass; (2) in contact-metamorphic rock; (3) in veins in granite and as an impregnation of the adjoining wall rocks. The miner makes no distinction between the first and second modes of occurrence. In general it may be said that the ore of the first type is apt to be of low grade, and that the second is an unlikely source of tin ore. The third is the normal type of lode tin the world over.

Some of the dikes cutting the limestone show margins which are strongly tourmalinized. Large masses of bluish tourmaline occur, and some of these carry rich bunches or pockets of tin ore. The limestone adjoining the dikes has here and there been converted into coarse white spar in which numerous prisms and columns of tourmaline are embedded. In places it is difficult to discriminate between tourmalinized limestone and tourmalinized dike rock. The tourmalinization, however, appears to be purely local and erratic in occurrence. Furthermore, the tourmaline, though, as already stated, in some places rich in cassiterite, is in general quite barren.

The contact rocks adjoining the main granite mass and some of the granite sills have been prospected at a number of places. A heavy green rock, here and there showing pyrrhotite, has been regarded as tin ore, but microscopic and chemical analysis fail to reveal

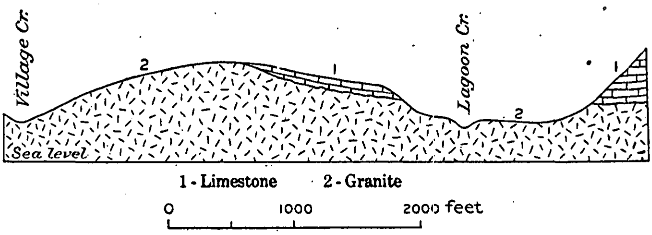

FIG. 7.—Section across Lagoon Creek, Cape Mountain, one-half mile below Canoe claim, showing thin capping of limestone resting in granite.

any tin. The green rock is locally known both as "greenstone" and as "tinstone." It is a finely granular rock consisting of augite and fluorite in equal proportions. This rock is well exposed in a cut on the Canoe claim, where a few feet of it directly overlie a granite sill 8 feet thick. At other points on Cape Mountain, notably half a mile north of the Lucky Queen, the augite is embedded in calcite. The augite, which is unusually well developed for a contact-metamorphic rock, is of brown color and does not look unlike cassiterite. Where tin is suspected in such rocks, assays can give the only reliable information.

The statements regarding deposits of contact-metamorphic origin made for the Ear Mountain region are equally applicable to Cape Mountain. (See fig. 7.) In addition, the highly irregular nature of the granite contact makes prospecting for such deposits difficult, and would entail heavy and probably unwarrantable expenses in mining them.

Up to the present time a single narrow quartz vein has been found in place, cutting the granite on the north side of Cape Mountain at an altitude of 1,850 feet. The vein is accompanied by some alteration to greisen and by partial tourmalinization of the adjoining granite—changes characteristic of tin-bearing veins. At other points on Cape Mountain cassiterite accompanied by tourmaline is found as an impregnation of the granite adjoining slips or fault planes. This type of occurrence, in the opinion of the writer, holds out greater possibilities for the future of the district as a tin producer than do the other two. Unfortunately exploratory work has been confined mainly to the contact deposits.

DEVELOPMENTS.

At the time of visit two properties only were being actively worked—those of the United States Alaska Tin Mining Company and the Bartels Tin Mining Company. The former property is situated near the summit on the north side of Cape Mountain. Developments up to the end of July, 1907, consisted of a shaft reported to be 22 feet deep, now filled with water, and a 7-foot tunnel 270 feet long. The company has also erected a 10-stamp mill near the beach at Tin City. Four men were employed at the time of visit. The shaft is sunk upon a quartz ledge 1 foot thick, striking N. 45° W. (magnetic) and dipping 80° E. The tunnel, whose altitude is 1,600 feet according to aneroid, is driven in a direction S. 40° W. through hard, firm granite and is expected to tap the ledge 250 feet below the collar of the shaft.

The main development work by the Bartels Tin Mining Company has been done on the North Star property. Eight men were employed during the summer of 1907. The main tunnel with its drifts and winzes aggregated 750 feet in length. This tunnel is being driven to catch the granite-limestone contact at a depth of 100 feet below the workings of the Lucky Queen tunnel. About 400 feet from the mouth of the tunnel a band of granite was encountered carrying numerous visible crystals of cassiterite, associated with some tourmaline. The width of this band is about 18 inches. The granite is soft and iron stained. The succeeding 3 feet consists of gray hard granite carrying pyrite disseminated through it. This is followed by 15 feet of iron-stained granite. At the time of visit the 18-inch belt of rich tin ore had not been drifted on to prove its persistence. The drifts branching off from the main adit follow the contact of a large limestone block which was evidently torn off from the main limestone mass during the intrusion of the granite. In following this contact, which proved to be of a highly irregular nature, several winzes were necessary.

A new tunnel, 67 feet below the North Star tunnel, is being run from the surface to connect with the lowest drifts reached by these winzes. The granite along the limestone contact is charged with numerous radiating groups of tourmaline prisms, with iron oxide, and locally with pyrite and tin ore. Some crushing has taken place along the contact, and heavily iron-stained gouge matter, a foot in thickness, has been produced. At points where the red clayey material is absent the granite is fresh and the progressive increase of fineness of grain as the contact is approached can be noted.

A considerable portion of the energies of the company has been expended on assessment work on the numerous claims which it holds on Cape Mountain.

LOST RIVER.

Lost River is a small stream rising near Brooks Mountain in the northwestern part of Seward Peninsula and flowing southward into Bering Sea. The tin prospects of this region are located 6 miles from the coast on Cassiterite Creek, a branch of the river.

GENERAL GEOLOGY.

The bed rock of the Lost River region is prevailingly limestone, known as the Port Clarence limestone, which has been determined on fossil evidence to be of Silurian age. The Port Clarence limestone dips to the north at an angle of about 20°, and in this region has a thickness of not less than 2,000 feet. Two types of rock can readily be distinguished. One consists of a dark leaden-gray limestone forming massive beds. It breaks into large blocks and on fracture appears somewhat crystalline. The other is ashy gray in color and is of dense texture, like lithographic stone. It breaks readily into large thin slabs and many of these are covered with fragments of fossil seaweeds. Some shale is locally associated with the limestone. Near the head of Cassiterite Creek the limestone is intimately banded with shale and intensely crumpled.

On Tin Creek, another tributary of Lost River, a small granite boss a third of a mile in diameter is intruded into the limestone. Its principal effect has been to convert the surrounding limestone into a white marble, though locally some large masses of contact-metamorphic minerals have been formed, consisting chiefly of brown garnet and vesuvianite. A considerable number of quartz porphyry dikes pierce the limestone. They are fairly persistent and can be traced for several miles across the country. The quartz porphyries are light-colored rocks containing small glassy quartz crystals embedded in a matrix irresolvable by the naked eye. The main tin prospects of the region occur in highly altered dikes of this character. The various other dikes have all received separate names and have been more or less prospected, on what encouragement, however, the writer is unable to understand. They are usually unmineralized, except for sporadic cubes of pyrite, and there is no known reason why they should become tin bearing with depth.

CASSITERITE PROSPECTS.

At Tin Creek some thin quartz-cassiterite stringers have been found in the granite. Collier has shown that some pyritiferous granite from the same locality contains 0.3 per cent of tin. A cut has been opened on this occurrence and shows a number of narrow bands of altered granite carrying finely divided pyrite and arsenopyrite.

The principal tin prospects are located on Cassiterite Creek and occur in the quartz porphyry dike known as the Cassiterite lode. This dike is 6 to 10 feet thick and can be traced from the head of Tin Creek in a northwesterly direction over to Lost River, a distance of 9,000 feet. The conspicuous features of the dike rock are its white color and the numerous fine crystals of quartz embedded in it. The quartz porphyry dike has broken through an older dike, a feldspar porphyry, along a portion of its course.

The tin-bearing portion of the dike has a maximum length of 3,000 feet. This portion is marked by a large amount of alteration, a highly varied mineralization, and an intense seaming of the adjacent limestone with innumerable veinlets. The tin ore contains cassiterite and wolframite, associated with iron oxide, pyrite and arsenopyrite, some molybdenite, and rarely a little galena and sphalerite. The gangue material consists of kaolin, quartz, fluorite, zinnwaldite, topaz, and calcite, though all are not present together. The richest tin ore is associated with quartz and lithia mica seams an inch or so in thickness, cutting the quartz porphyry. Considerable alteration has taken place in the rock adjoining the seams, and cassiterite occurs as an impregnation in belts parallel to the stringers. Wolframite is constantly associated with the cassiterite, and though no actual tests have been made, it is probable that the tungsten content of the lode is as valuable as the tin. Where no such seams occur the quartz porphyry is hard and barren and contains no cassiterite. The dike is intensely and irregularly slickensided. Clay gouge is common and the whole mass of rock is stained red with iron oxide. The limestone wall rock, however, is firm and hard. It is considerably impregnated with fluorite, which glows with a greenish light when struck with the pick. No cassiterite appears in the wall rock.

A few hundred feet north of the Cassiterite lode is another quartz porphyry dike, known as the Ida Bell lode. It is about 35 feet thick on the summit of the hill between Lost River and Cassiterite Creek. The rock is dense and fine grained. In the vicinity of Cassiterite Creek stringers of quartz and cassiterite with some wolframite, an inch or so in thickness, cut the porphyry dike. The alteration that is so characteristic a feature of the Cassiterite lode is conspicuously absent from the Ida Bell quartz porphyry dike.

At the time of visit five tunnels had been driven on the Cassiterite lode, three of which were open and could be examined. Tunnel B, 260 feet above Cassiterite Creek, was 180 feet long. The tunnel follows the southern margin of the dike and is partly in limestone. At 45 feet from the mouth a drift has been run 10 feet to the north, crosscutting the lode. Tunnel A 1, 170 feet above the creek, was 80 feet long. The dike rock is soft and can be augered, so that an advance of 4 feet per day (single shift) is easily made. Both these tunnels are on the east side of Cassiterite Creek. On the west side is Tunnel E, 100 feet long. A 9-foot crosscut has been driven 50 feet from the mouth of this tunnel. From the foregoing statements it is apparent that developments are substantially the same as recorded by Hess[a] for 1905.

One mile north of the Cassiterite lode is another tin-bearing quartz porphyry dike which has been named the Dolcoath lode. It is from 2½ to 3 feet thick, strikes N. 50° E. (magnetic), and dips 65° NW. This dike differs considerably from the two previously described, both in its mineralogy and in the mode of occurrence of the tin ore. It is so highly altered that its original quartz porphyry character is not readily apparent. Some movement has taken place along the walls of the dike, especially on the hanging wall, forming a crush zone 1 to 6 inches thick. The dike rock is heavily charged with arsenical pyrites and tourmaline and contains some cassiterite disseminated through it. The limestone wall rock has been converted into coarse white spar, much of which contains numerous small white prisms of tremolite. Cassiterite occurs embedded in this spar, and is locally somewhat rich. These bands of wall rock carrying tin ore, occurring on both foot and hanging walls, are nowhere more than 6 inches thick. Cassiterite also occurs in the wall rock intimately intergrown with pocket-like masses of danburite, which is a borosilicate related to topaz. The Dolcoath dike has been opened by four cuts, of which the extremes are 3,000 feet apart. An assay of ore from one of the crosscuts was reported to have yielded 1.15 per cent of tin.

A highly interesting mineral deposit, occurring opposite the mouth of Tin Creek, on the ridge between Lost River and Left Fork, was shown to the writer as a galena prospect. As pointed out at the time, however, wolframite is probably the most valuable part of the deposit and the presence of tungsten has subsequently been verified in the chemical laboratory of the Survey. In addition to the wolframite, considerable galena is present. Much of it is intercrystallized with a brown-black mineral which gives reactions for tin, cop-

[a] Bull. U. S. Geol. Survey No. 284, 1906, pp. 146–150.

per, zinc, iron, and sulphur, and has been identified as stannite. This is the only known occurrence of stannite in the Alaskan tin region. These various minerals occur embedded in a gangue of topaz, with some deep-purple fluorite. The topaz is crystallized in fine radial aggregates, a few of them half an inch in diameter. The high specific gravity of topaz (3.5) accounts for the unusual weight of the ore. Assays are claimed to show also returns in silver.[a] The surface ore is stained black by manganese derived from the decomposition of the wolframite. Some azurite is also present and is doubtless derived from the copper in the stannite. Little has been done to prove this property. The surface indications show that the mineralization has taken place along a fault zone, running east and west, which has been brecciated and recemented. An open cut shows stringers of ore occurring in a belt 1 foot thick, forming a stringer lode.

Stannite is not a valuable ore of tin. Its occurrence in amounts sufficient to form an ore is extremely rare. In only one place in recent years has it been found in such amounts—at the Oonah mine in Tasmania, where an argentiferous stannite is associated with pyrite and chalcopyrite. Here it was mined for silver and copper, and the tin was rejected as waste product. Arrangements were finally made with the smelter that for ore containing at least 8 per cent of tin $5 per ton should be paid in addition to the ordinary returns for silver and copper.[b] Wolframite, which occurs associated with both the cassiterite and stannite of the Lost River region, is valuable for its tungsten content. Wolframite is a tungstate of iron and manganese, the pure mineral containing 76 per cent of tungstic trioxide (WO_3). Tungsten ores which are used for steel hardening are paid for on the basis of their percentage of tungstic trioxide, the present price being about $10 per unit. Ores concentrated up to 60 or 70 per cent would therefore have a value of $600 to $700 per ton. Wolframite is distinguished by its high specific gravity, perfect cleavage, black color, and brilliant submetallic luster on its cleavage faces. It is softer than cassiterite and can be scratched with the knife. In the Lost River region the iron-rich zinc blende of Brooks Mountain resembles wolframite in color and luster, but differs in the fact that its cleavage faces show six different directions, whereas in wolframite all cleavage faces are strictly parallel. In the absence of chemical tests this is the only means of distinction between the two minerals.

[a] Since this paper was written returns from an assay made by Ledoux & Co., of New York, on a sample submitted by the Survey show 22.9 ounces of silver per ton.

[b] Waller, G. A., Report on the Zeehan silver-lead mining field, Govt. Geol. Office, Tasmania, 1904.

PLACERS.

BUCK CREEK.

Developments subsequent to 1905 have revealed few new facts of interest in regard to the placers of Buck Creek. The gravels have a length of about 4 miles and are of shallow depth. Work below the mouth of Sutter Creek has shown that the gravel is from 120 to 160 feet wide, averaging about 125 feet. A pit averaging 5 feet in depth has shown that the gravel may run as high as 25 pounds of concentrates per cubic yard. The richest gravel rests immediately upon bed rock and is exceedingly clayey and toughly bound together. It gives difficulty in washing, the clay having a tendency to roll up in balls and carry cassiterite nuggets over the sluice boxes. The bed rock is a broken shale or slate that is very clayey but contains no cassiterite. On Sutter Creek, the large southern branch of Buck Creek, there is a considerable body of gravel, and the discovery of stream tin has recently been reported. The other tributaries, gulches, and "benches" of Buck Creek contain little or no gravel, at least in amounts sufficient to warrant any considerable outlay for the purposes of placer mining.

The stream tin of Buck Creek is clearly derived from the erosion and concentration of the cassiterite occurring in the quartz stringers so abundant throughout the area. This source was partly supplemented by the cassiterite occurring in the actinolite rock, and to lesser extent by that contained in the quartz porphyry dikes. As these bed-rock sources are known to occur in place on the summit of the hills, at the head of Buck Creek, it is probable that the creeks flowing into Lopp Lagoon carry stream tin. But whether cassiterite is present in paying quantities is purely a matter of accurate sampling and not of opinion or theory.

Two companies were in operation on Buck Creek during the last season, but on account of the number of adverse circumstances the output was less than anticipated. Placer mining was confined to a small strip just below the mouth of Sutter Creek. The production for the season was approximately 50 tons.

At the beginning of the season the American Tin Mining Company was working its ground by means of an automatic scraper and belt conveyor operated by a 35-horsepower oil-burning engine. Early in August, however, extortionate freight rates on the transportation of crude oil from Nome to York and the imperfect adaptation of the scraper to the character of the gravel necessitated a change in the method of working. Shoveling in was then resorted to, with results at least more satisfactory than those attained with machinery.

GROUSE CREEK.

Assessment work was done on a number of claims on Grouse Creek and two of its tributaries, Sterling and Skookum creeks. The results are not known. Some gold sifted out of the concentrates from Sterling Creek was flat and coarse, not greatly waterworn, and with quartz still adhering to it.

FAIRHAVEN DISTRICT.

A sample of black-sand concentrate sent in for determination from Humboldt Creek proved to be a very rich tin ore, containing less than $5 per ton in gold. About two-thirds of the sample was pyrite. Another sample sent in from Kougarok River was found to contain considerable cassiterite, but far less than that from Humboldt Creek. It contained, however, 85 ounces of gold per ton. The sample was two-thirds pyrite and contained about 10 per cent of magnetite. As the headwaters of Humboldt Creek drain the Hot Springs granite area, the tin was probably derived from that region. Collier states that samples of tin ore purporting to come from it were brought to Nome late in the season of 1902.

RÉSUMÉ AND CONCLUSIONS.

The Alaskan lode tin deposits are associated with granitic intrusives. The ore occurs in a variety of ways:

(1) In highly altered quartz porphyry dikes.

(2) In tourmalinized margins of granite masses and granitic dikes.

(3) In contact metamorphic deposits.

(4) In quartz stringers cutting slates and limestones.

(5) In quartz veins cutting granite and accompanied by impregnation of the adjoining granite.

(6) In beds of actinolite rock interstratified with slates.

Inasmuch as the granite intrusives have in many places profoundly modified the sedimentary rocks surrounding and enveloping them, with the production of numerous unusual and heavy minerals, it has happened that the contact-metamorphic deposits have received the most attention. This tendency to regard the contacts as favorable ore horizons has been strengthened partly by the fact that some rich masses of tin ore have been found near tourmalinized limestone, and partly by the deceptive resemblance which the heavy contact minerals, such as garnet, bear to cassiterite. The chances of finding workable tin mines in deposits of this type are, however, extremely slight. Quartz porphyry dikes, locally known as lodes or even as quartz veins, have received considerable attention owing to the fact that the original discovery of lode tin in Alaska was made on a highly altered dike of this character. The unwelcome fact should be speedily realized that few of these dikes hold out any inducements whatever as prospective tin producers. Of the other types of occurrence, some of which are of promising character, it can be said that, from the point of view of the conservative mining man, their value remains yet to be proved.

Developments throughout the region are for the most part still in the prospecting stage. Many of the open cuts have not reached solid bed rock. No tonnage of ore, with one exception on Lost River, has yet been blocked out. It follows, then, that, on account of inadequate development, no data are available for a safe estimate of the future commercial importance of the Alaska tin deposits. The region is plainly not "a poor man's country," but appears, however, to offer a limited field for cautious exploration by capital.

The placer deposits, and those from a single stream only—Buck Creek—have so far supplied the bulk of the Alaskan tin.

THE MINERAL DEPOSITS OF THE LOST RIVER AND BROOKS MOUNTAIN REGION, SEWARD PENINSULA.

By Adolph Knopf.

INTRODUCTION.

Lost River is a small stream rising in the heart of the York Mountains, in the western part of Seward Peninsula. It flows southward into Bering Sea and has a total length of 9 miles. Its valley is broad and open and furnishes a good wagon roadway. The region is destitute of vegetation, even the arctic mosses being scarce. The general geologic features are described in the preceding paper. The Lost River region displays a varied mineralization, and prospecting has disclosed, in addition to the tin deposits previously described, occurrences of silver-lead, tungsten-lead, copper, and perhaps gold deposits.

ALASKA CHIEF PROPERTY.

The Alaska Chief is situated 4½ miles from Bering Sea on Rapid River, the large western branch of Lost River. The workings are located on a small gulch tributary to Rapid River. The country rock in the vicinity of this property is a tough, fine-grained limestone, lying nearly horizontal. Locally the strata are buckled and show crushing in the crests of the buckles. A fault breccia, 15 feet wide, consisting of small angular fragments of limestone cemented together by white calc-spar, is exposed in the creek one-third of a mile west of the mine. Basalt, in the form of a narrow dike 1 foot thick, is the only other rock known to be in place in the near vicinity. A few thousand feet to the east a number of quartz porphyry dikes can be seen cutting the limestone.

The original shaft was sunk on a heavy body of porous red iron oxide containing galena, reported to be 12 feet thick. At a depth of 35 feet work was suspended. An adit, 143 feet long, driven 85 feet below the collar of the shaft, encountered the same ore body 50 feet below the bottom of the shaft. The ore was still oxidized. About 7 feet of low-grade galena ore was exposed.

On the east side of the gulch a devious tunnel, about 600 feet in length, was driven to catch another body of galena indicated on the surface. The tunnel follows a zone of crushed limestone, in many places bounded by fine walls marked with striæ. The " ledge matter " consists of small fragments of limestone bound together by coarse calc-spar, clay, and red iron oxide. No ore was encountered. The tunnel on the west side of the gulch was then commenced, and the ore body already mentioned was struck late in August, 1907.

IDAHO CLAIM.

A few yards below the mouth of Tin Creek a copper prospect has been opened on the edge of the 15-foot bench fronting Lost River. Enough work had been done to expose the face of ore at this point. The deposit occurs in an irregular shatter zone in the limestone, 15 feet wide, and includes numerous horses of unmineralized limestone. The ore mineral is chalcopyrite, associated with abundant pyrrhotite (magnetic iron pyrites), and occurs in a gangue of calcite, fluorite, and small fragments of slickensided rock. Some of the fluorite is rose tinted and is locally known as ruby quartz. Stripping has shown that the same ore body extends at least 50 feet to the east, where a strong gossan has been uncovered. The relatively great width of the deposit, combined with the low chalcopyrite tenor and the large amount of pyrrhotite present, reduces the copper percentage to a small figure.

TIN CREEK.

On Tin Creek a galena prospect has been opened up on some gossan croppings at an altitude of 1,100 feet, or 800 feet above the bed of the creek. The deposit occurs in a fracture zone in the limestone, which has been coarsely recrystallized in the immediate vicinity, forming spar crystals up to an inch in size. The gossan consists of honeycombed masses of iron oxide containing abundant galena and numerous white and colorless crystals of cerusite (lead carbonate). It was planned to prove the value of this deposit during the winter of 1907.

A small trench, 650 feet below the galena prospect, has been dug in the effort to locate the bed-rock source of some loose bowlders composed of arsenopyrite flecked with a small amount of cupriferous pyrite. Assays made in Nome are reported to have yielded $12 to the ton in gold.

On the divide at the head of Tin Creek stibnite associated with a deep-purple fluorite was found by a member of the Survey party.

BROOKS MOUNTAIN.

Brooks Mountain is the dominant peak of the York Mountains, and lies in the watershed of the Bering and Arctic drainages. It is easily accessible from the coast by way of Lost River, a distance of 9 miles. The mineral deposits of Brooks Mountain are all of contact-metamorphic origin.

A large granite mass, 2 miles long by two-thirds of a mile wide, forms the southern flank of the mountain. The rocks surrounding the granite are chiefly limestones, excessively crumpled over much of the region. The granite is characterized by the presence of numerous large crystals of feldspar, commonly an inch in diameter, and large crystals of smoky quartz exceeding peas in size. Through the body of the rock are scattered many small flakes of black mica. Along the margin of the granite mass the granite has been strongly tourmalinized, and large masses of black tourmaline are of common occurrence. Theoretically, it might be expected that such a granite would have exerted a considerable influence on the surrounding rocks. This expectation is completely realized. A great variety of contact-metamorphic minerals have been produced, among which a green or brown-green vesuvianite is the most abundant. Much of the vesuvianite occurs in beautiful crystals embraced in a matrix of white spar, and the interesting discovery has been made that it contains boron, the element characteristic of tourmaline. Among the other minerals produced in the rocks adjoining the granite are garnet, magnetite, argentiferous galena, a brilliant black sphalerite, pyrrhotite, pyrite, arsenopyrite, fluorite, mica, tourmaline, a coal-black iron borate (as at Ear Mountain), a magnesian iron borate, and a fibrous green borate resembling ludwigite. This array of minerals, consisting of numerous species foreign to the prospector's acquaintance and of relatively high specific gravity, has naturally excited some attention, and a number of prospects have been opened on these contact-metamorphic deposits. It seems desirable to repeat the cautions given in connection with the similar types occurring on Ear Mountain. Contact-metamorphic deposits are, as a rule, characterized by extreme irregularity of form; they can not persist into the granite; furthermore, such deposits as occur in small masses of limestone, resting upon or embedded in the granite, can have only a very small extent. It is therefore advisable to consider carefully the geologic surroundings of even the most promising surface indications.

At the west end of the Brooks Mountain granite mass a prospect trench discloses a body of argentiferous galena ore. The deposit occurs 20 feet from the granite contact, in a coarsely crystalline white limestone. The strike of the ore body, as revealed in the open cut, is N. 15° W. (magnetic) and the dip 65° toward the granite. A body of solid ore 3½ feet thick is exposed. The galena is strongly mixed with lustrous black zinc blende. Some pyrrhotite is also present, but is comparatively rare. Where any gangue mineral is visible, it consists of fluorite. The ore body is frozen to both walls. The hanging wall shows a belt of finely granular fluorite several inches thick, succeeded by extremely coarse calcite containing a few crystals of diopside and some galena. The grain of the calcite decreases away from the ore body.

In the vicinity of the galena prospect contact-metamorphic rocks are found containing vesuvianite and a fibrous green boron mineral intercrystallized with galena. It is clear that the galena ore, with its unusual mineral associations, is of contact-metamorphic origin. Assays made in Nome yielded 34 per cent of lead and 11 ounces of silver per ton. Other assays were reported to give an ore value of $17 and $44 per ton.

In the same general locality some contact masses of vesuvianite have been prospected for nickel. The vesuvianite is finely granular and gives the rock a general green color. This feature and the unusual weight of the rock (that is, compared with quartz) are doubtless responsible for the nickel prospecting. No indications of nickel are present, and it may be added that such a mode of occurrence for nickel is totally unknown.

In the canyon below the galena claim some assessment work has been done on a showing of contact-metamorphic minerals. This deposit is interesting from a scientific standpoint, inasmuch as a hitherto unknown boron mineral has been discovered in it, but nothing of commercial importance has been found here. The minerals comprise brown garnet, much of it showing rhombic faces, green or yellowish-green vesuvianite, and abundant magnetite closely associated with the new mineral—a black mineral showing a fine cleavage and a bright submetallic luster. These various minerals are all included in a matrix of coarse white spar.

At the head of the same canyon some more contact-metamorphic deposits have received attention. Here, at an altitude of 2,000 feet, a small prospect hole exposes a mass of metamorphic minerals occurring in a white marble a few feet from the granite contact. Tourmaline, fluorite, calcite, pyrite, arsenopyrite, and brilliant black sphalerite (an iron-rich zinc blende) occur confusedly intergrown. The ore body is 4 feet thick and penetrates the marmorized limestone in irregular tongues. Some galena was noted in the ends of these tongues. The value of this deposit is problematic. A few hundred feet farther north the limestone has undergone an intense contact metamorphism. The resulting product consists of vesuvianite, calcite, and garnet interspersed with minute flakes of mica (phlogopite). Some of this rock contains sphalerite and other sulphurets, which on oxidizing give it a gossan appearance. High gold assays were claimed from this type of rock. Ledoux & Co., of New York, report on an assay sample submitted by the Survey: Gold, trace; silver, 0.23 ounce.

On the north side of Brooks Mountain, at an altitude of 1,850 feet, is located a small galena prospect. The galena occurs in a gossan, the skeleton of which consists of tourmaline. The iron oxide of the gossan contains lead and bismuth.

WATER SUPPLY OF THE NOME AND KOUGAROK REGIONS, SEWARD PENINSULA, 1906-7.

By Fred F. Henshaw.

INTRODUCTION.

The operation of the gold placers in Seward Peninsula had by 1906 reached such a stage of development that its future success was largely dependent on the possibility of mining large bodies of relatively low-grade gravel. The most common method of working such ground has been by hydraulicking. For this method a large and steady supply of water under a high head is a necessity. To obtain such a supply a large number of ditches have been built, many of them long and constructed at great expense. There was little exact information as to the available water supply, and many of these hydraulic works have been failures owing to insufficiency of water. Most of these failures could have been averted had reliable data been at hand in regard to stream flow.

For these reasons the United States Geological Survey started systematic measurements of the flow of streams in Seward Peninsula in 1906.[a] Owing to the smallness of the funds available, the work was confined to the southern portion, and especially to the streams from which water could have been taken for working the rich placers near Nome, as shown on the Nome and Grand Central topographic sheets. In 1907 the work in this district was continued and the investigations were extended into the Kougarok region, north of the Kigluaik Mountains.

These investigations consisted in (*a*) determining both the total flow and the distribution of the flow of various streams during the mining season; (*b*) collecting facts in regard to general conditions affecting water supply; (*c*) gathering statistics in regard to the diversion and use of water:

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[a] Hoyt, J. C., and Henshaw, F. F., Water supply of Nome region, Seward Peninsula, 1906: Water-Sup. and Irr. Paper No. 196, U. S. Geol. Survey, 1907; Bull. U. S. Geol. Survey No. 314, 1907, pp. 182–186.

MEASUREMENTS.

Discharge measurements were made at 45 points in 1906 and at 42 in the Nome region and 32 in the Kougarok in 1907. The detailed results of these measurements are given in Water-Supply Paper No. 218, from which the following summaries are taken. Table 1 shows the monthly discharge at stations where daily discharges could be computed. Table 2 gives the minimum flow of streams rising in the foothills, in the mountains, and in the Kougarok region. The results are in second-feet. To reduce to miner's inches of 1.5 cubic feet per minute, multiply by 40; for miner's inches of 1.2 cubic feet per minute, multiply by 50.

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7.*

STREAMS RISING IN FOOTHILLS.

NUGGET CREEK AT MIOCENE INTAKE.

[Drainage area, 2.1 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 9-31	12.0	3.8	5.7	2.71	2.32
August	10.6	2.8	6.2	2.95	3.40
September	40	6.8	11.0	5.24	5.85
84 days	40	2.8	7.8	3.71	11.57

JETT AND COPPER CREEKS (COMBINED).

[Drainage area, 2.25 square miles.]

1907.					
July	40	5.9	17.3	7.69	8.87
August	15	3.9	7.1	3.16	3.64
September	49	2.9	9.6	4.27	4.76
92 days	49	2.9	11.3	5.04	17.27

DAVID CREEK AT MIOCENE INTAKE.

[Drainage area, 4.3 square miles.]

1907.					
July	76	10.9	32.2	7.49	8.64
August	30	8.9	14.2	3.30	3.80
September	107	8.3	20.7	4.81	5.37
92 days	107	8.3	22.4	5.20	17.81

HOBSON CREEK AT MIOCENE INTAKE.

[Drainage area, 2.6 square miles.]

1907.					
June 28-30	26.7	25.0	25.8	9.92	1.11
July	25.8	19.6	22.6	8.69	10.02
August	20.4	14.3	17.1	6.58	7.59
September	22.3	16.5	19.1	7.38	8.20
95 days	26.7	14.3	19.8	7.62	26.92

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN FOOTHILLS—Continued.

SNAKE RIVER ABOVE GLACIER CREEK.

[Drainage area, 69 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
June 25-30	540	258	401	5.81	1.30
July	308	120	177	2.56	2.95
August	135	77	108	1.56	1.80
September 1-15	540	111	207	3.00	1.67
83 days	540	77	173	2.51	7.72

PENNY RIVER AT SUTTON INTAKE.

[Drainage area, 19 square miles.]

1907.					
July	181	55	78.7	4.14	4.77
August	88	33	59.0	3.11	3.58
September	175	45	71.1	3.74	4.17
92 days	181	33	69.6	3.66	12.52

STREAMS RISING IN KIGLUAIK MOUNTAINS.

NORTH FORK OF GRAND CENTRAL RIVER AT THE FORKS.

[Drainage area, 6.9 square miles.]

1907.					
July 8-31	80	32	48.7	7.06	6.30
August	152	27	58.1	8.42	9.71
September 1-23	238	21	64.7	9.38	8.02
78 days	238	21	57.2	8.29	24.03

NORTH FORK OF GRAND CENTRAL RIVER NEAR DITCH INTAKE.

[Drainage area, 5.4 square miles.]

1906.					
July (17 days)	----------	23	39.9	7.39	4.67
August	71	25	36.7	6.80	7.84
September 1-18	----------	25	31.6	5.85	3.92

NORTH FORK OF GRAND CENTRAL RIVER AT PIPE INTAKE.

[Drainage area, 2.3 square miles.]

1906.					
July 1-4, 20-31	48	21	30.3	13.2	7.86
August	53	19	27.4	11.9	13.7
September 1-18	31	17	22.2	9.65	6.46
65 days	----------	17	26.6	11.6	28.0
1907.					
July 8-31	64	26	39.0	16.9	15.1
August	110	20	43.5	18.9	21.8
September 1-23	171	15	46.5	20.2	17.3
88 days	171	15	43.0	18.7	54.2

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS—Continued.

WEST FORK OF GRAND CENTRAL RIVER AT THE FORKS.

[Drainage area, 7.7 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 8–31	140	42	84.5	11.0	9.82
August	291	42	81.0	10.5	12.1
September 1–23	406	34	100	13.0	11.1
78 days	406	34	87.8	11.4	33.0

WEST FORK OF GRAND CENTRAL RIVER AT DITCH INTAKE.

[Drainage area, 5.4 square miles.]

1906.					
July 1–5, 10–31	162	22	62.0	11.5	11.5
August	54	21	32.5	6.02	6.94
September 1–18	44	19	25.5	4.72	3.16
76 days	162	19	41.3	7.65	21.6
1907.					
July 8–31	110	28	60.0	11.1	9.90
August	103	35	50.2	9.30	10.7
September 1–23	149	31	50.7	9.39	8.03
78 days	149	28	53.4	9.89	28.6

WEST FORK OF GRAND CENTRAL RIVER AT PIPE INTAKE.

[Drainage area, 2.8 square miles.]

1906.					
July 1–4, 11–31	72	12	27.0	9.64	8.96
August	30	7.6	13.9	4.96	5.72
September	22	6	9.4	3.36	2.25
74 days	72	6	17.2	6.14	16.93
1907.					
July 8–31	48	12	26.4	9.43	8.42
August	52	11	17.6	6.29	7.25
September 1–23	74	10	20.5	7.32	6.26
78 days	74	10	21.2	7.64	21.93

CRATER LAKE OUTLET.

[Drainage area, 1.8 square miles.]

1906.					
July 1–5, 10–31	69	8	22.3	12.4	12.4
August	31	5	11.8	6.56	7.56
September 1–18	13	3.1	5.2	2.89	1.93
76 days	69	3.1	14.0	7.78	21.9
1907.					
July 8–31	40	12	24.4	13.6	12.1
August	52	8	26.0	14.4	16.6
September 1–23	106	3.5	21.0	11.7	10.0
78 days	106	3.5	24.0	13.3	38.7

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS—Continued.

GRAND CENTRAL RIVER BELOW THE FORKS.

[Drainage area, 14.6 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1906.					
July 1–5, 9–31	370	56	144	9.86	10.27
August	210	53	85.2	5.84	6.73
September 1–18	100	47	62.0	4.25	2.84
77 days	370	47	101	6.92	19.84

THOMPSON CREEK.

[Drainage area, 2.5 square miles.]

1906.					
July 1–4, 11–31	52	10	20.5	8.20	7.62
August	40	9	16.6	6.64	7.66
September 1–18	19	5	7.6	3.04	2.10
74 days	52	5	15.7	6.28	17.38
1907.					
July 8–31	87	27	42.2	16.9	15.1
August	50	9	27.0	10.8	12.4
September 1–23	100	5	22.8	9.12	7.80
78 days	100	5	30.4	12.2	35.3

GOLD RUN.

1906.					
July 1–4, 11–31	69	13	29.0		
August	68	15	27.6		
September 1–18	30	10	15.3		
74 days	69	10	25.1		
1907.					
July 8–31	86	18	47.0		
August	90	13	41.1		
September 1–23	120	10	32.1		
78 days	120	10	40.1		

KRUZGAMEPA RIVER AT SALMON LAKE.

[Drainage area, 81 square miles.]

1906.					
May 28–31	3,270	2,180	2,720	33.6	5.00
June 1–7, 23–30	2,520	308	1,160	14.3	8.00
July	2,130	245	571	7.05	8.13
August	475	175	259	3.20	3.69
September	1,455	175	456	5.63	6.28
111 days	3,270	175	610	7.53	31.00
1907.					
June 15–30	2,360	935	1,480	18.3	10.9
July	875	295	548	6.77	7.80
August	555	229	335	4.14	4.77
September	1,560	217	477	5.89	6.57
October 1–5	205	178	187	2.31	.43
113 days	2,360	178	587	7.25	30.47

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906-7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS—Continued.

NOME RIVER AT MIOCENE INTAKE.[a]

[Drainage area, 15 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1906.					
July	260	21	51.4	3.43	3.95
August	176	20	50.4	3.36	3.87
September	194	25	64.4	4.29	4.79
92 days	260	20	55.4	3.69	12.61
1907.					
June 15-30	384	124	202	13.5	8.03
July	168	23	72.2	4.81	5.54
August	75	16	32.9	2.19	2.52
September	307	18	58.4	3.89	4.34
108 days	384	16	76.4	5.09	20.43

UPPER SINUK RIVER.

[Drainage area, 6.2 square miles.[b]]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	100	24	52.3	8.44	9.73
August	100	22	45.0	5.49	6.33
September 1-22	160	7	53.7	6.55	5.36
84 days	160	7	50.0	6.86	21.42

NORTH STAR CREEK.

[Drainage area, 2.3 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	30	4	14.8	6.43	7.41
August	25	4	8.3	3.61	4.16
September 1-22	40	2	8.9	3.87	3.16
84 days	40	2	10.9	4.74	14.73

WINDY CREEK.

[Drainage area, 12 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	140	40	91.5	7.62	8.78
August	125	32	59.2	4.93	5.68
September 1-22	200	15	68.1	5.68	4.65
84 days	200	15	73.4	6.12	19.11

STREAMS IN THE KOUGAROK REGION.

KOUGAROK RIVER AT HOMESTAKE INTAKE.

[Drainage area, 44 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 15-31	29	6.3	12.4	0.28	0.18
August	110	3.2	22.8	.52	.60
September 1-20	351	26	79.1	1.80	1.34
68 days	351	3.2	36.8	.84	2.12

[a] These values are the natural flow of the river and have been found by subtracting the flow of the David Creek, Nugget Creek, and Jett Creek ditches from the actual flow, and adding that of Campion ditch.

[b] 8.2 after August 1.

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS IN THE KOUGAROK REGION—Continued.

TAYLOR CREEK AT CASCADE INTAKE.

[Drainage area, 74 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 15–31	186	8	29.9	0.40	0.25
August	186	3.9	54.2	.73	.84
September 1–20	441	35	119	1.61	1.20
68 days	441	3.9	67.1	.91	2.29

KOUGAROK RIVER ABOVE COARSE GOLD CREEK.

[Drainage area, 250 square miles.]

1907.					
July 14–31	200	33	67.2	0.27	.18
August	490	16	141	.56	.65
September 1–20	1,240	130	388	1.55	1.15
69 days	1,240	16	193	.77	1.98

TABLE 2.—*Minimum daily flow of streams in Seward Peninsula, 1906–7.*

STREAMS RISING IN FOOTHILLS.

Stream.	Elevation.	Drainage area.	1906.			1907.		
			Date.	Minimum flow.	Minimum run-off per square mile.	Date.	Minimum flow.	Minimum run-off per square mile.
	Feet.	*Sq. m.*		*Sec.-ft.*	*Sec.-ft.*		*Sec.-ft.*	*Sec.-ft.*
Iron Creek below mouth of Canyon Creek.	450	50	Aug. 14	17.1	0.34	Aug. 11–14	33	0.66
Eldorado River below mouth of Venetia Creek.	400	51	Aug. 14	44	.86			
Jett Creek	800	1.4	Sept. 10	[a]4.2	3.0	Sept. 23 (Jett and Copper creeks)	[b]2.9	1.3
Copper Creek	800	.85	Aug. 11	.8	.94			
Nugget Creek	785	2.1	June 28	[c].96	.46	Aug. 10–11	2.8	1.3
David Creek	590	4.3	Aug. 19	3.3	.77	Sept. 30	8.3	1.9
Dorothy Creek	500	2.7	Aug. 18	2.9	1.1			
Hobson Creek	500	2.6	July 4	10.5	[d]4.0	Aug. 19	14.3	5.5
Slate Creek (tributary to Stewart River).	700	2.1	Aug. 19	2.2	1.05			
Stewart River	400	36	Aug. 19	11.4	.32			
Snake River	40	69				Aug. 12	77	1.1
Penny River	120	19	Aug. 1	[a]36	1.9	Aug. 15	33	1.7

[a] Lowest measurements obtained. The flow was less on certain dates.
[b] Jett and Copper creeks combined.
[c] The lowest flow later in 1906 was 3.0 second-feet, or 1.4 second-feet per square mile, on August 11.
[d] The flow of Hobson Creek is from large limestone springs whose catchment area may not coincide with the surface watershed.

TABLE 2.—*Minimum daily flow of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS.

Stream.	Elevation.	Drainage area.	1906. Date.	1906. Minimum flow.	1906. Minimum run-off per square mile.	1907. Date.	1907. Minimum flow.	1907. Minimum run-off per square mile.
	Feet.	*Sq. m.*		*Sec.-ft.*	*Sec.-ft.*		*Sec.-ft.*	*Sec.-ft.*
North Fork of Grand Central River near ditch intake.	750	5.4	July 1	23	4.3			
West Fork of Grand Central River at ditch intake.	850	5.4	Sept. 15–17	19	3.5	July 29	28	5.2
Crater Lake outlet	925	1.8	Sept. 15–17	3.1	1.7	Sept. 22–23	3.5	1.9
Thompson Creek	720	2.5	Sept. 16–17	5	2.0	Sept. 22–23	5	2.0
Grand Central River below forks.	690	14.6	Sept. 16–17	47	3.1	Aug. 15	72	4.9
Grand Central River below Nugget Creek.	455	39	Sept. 16–17	90	2.3			
Grand Central River between station below the forks and station at Nugget Creek.		24.4	Sept. 16–17	43	1.76			
Kruzgamepa River	442	81	Aug. 19 and Sept. 17.	175	2.16	Oct. 5	178	2.2
Crater Creek	550	11	Sept. 16–17	39	3.5			
Fox Creek	550	11	Aug. 16	17.3	1.6			
Nome River	575	15	Aug. 5	20	1.3	Aug. 15	16	1.1
Buffalo Creek	800	4.4	Aug. 3	9.1	2.1			
Sinuk River	770	[b]6.2	Aug. 3	20	3.2	Aug. 15	[a]22	2.7
North Star Creek	900	2.3	Aug. 10	2.9	1.26	Aug. 7	[a]4	1.7
Windy Creek	650	12	Aug. 3	32	2.7	Aug. 15	[a]32	2.7

STREAMS IN THE KOUGAROK REGION.

Stream.	Elevation.	Drainage area.	1906. Date.	1906. Minimum flow.	1906. Minimum run-off per square mile.	1907. Date.	1907. Minimum flow.	1907. Minimum run-off per square mile.
Kougarok River at Homestake intake.		44				Aug. 13	3.2	0.07
Kougarok River above Coarse Gold Creek.		250				Aug. 9–12	16	.06
Taylor Creek at Cascade intake.		74				Aug. 14	3.9	.05
Henry Creek at mouth		50				Aug. 13	6.8	.14
North Fork above Eureka Creek.		66				Aug. 15	9.6	.15
Noxapaga River		340				Aug. 16	62	.18
Turner Creek		13				Aug. 15	.7	.05
Budd Creek		58				Aug. 21	25	.43

[a] Minimum in midseason. [b] 8.2 after August 1, 1907.

AVAILABLE WATER SUPPLY.

In order to show the water supply available during 1906 and 1907 for the Nome and Kougarok regions the mean flow of streams in each drainage basin has been tabulated by weekly periods. The following table should not be taken as indicating the amount of water that could be used, which will, of course, be limited by the capacity of the ditches that have been or may be built.

The working season of the Miocene ditch was from June 20 to October 13, 1906, and from June 27 to October 3, 1907. The water of Hobson Creek was running in the ditch between these dates. The Nome River water was used from June 26 to October 12, 1906, and from July 3 to October 3, 1907. These dates mark the limit of the period during which water could have been used in any of the ditches of the Nome region. The season for Grand Central and Sinuk rivers would have been at least a week shorter at each end of both years, as the snow lasts longer and the slush ice begins to run earlier at the higher elevations where these streams rise. The working season may begin somewhat earlier in the Kougarok region than it does south of the mountain, as there is a lighter snowfall, and the ditches can be cleaned out earlier. The season closed on September 21, 1906, and September 20, 1907.

Especial attention is called to the small rate of run-off from the streams in the Kougarok region as compared with that of Grand Central, Nome, and Sinuk rivers. This is due to the extremely small rainfall in the northern area, as indicated by the records obtained at Shelton and Taylor. (See p. 282.) This condition is believed to prevail over the entire northern portion of Seward Peninsula. Caution should therefore be used in future hydraulic development in that section, to determine whether the water supply is sufficient.

Mean weekly water supply, in second-feet, available for use back of Nome, 1906–7.

Date.	Available for use at elevation 220 to 280 feet, Nome River low level.	Available for use at elevation 400 to 450 feet.				Total.
		Nome River high level.	Upper Grand Central River, Thompson Creek, and Gold Run.	Nugget, Copper, and Jett creeks.	Sinuk River, Windy and North Star creeks.	
1906.						
July 1–7	43	45	153	7	88	324
July 8–14	155	144	[a]343	26	173	796
July 15–21	52	58	179	15	90	378
July 22–28	43	49	156	12	79	325
July 29–August 4	36	42	101	8	50	223
August 5–11	39	45	108	8	49	236
August 12–18	49	53	91	8	42	228
August 19–25	81	84	138	10	62	352
August 26–September 1	130	128	202	22	94	540
September 2–8	68	73	101	14	51	287
September 9–18	48	53	68	9	36	199
September 19–30	120	118	250	20	125	599
Mean	72	74	158	13	78	375
Maximum	155	144	343	26	173	796
Minimum	36	42	68	7	36	199
1907.						
July 1–7	135	199	([b])	36	152	522
July 8–14	102	152	292	27	172	745
July 15–21	84	107	228	21	143	583
July 22–28	60	77	183	15	105	440
July 29–August 4	44	59	144	11	77	335
August 5–11	36	49	107	8	50	250
August 12–18	49	62	190	13	95	409
August 19–25	47	61	245	15	86	454
August 26–September 1	72	89	318	18	124	621
September 2–8	51	63	142	14	72	342
September 9–15	176	204	418	40	167	1,005
September 16–23	60	76	115	24	62	337
September 24–30	45	56	([b])	15	([b])	116
Mean	74	96	216	20	109	473
Maximum	176	204	418	40	172	1,005
Minimum	36	49	107	8	50	116

[a] Too small; no record of highest water.
[b] No record. No water could have been used from Grand Central River the first week in July on account of snow, nor from either Grand Central or Sinuk rivers the last week in September on account of slush ice.

Mean weekly water supply, in second-feet, of Kougarok River drainage basin, 1907.

Date.	For Dahl Creek at elevation 300 to 350 feet.			For upper Kougarok at elevation 600 to 700 feet.					
	Kougarok River.	North Fork.	Total.	Kougarok River.	Taylor Creek.	Henry Creek.	Coarse Gold Creek.	North Fork.	Total.
July 15-21	57	22	79	14	16	19	12	5.2	66
July 22-28	88	22	110	13	53	14	9.6	3.0	93
July 29-August 4	33	12	45	6.7	7.3	7.3	3.8	1.2	26
August 5-11	21	10	31	5.4	5.0	6.3	3.3	1.0	21
August 12-18	26	13	39	4.5	9.0	5.4	3.9	1.0	24
August 19-25	328	73	401	60	117	28	29	30	264
August 26-September 1	262	83	345	33	117	21	26	27	224
September 2-8	331	76	407	57	100	33	27	21	238
September 9-15	584	117	701	133	181	94	100	44	552
September 16-20	228	45	273	46	68	33	39	17	203
Mean	196	47	243	37.3	67.3	26.1	25.4	15.0	171
Maximum	584	117	701	133	181	94	100	44	552
Minimum	21	10	31	4.5	5.0	5.4	3.3	1.0	21

SUMMARY OF DITCHES IN NOME REGION.

The following table has been prepared to show in a concise manner the flow of the ditches which take their water supply from Nome River and its tributaries, and from near-by streams. It is also of value for comparison with the discharge of the streams from which the water is taken, to show the percentage of flow that can be delivered by a ditch at the point where it is to be used.

Monthly discharge of ditches in Nome region, 1907.

Ditch.	Point of measurement.	Yearly maximum.	July.		August.	September.
		Sec.-feet.	*Days.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*
Campion	Black Point	18.0	25	9.0	12.9	12.5
Miocene	Black Point	42.6	29	28.0	34.4	38.7
	Clara Creek	37.0	29	25.4	28.7	33.7
	Above Hobson Creek	34.9	29	23.6	27.4	31.8
	Below Hobson Creek	54.7	31	43.8	45.3	47.9
	Flume	55.2	31	45.1	44.0	50.4
	David Creek branch	16.5	15	11.3	11.8	9.0
	Jett Creek branch	8.2	20	4.9	6.1	[a]6.1
	Grand Central branch	13.4	23	5.7	6.2	9.0
Seward	Nome River intake	29.0	21	23.9	26.2	25.7
	Hobson Creek branch		26	5.2	4.3	4.5
Pioneer	Nome River intake [b]	26.8	16	20.4	22.2	21.8
	Hobson branch					5.8
Sutton	Intake	35.0	31	23.9	23.8	31.8
Cedric	Penstock	17.8	10	12.3	12.9	9.6

[a] Mean for 14 days.
[b] Values for Pioneer ditch have been estimated at 85 per cent of those for Seward ditch; this was the proportion during the time for which records were obtained on both ditches.

RAINFALL.

In connection with the stream gaging, rainfall records were obtained at three stations in 1906 and at six in 1907. Observations of rainfall, precipitation, temperature, and barometric pressure were made during the winter at Nome by Arthur Gibson, C. E.

Monthly rainfall, in inches, at stations on Seward Peninsula, 1906–7.

Station.	Elevation.	June.	July.	August.	September.	Total, June to August.	Total, June to September.	Total, July to September.
1906.	*Feet.*							
Nome	40	Trace.	2.38	2.50	1.02	4.88	5.90	5.90
Salmon Lake	450	Trace.	4.92	3.33	3.26	8.25	11.51	11.51
Ophir	200	Trace.	3.57	1.91	(a)	5.48	----------	----------
1907.								
Nome	40	1.31	2.08	2.68	1.41	----------	7.48	6.17
Black Point	575	2.62	1.94	2.85	3.26	----------	10.67	8.05
Salmon Lake	450	2.31	1.79	3.65	2.26	----------	10.01	7.70
Grand Central	690	(a)	3.61	7.19	5.06	----------	----------	15.86
Shelton	60	(a)	.71	1.33	.47	----------	----------	2.51
Taylor	550	(a)	.66	.96	1.17	----------	----------	2.79

[a] No record.

Monthly summary of weather observations at Nome, December, 1906, to November, 1907.

	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Annual.
Rainfall,[a] inches	1.91	2.64	1.46	3.37	0.10	1.12	1.31	2.08	2.68	1.41	0.16	0.06	18.30
Snowfall, inches	20.8	25.2	13.9	28.8	......	......	......	......	......	......	1.7	1.5	91.9
Temperature (°F.):													
Monthly maximum	29	33	31	33	41	49	65	66	69	52	44	39	69
Monthly minimum	−15	−24	−31	−32	−14	15	30	34	30	29	3	−12	−32
Mean of daily maxima	13.3	19.7	−0.8	14.2	25.9	39.5	52.1	55.9	55.8	46.4	30.0	15.9	30.7
Mean of daily minima	−0.2	4.2	−14.4	−3.1	12.1	29.1	38.9	44.2	43.8	35.7	19.0	3.1	17.7
Mean	6.8	11.9	−7.6	5.6	19.0	34.3	45.5	50.0	49.8	41.1	24.5	9.5	24.2
Mean barometer, inches	30.17	30.24	30.02	30.01	30.01	30.03	29.91	29.88	29.74	29.64	29.74	29.65	29.92
Number of days—													
Clear	16	10	19	11	18	10	12	10	8	13	15	10	152
Partly cloudy	4	4	2	2	2	5	5	4	9	6	3	4	50
Cloudy	11	17	7	18	10	16	13	17	14	11	13	16	163

[a] Including melted snow.

NOTE.—The rainfall for October, 1906, was 0.93 inch, and for November, 1906, 0.32 inch.

The following statement gives briefly the climatic conditions existing in this area during the years 1899–1907:

1899. July, four rainy days; August, fourteen rainy days; September, fourteen rainy days; recorded at Teller.

1900. June and July, warm and dry, tundra fires common; August to end of September, rain.

1901. June to August, inclusive, cold and foggy with some rain; September and October, usually clear and cold with one or two hard rains of a few days' duration.

1902. June, dry; July, ten rainy days; August, six rainy days; September, three rainy days; recorded at Teller.

1903. Summer warm; little rain, but considerable fog.

1904. June, dry; rainy days as follows: Ten in July, ten in August, ten in September; temperature moderate.

1905. Very wet and cold the whole season.

1906. Very warm and dry; tundra fires common; maximum temperature 85°.

1907. A heavy snowfall and a late spring; rainfall not excessive, but water supply of Nome region good on account of its even distribution throughout the season.

HYDRAULIC DEVELOPMENTS IN 1907.

NOME REGION.

Construction work was done on several ditches in the Nome region during 1907, but so far as known no new ones were started.

The Nome River ditch of the Pioneer Mining Company was completed about July 15. Three siphons were required—one across Hobson Creek, 545 feet long, one across Banner Creek, 1,050 feet long, and one across Dexter Creek, 755 feet long.

The Independent ditch on Osborne Creek, which has been described by Moffit,[a] was completed in July and the water was used during about half of the season.

On the developments in upper Grand Central River little work was done, pending a settlement of the question of the ownership of the water rights. The Miocene Ditch Company built somewhat less than a mile of ditch. The Wild Goose Mining and Trading Company put together about a mile of its wood-stave pipe line. No work was done on the power plant at Salmon Lake.

IRON CREEK.

Two ditches were built to work ground on lower Iron Creek. One has its intake below Canyon Creek, and is 2 miles long and 6 feet wide on the bottom. A head of 50 feet is obtained. The other ditch, which was mentioned by Smith,[b] takes its water from Rock, Slate, and Willow creeks, tributaries of Kruzgamepa River, and conveys it over the divide to work ground on Bobs and Iron creeks. The ditch is 8 miles long and 3 feet wide on the bottom, but will probably be enlarged. A head of 350 feet above the bed of Iron Creek is obtained.

KOUGAROK REGION.

Much activity was shown in ditch building in the Kougarok region and in the territory immediately adjoining it. Of the ditches on Kougarok River and its tributaries which have been previously described,[c] those on Henry Creek and North Fork were not used in 1907. Much sodding and other repair work was done on the other four—the Homestake, North Star, Cascade, and Irving ditches—and water was turned into them on different dates in July and August. No ditch operator was able to mine throughout the season, on account of delay in starting and the extreme drought that occurred during the first half of August.

[a] Moffit, F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 142.

[b] Smith, P. S., Geology and mineral resources of Iron Creek: Bull. U. S. Geol. Survey No. 314, 1907, p. 163.

[c] Moffit, F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, pp. 143–144. Brooks, A. H., The Kougarok region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 169–170.

A number of other ditches were begun in 1907. The Coarse Gold ditch takes its water from that creek about 5 miles above its mouth, and extends along its south bank to Twobit Gulch, a small tributary of Kougarok River, a distance of between 5 and 6 miles. The ditch is 8 feet wide, but it is planned to widen it and extend it eventually to Dahl Creek. The McKay Hydraulic Mining Company built about 17 miles of 4-foot and 5-foot ditch from Turner Creek to the benches of Noxapaga River near Goose Creek. Most of this ditch was built over ground ice, which caused much trouble by thawing and settling. The Pittsburg-Dick Creek Mining Company finished its ditch on Bryan Creek and began another which will take water from Quartz and Bismarck creeks. The Bryan Creek ditch is 6½ miles long and 6 feet wide, and gives a pressure of about 170 feet at the mouth of Dick Creek, a tributary of Bryan Creek which will be mined.

The Quartz Creek ditch is 8 miles long and 8 feet wide on the bottom. It will discharge into the Bryan Creek ditch, which is about 350 feet lower in elevation, but it is possible to extend it to the head of Dick Creek, a total distance of over 20 miles.

The Budd Creek ditch of the Ottumwa Gold Mining Company has its intake at the large spring on that creek and extends for 8 miles along the north bank to a point below the mouth of Windy Creek, giving a head at the lower end of 160 feet. This waterway is 9 feet wide, and has a grade of 3.7 feet per mile. A second ditch was built by the same company on Million and Ohio creeks, tributaries of Windy Creek.

FAIRHAVEN PRECINCT.

No member of the Geological Survey has visited the Fairhaven district since 1903. The following notes on some of the developments in that section have been compiled from reliable sources. Two of the longest ditches in Seward Peninsula have been built and a third has been begun.

The Fairhaven ditch was built during 1906 and 1907 by the Fairhaven Water Company. It takes its water supply from Imuruk Lake, the source of Kugruk River. A dam about 500 feet long has been constructed across the outlet of the lake to conserve the run-off.

The upper section of the ditch is 17 miles long, the first 8 miles of which is through a lava formation. The water is dropped into upper Pinnell River and flows down this stream for about 4 miles. The lower section takes the water from Pinnell River on its right bank and extends for 23 miles to Arizona Creek, where a head of 500 feet is obtained. The ditch is 11 feet wide on the bottom and has a grade of 5 feet to the mile.

The Candle ditch was built during 1907 by the Candle-Alaska Hydraulic Gold Mining Company to furnish water for mining on

Candle Creek. It has a total length of 33.6 miles, a bottom width of 9 feet, and a grade of 3.69 feet per mile. The estimated capacity is 35 second-feet.

It takes its supply from the western tributaries of Kiwalik River. The present intake of the ditch is on Glacier Creek. The water is carried across Dome Creek in a siphon 2,250 feet long composed of 28-inch pipe; across Bonanza Creek in 900 feet of 32-inch pipe; and across Eldorado Creek in a siphon 12,100 feet long composed of equal lengths of $35\frac{1}{2}$, $37\frac{1}{2}$ and $39\frac{1}{2}$ inch pipe. Eldorado Creek will be tapped with a lateral ditch about 6 miles long. An extension 8.1 miles long of 6-foot ditch will be built to Gold Run. It will also be possible to divert the flow from the headwaters of First Chance Creek a tributary of Koyuk River, over a low divide into Gold Run.

The fall obtained is 250 feet at the mouth of Candle Creek and 132 feet at the mouth of Patterson Creek. The surveyed line crosses Candle Creek about 1 mile above the mouth of Willow Creek. Candle Creek was nearly dry during 1907, the flow some of the time being less than half a second-foot.

Construction was begun late in 1907 by the Miners' Hydraulic Ditch Company on a second large ditch to Candle Creek. It will have its intake on Quartz Creek, a tributary of Kiwalik River from the east, and will extend along the right bank of that stream, crossing Hunter and Lava creeks by means of siphons and picking up their flow in lateral ditches. The ditch will have a length of about 60 miles and a bottom width of 12 feet.

A ditch was built in 1907 on Bear Creek, a tributary of West Fork of Buckland River. It has its intake below the mouth of May Creek and extends along the right bank to Split Creek, diverting Eagle, Polar, and other small creeks. The ditch has a length of about 6 miles, a bottom width of 6 feet, and a grade of 4 feet to the mile. The head obtained at the lower end is about 200 feet.

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