THE NOME REGION.

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INTRODUCTION.

The work of the Geological Survey in the Nome region was initiated by Schrader and Brooks during the year following the gold discoveries on Anvil Creek in 1898. Their investigations, although undertaken in the late fall and prosecuted under many difficulties, nevertheless resulted in the first statements regarding the high bench gravels and the probable presence of other gold-bearing beaches back of the present beach, whose wealth had then just been revealed. It is worthy of note that this prediction[a] has since been fully justified.

The investigation thus begun was continued in 1900. A geologic reconnaissance was carried on by Brooks, and a topographic reconnaissance map, including a large part of the southern half of the peninsula was made by Barnard. Geologic work was again undertaken in the region in 1903 by Collier, but formed only a part of his studies for that year. The field work of these three seasons was of a reconnaissance character and had as its prime object a study of the occurrence and distribution of the gold. Detailed study of the region was made possible when a much more accurate map representing an area which includes the beach from Cape Nome to a point 3 miles west of the mouth of Snake River, a distance of 15 miles, and extends from the coast to the Kigluaik or Sawtooth Mountains, slightly more than 35 miles, was completed by Gerdine in 1904. (See fig. 5.) Field work was begun in the following spring (1905) by Frank L. Hess and the writer and carried to completion during the summer of 1906 by Philip S. Smith and the writer. The chief aim in this work was to secure, as far as possible, the facts throwing light on the bed-rock source of the gold now found in the gravels and to investigate the processes governing the present distribution of that gold.

It is a fact well known among mining men that by far the greater number of gold placer deposits are largely worked out in a comparatively small number of years, and that lode deposits, though they often yield much smaller values in return for the capital and labor

[a] Schrader, F. C., and Brooks, A. H., Preliminary report on the Cape Nome gold region; a special publication of the U. S. Geol. Survey, 1900, p. 22.

expended in the same length of time, nevertheless tend toward the permanence and stability of a mining camp. While it is believed that the gravel deposits of the Nome tundra, as well as the stream and bench gravels of the district, are sufficiently great in amount and rich in gold content to insure Nome an important place among gold-producing districts for many years to come, still the discovery of valuable lode deposits can be of no small importance for the interests of the region. The discovery and exploitation of such deposits are not made in most mining communities until the available placer ground is largely taken up or until failure of the valuable content compels capital to seek other investment. It is therefore not to be wondered at that only slight attention has yet been given to lode mining in the Nome region.

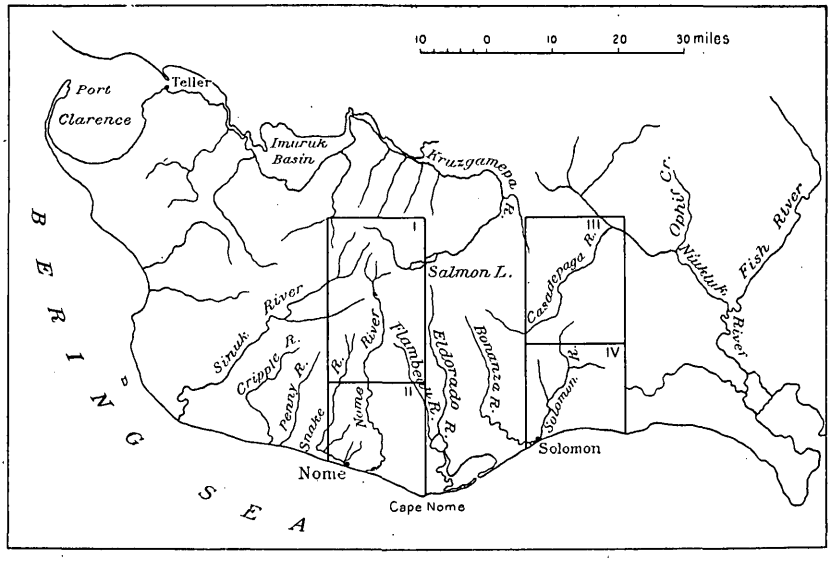

FIG. 5.—Sketch map of southern Seward Peninsula, showing the area covered by detailed topographic maps. I, Grand Central special; II, Nome special; III, Casadepaga quadrangle; IV, Solomon quadrangle.

It is an unfortunate fact that the work of a mining geologist can not be entirely separated from that of the miner, and that the data he requires for the solution of many problems arising in the extension or exploitation of mining properties can be secured only after development has reached a more or less advanced stage, and in many places only after large sums of money have been expended. We have here one reason for the distrust in geologists which mining men not infrequently show. A better realization by both classes of the interdependence of interests, which is already becoming evident, is greatly to be desired and must lead to a greater appreciation of what each owes to the other.

It is the purpose of this paper to give a preliminary statement of the more important facts gathered during 1905 and 1906 bearing on the geology and the source and distribution of placer gold in the portion of Seward Peninsula represented by the two topographic sheets known as the Nome and Grand Central special maps. The paper is not complete, since it goes to press too early to permit a thorough study of the data collected. The final conclusions, together with the two maps mentioned, will be published in a forthcoming bulletin of the Survey.

GENERAL GEOLOGY.

The important features of the bed-rock geology of the region were recognized and correctly interpreted by Brooks and Collier. As stated by them, the rocks are chiefly sedimentary, limestones and schists, but in many places have been intruded in an intricate manner by igneous rocks of several kinds, more especially by greenstones and granite or rocks of a granitic character. Brooks referred the sediments to three periods of time and described them under the names of Kigluaik, Kuzitrin, and Nome series.[a] A brief account of these will be given.

KIGLUAIK SERIES.

The oldest known sedimentaries of this region are exposed in the Kigluaik or Sawtooth Mountains and are well represented in Mount Osborn, a short distance north of the northern limit of the area shown on the Grand Central map. The relative age of the beds is known only by their stratigraphic position, for no fossil remains have yet been found in any of the rocks to be described.

They comprise biotite and graphitic schists and limestones, together with gneisses and granite or related intrusives. In Mount Osborn the schist and limestone beds lie in a nearly horizontal position, but on the southern side of the Kigluaik Range they dip rather gently to the south and beneath the younger sedimentaries. This succession of beds was given the name of Kigluaik series.

KUZITRIN SERIES.

A highly irregular series of beds consisting of siliceous graphitic schists occurring along the south flank and east end of the Kigluaik Range was called by Brooks the Kuzitrin series. It has a regular southerly dip and is not found south of the Salmon Lake valley, but is possibly represented by beds occurring on Charley Creek south of Sinuk River. No conclusive evidence was found within the Grand Central area, however, showing that these black schists should be

[a] See p. 83 (footnote *b*) in regard to use of the term "series."

separated from the underlying Kigluaik series, and in fact exactly similar beds are found interstratified with the biotite schists of that series. A doubt therefore arises as to whether these two should be separated.

NOME SERIES.

South of the Salmon Lake and Sinuk River valleys and extending to the coast of Bering Sea is a region of schist and limestone intruded by greenstone, and in the vicinity of Cape Nome by granite, to all of which the name Nome series was given. In general the strata dip to the north in the portion of the region south of the latitude of Mount Distin and to the south in the portion north of that latitude, thus forming a broad synclinal trough on whose axis Mount Distin is situated. The rocks forming this trough are chiefly schists, with limestone in lesser amount. The greenstones cut both of these in the form of sills and dikes. All have been highly metamorphosed. The limestones, which are found most abundantly in the upper part of the Nome series, have been entirely recrystallized and any organic remains they may have contained are now seemingly obliterated. The original argillaceous sediments, more highly developed in the lower portion of the series, and the greenstones intruded in them are also recrystallized and possess a well-developed schistose structure. The schists may be described freely as micaceous, feldspathic, or graphitic in character according as the minerals mica, feldspar, or graphite are prominent. The micaceous schists, in places highly siliceous, are usually green or silvery gray in color; the feldspathic schist is green, though this color is partly hidden by the development of numerous small feldspar crystals; the graphitic schists are black, becoming gray as the amount of carbonaceous matter decreases and quartz becomes more evident. The feldspathic schists are in many places conspicuous by reason of the abundance of small albite crystals, which are especially noticeable on the weathered surface. They are derived in part from original sediments, but probably in the main from intruded greenstones.

Greenstones are more common as sills than as dikes and are usually highly altered. In general their conspicuous minerals are chlorite and albite, but in some localities they are filled with red garnets. Like the feldspathic schists, into which they grade locally, they are more abundant on the east side of Nome River than on the west and are perhaps most highly developed in the area between Osborn Creek and Nome River.

Only one notable area of granite is found within the Nome series in the region under consideration. It is seen in the two ridges running northward and northwestward from Cape Nome. This granite,

however, does not appear to extend north or west of Hastings Creek, and the entire area occupied by it within the boundaries of the district mapped on the Nome sheet is about 6 square miles. East of the boundary the granite area is probably slightly larger.

STRUCTURE.

It has been stated that the Nome series forms a broad synclinal trough, with an approximately east-west axis, extending from the coast of Bering Sea to the Kigluaik Mountains. There is, however, abundant evidence of an earlier deformation, due to forces acting almost at right angles to those which gave rise to the broad east-west folds and producing other folds much more intense in character and with axes running from north to south or from north-northwest to south-southeast. Yet, in spite of these deformations, it was found that the bedding of the sediments and the cleavage or schistosity are nearly everywhere the same, although exceptions are known.

The Nome series has been deformed under conditions of comparatively light load, as a result of which the strata are much broken, locally with more or less displacement. In places the limestones especially appear to have been crushed, much as a marble block is sometimes crushed under a heavy weight, but on a far greater scale. Faulting of lesser degree is exceedingly common, but direct evidence of large displacements is hard to secure. This is due to the difficulty of finding any reference beds and the well-nigh hopeless task of correlating strata in different or even in neighboring parts of the field. Evidence of faulting is most readily obtained in localities where limestones are present. It is rarely the case that one can actually place hands on the contact of faulted beds, and the displacement is usually indicated by an offsetting of outcrops or the abrupt termination of beds along their strike.

VEINS.

Deformation and rupture of the series has given opportunity for the circulation of mineral-bearing solutions and the deposition of veins of quartz and calcite. Quartz occurs principally as lenses and stringers in the schist, but also as well-defined veins cutting the schist. Veins of white quartz of considerable thickness—10, 12, or even 20 feet—occur, but in no observed case do they show as great mineralization as some of the smaller veins. In several localities prospect holes or short tunnels driven in the large quartz masses show them to be much broken and faulted, and, while the weathered surface is milky white, joint planes and cracks are stained with iron oxide.

Small quartz veins, though less conspicuous, are far more numerous, and, as noted, are here and there well mineralized. They appear as small lenses, either lying in the cleavage or crossing it, as filling along

joint planes, and as narrow veins of fairly regular thickness but small longitudinal extent—that is, much flattened lenses. A broken surface of such a vein may show sulphides, generally pyrite, or more commonly a cavernous interior filled with iron oxide derived from the alteration of pyrite. Some of these veins are known from numerous assays to carry gold in small quantity.

Calcite veins are almost restricted to the limestone areas, or at least to these areas and their immediate vicinity. They reach thicknesses of several feet at various exposures, but like the quartz veins have not been found to continue horizontally for any considerable distance. It should be stated, however, that the lack of outcrops, due to the covering of loose weathered material or of moss, is a serious obstacle confronting the prospector who attempts to trace veins in this region, and makes it quite impossible without much labor and expense to determine their extent on the surface.

Numerous calcite veins are exposed in the limestone area of Anvil Mountain and its continuation east of Dry Creek. Prospect holes have been sunk on some of them and many have been staked as mining property. Free gold is found in small amount in some of these veins.

Besides the veins of quartz and calcite described above there are also veins made up of quartz, chlorite, and albite. These were observed most frequently in the Anvil-Newton Peak area.

No well-defined belt of mineralization has yet been established. There are restricted areas, nevertheless, where such secondary deposits are more highly developed than in the remaining parts of the region. The most important of these includes the upper portion of Anvil and Dexter creeks, the lower part of Glacier Creek, and a portion of Snake River extending north from Glacier Creek. Excavations on the third-beach line have shown that there also much of the schist bed rock is filled with small mineralized quartz veins. In this connection it may be stated that north of Rock Creek and on Pioneer Gulch gold is found in the surface débris, where concentration is due to decomposition of the bed rock and removal of the lighter material, the heavier constituents of the rock being left almost in place, since their movement is chiefly downward rather than in a lateral direction. In both places the bed rock is known to contain small mineralized quartz veins, and north of Rock Creek they carry sufficient gold to lead to some attempt at development. No unquestionably igneous rock bodies are known in this disturbed area. The greenstones either do not occur in any considerable amount or their identity is lost through alteration. One small exposure of greatly altered siliceous rock north of Specimen Gulch was at first considered to be an acidic granite, but there is much doubt concerning it.

Brooks (p. 25) emphasizes the fact that many of the most important placer deposits of the peninsula are found in localities where both

schists and limestones occur. In accounting for this he points to the contacts of different kinds of rock and the immediate vicinity of such contacts as loci of maximum weakness and greatest adjustment when the rocks are subjected to disturbing forces, as a result of which a freer circulation is there possible for mineral-bearing waters. This relation has been brought to the attention of the writer also by mining men in Nome and should be kept in mind by prospectors, since such contacts are favorable localities. Heavy limestones are found in the southern part of the mineralized area of Anvil and Glacier creeks, and thinner beds occur in the ridge between the two streams. To the northwest, however, their number decreases, and here some of the greatest mineralization is seen. It does not appear, then, that in this last-named place the presence of limestone was essential to the formation of mineral deposits. In fact, it would be difficult to prove that the limestone-schist contacts to the southeast are more highly mineralized than the schists themselves, but the occurrence of nearly all the placer-gold deposits of the peninsula in such areas suggests the relationship mentioned. Buster Creek affords a good example of a disturbed limestone-schist area where small secondary quartz deposits are numerous.

UNCONSOLIDATED DEPOSITS.

GENERAL DESCRIPTION.

Unconsolidated deposits may here be divided into two classes—those which have undergone a sorting process and deposition in water and those which have not. To the first class belong present stream and lake gravels, bench gravels, and the gravels of the Nome tundra; to the second, the loose débris mantling the slopes of hills and derived from the decomposition and weathering of the rock beneath or on the slopes above, together with part of the morainic material resulting from glacial action.

In by far the greater number of small streams the gravels consist of material like that of the hills surrounding the valley and appear to be entirely of local origin—that is, they are derived from bed rock in the drainage basin where they now lie and within a comparatively short distance of their present location.

In the larger streams, such as Nome, Snake, Stewart, and Sinuk rivers—that is, in streams heading toward the Kigluaik Mountains—together with a few of their tributaries, and in the Nome tundra a considerable portion of the gravel is derived from a more distant source, and its distribution is such as to indicate that part of it was laid down under conditions different from those prevailing at the present time.

Rounded granite bowlders derived from some source in the Kigluaik Mountains are found in Sinuk and Stewart River valleys, along Snake River, on Anvil and Dexter creeks, along Nome River, and at various

other localities at elevations as great as 800 or 900 feet, 1,400 feet in one place, above sea level. Such foreign fragments are rare if they occur at all in the deep elevated gravels at Dexter station, on the Nome Arctic Railway, but are numerous in the surface gravels at the head of Grass and Specimen gulches. They are often seen in the gravel deposits of Nome tundra, both at the surface and in the old beach deposits, where the fragments appear to be smaller and perhaps more rounded and weathered than those above. It is probable that much of the granite in the old beaches was brought by ordinary stream transportation or was carried along the shore from such localities as Cape Nome by the surf and ocean currents, and that most of the large surface bowlders were brought to their present location through the agency of ice, though in some places their position and quantity are such as to make it appear doubtful whether transportation by floating ice offers a complete explanation of their presence.

An examination of the deposits in the field therefore confirms the opinion concerning the character of the stream gravels which one would reach by a study of the maps alone—namely, that the gravels of the large southwestward, southward, and southeastward flowing streams show a greater variety of material than is seen on the smaller tributaries whose loose deposits are of more local origin. The fact which it is desired to bring out, however, is that on these small streams most of the gravels were laid down under present-day conditions such as will not account for the peculiarities and position of much of the gravels along the larger streams and of the elevated gravels. Two explanations have been suggested to account for such gravel accumulations as are found on the divides at the head of Dexter Creek, which in the saddle at Dexter station have a thickness of 135 feet. The first is that they are remnants of an extensive gravel sheet deposited at a time when the land had an elevation at least 600 feet lower than now and when the drainage systems may have been quite different. The second would account for their presence by considering them to have been deposited when the main stream valleys were occupied by glacial ice and the waters were ponded in some of the tributary streams. It does not seem possible, with the present knowledge, to say definitely that these gravel deposits are to be ascribed wholly to either cause, and it is not impossible that both conditions may have prevailed in some degree. The bed rock and pay streak at Dexter station, however, are such as to make it appear probable that the gold there was deposited by a southward-flowing stream or streams, since two well-defined stream channels at slightly different elevations lead from the head of Nekula Gulch through a bed-rock depression on the south toward Deer and Grouse gulches.

TUNDRA GRAVELS.

The Nome tundra gravels occupy the crescent-shaped lowland extending from Cape Nome to the hills west of Cripple River (see fig. 6), about half the area being within the boundaries of the district shown on the Nome special map. The tundra deposits were laid down in part by ocean currents and in part by streams, and consist of silt, interstratified fine sands, well-rounded gravels, and beds containing angular fragments and blocks up to 2 feet or more in greatest diameter. These large pieces are usually flattened slabs of schist, more rarely limestone. Large bowlders of granite, worn

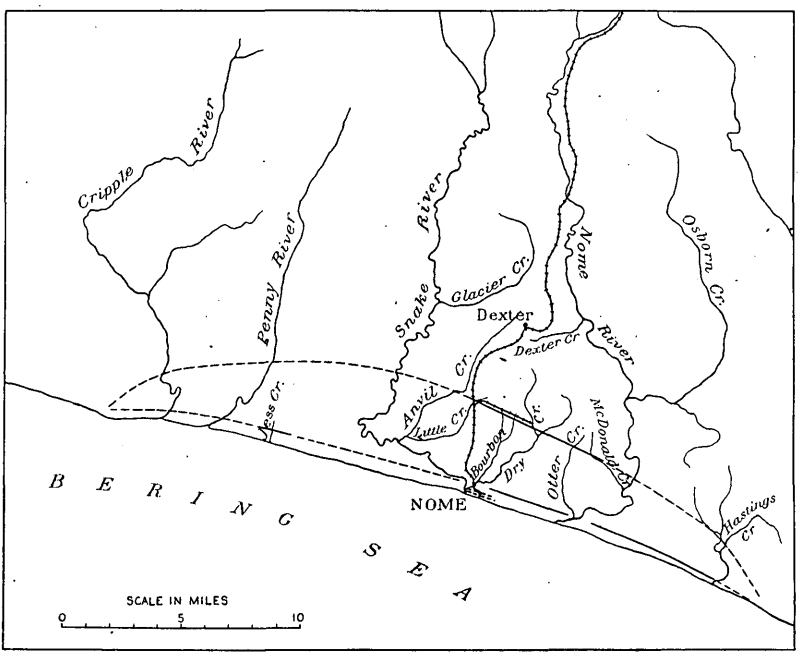

FIG. 6.—Sketch map showing the known parts of the second and third beaches (full lines) at Nome and their hypothetical continuations (dashed lines). The upper line also shows approximately the area of the Nome tundra.

and more or less rounded, are found on the surface, but were not observed in the coarse material below. Flattened and striated fragments of limestone are also found near the surface.

Our knowledge of the tundra has been greatly increased during the last two years by developments on the buried beaches. Two well-defined ancient gravel deposits of this sort have now been explored through a part of their length. (See fig. 6.) One of these, near Nome, lies about three-fourths of a mile north of the present coast line and extends eastward to a point within a short distance of Cape Nome. At Hastings Creek it is about a fourth of a mile distant from tide water, but east of that locality its position is not

known, and it appears to have been removed through erosion. To the west it is probably represented by the beach deposits of Jess Creek. Its elevation above sea level is 37 feet and its location is in most places indicated by a steep moss-covered gravel bank at whose foot it lies. The other beach line is definitely located from the place where it is crossed by the railroad tracks at Little Creek to McDonald Creek, a distance slightly more than 5 miles. Its elevation above sea level, according to reliable information obtained at Nome, is 79 feet. It extends in a nearly straight or slightly curved line between the points mentioned, yet shows slight undulations and is interrupted by the valleys of Nome River, Anvil Creek, and Snake River, these streams lying below its level. These two ancient coast lines are generally known as the second and third beaches, the present one being regarded as the first. Mention of others lying between is frequently heard, but although this is not only possible but even probable, no other continuous beach has yet been traced.

A generalized section of the deposits exposed along the third beach would show gravel or sandy gravel with coarse bowlders resting either on schist bed rock in which are a few limestone beds or, as is the case at the east end of the beach, on fine sands which in turn rest on schist bed rock. Above this is a considerable body of gravel overlain by "muck" and the surface vegetable matter. This general section is, however, subject to wide variations. The thickness of the muck varies from 1 or 2 feet to 20 feet or more. Underlying the muck in several shafts a blue clay was found. In places a heavy wash occurs near the surface. Here and there the gravels are slightly cemented by the deposition of lime or iron oxide. Marine gravels are interbedded with creek wash. The character of the material varies both in composition and in coarseness—in fact, the deposits where first exposed on Little Creek were so varied in appearance and manner of deposition as to cause doubt whether any of them were of marine origin.

The gold-bearing gravels or pay streaks vary in width from 25 to perhaps 100 feet and have a fairly constant southerly slope of about 1 foot in 10. They rest in some places on bed rock, in some places on other gravel, and toward the east, as has been stated, on fine sand.

Only a part of the shafts on the second beach have been sunk to bed rock, as the pay streak usually lies on a false bed rock of clay or sandy clay and gravel. There are few data, then, on which a complete generalized section could be based, but it appears that, though coarse angular material is by no means lacking, it is not as abundant as on the third-beach line. Furthermore, the quantity of garnet, or "ruby sand," is far greater on the second beach and the proportion of other sand and fine gravel is also greater. This is probably accounted for by the fact that much of the material of the third

beach has traveled a shorter distance from its source and has been less subject to stream and wave grinding.

In the third beach, then, irrespective of any greater differences which may have occurred in the meantime, we have definite proof that the land now stands not less than 79 feet higher than it did when the beach formed the coast line. Further evidence of elevation, though of lesser amount, is furnished by marine shells taken from various shafts between the second and third beaches. Such shells in an almost perfect state of preservation are found on Center Creek and suggest that in that locality they accumulated in comparatively quiet water. They occur in gravels 32 feet below the surface and at an elevation of about 20 feet above sea level. Numerous marine shells from Otter Creek were obtained at approximately the same height above sea but at a depth of 50 feet below the surface. They are in a good state of preservation.

As a rule the deposits of the beaches and of the tundra in general are frozen from top to bottom, but there are places where this is not the case. One such area is located near the intersection of the third beach and Holyoke Creek and has caused difficulty in working the Bessie Bench claim because of the large amount of water circulating through the gravel. The boundary between the thawed and frozen ground was here located by drilling, and care was taken not to bring the workings too close. Thawed ground is in some places overlain by frozen ground and here and there is underlain by it also. The reason for the presence of unfrozen areas is not entirely understood, but they are probably due in part at least to the circulation of water through the gravel.

These old beach lines indicate periods of temporary stability in an intermittently advancing or retreating coast line. It is possible that they mark the limits of encroachments of the sea at different periods, since in the case of the beaches mentioned the sea at the time of their formation was cutting fragmental deposits previously laid down. It is evident that if a sea floor gently sloping away from the land were gradually and uniformly raised, the beach line if affected by the elevation only would slowly move seaward, and that the beach deposits would be continuous from the time when elevation began till it ended. Such does not appear to have been the case on the Nome tundra.

The coast was not raised uniformly, and the upward movement may even have been interrupted by periods of depression. Nor are the tundra accumulations due to the work of the sea alone. Rivers and ocean both took part. Such streams as the Nome and Snake were already well established and spread their loads of loose material over the marine sediments at their mouths, carrying the shore line seaward and building up the lowland deposits. It seems probable, too, that

conditions such as prevail along the southern coast of Seward Peninsula to-day may have existed in the past and that the formation of lagoons shut off from the sea by sand bars, as may be seen east of Cape Nome and on a much smaller scale at localities like the mouths of Derby, Little Derby, and Cunningham creeks, may have taken place, and that these lagoons by subsequent filling may have played an important, though not the only, part in the construction of the Nome tundra.

This idea of the formation of the ancient beaches implies that the land formerly stood at a lower elevation, but it is also evident that it once had a greater elevation, for the rock valleys of Nome and Snake rivers are lower than the third-beach line at the places where they are crossed by it, and are even below the present sea level. The rock floor under the present beach also may have been above sea level when it was produced; it was surely little if any below it.

The formation of either of the old beaches was only an incident among the various changes which finally gave us the tundra as we see it to-day. A repetition of the same succession of events that led to the burial and preservation of the second and third beaches would in time add the present one to the tundra's treasury. From the geologist's standpoint these deposits are neither unique nor unusual. The concentration of heavy minerals by ocean waves is a commonly observed phenomenon, and it is only the value of the concentrated material which in this case brings the deposits to notice and makes them remarkable.

GLACIATION.

One of the difficult problems of the region is to discover what effect the action of glacial ice has had in modifying the former topography and in transporting loose material. That the upper valleys of nearly if not all the streams flowing south from the Kigluaik Mountains, as well as some of the tributary valleys of Grand Central River and Salmon Lake, have been occupied by ice masses in very recent time is beyond question. The morainic deposits at the head of Nome River indicate that at least the upper portion of that valley was occupied by ice, and several of the eastern tributaries of the river have well-formed cirquelike amphitheaters at their upper ends. There is no evidence available to show that the peninsula, or rather the southern portion of it, has ever been covered by an ice sheet. On the other hand, all the evidence seems to oppose that idea if our conceptions concerning the rate of rock weathering are correct. The occurrence of monumentlike rock masses, due to weathering, on the hilltops or slopes is one of the noticeable features of the region, and it seems extremely improbable that they could have withstood the advance of moving ice or that they could have been formed since the

disappearance of such ice unless it was present at a time very much earlier than the recent glaciation mentioned above.

Closer study of the region, however, especially of the distribution of gravels, has led to the observation of phenomena which are most easily explained as being due to ice action, and it may be that in valleys like that of Nome River ice streams from the Kigluaiks approached much nearer the coast than has heretofore been supposed. Since the evidence against a mantling ice sheet appears to be conclusive, it is altogether improbable that the tundra deposits have been affected in more than a minor degree by glacial ice except in the form of floating ice, for there are no known centers of local accumulation near the coast.

ECONOMIC GEOLOGY.

The progress in mining on Seward Peninsula has been presented from time to time in various publications of the Survey, and since this present form of report was adopted an account of each season's work has been published yearly. The economically important deposits may be divided into two classes—lode and placer deposits.

LODE DEPOSITS.

Some generalizations concerning the occurrence of veins have already been given and it now remains to describe in greater detail a few particular localities which have attracted some attention during the last year.

BISMUTH.

For a number of years bismuth has been known to be present on Charley Creek, a tributary of Sinuk River from the south. It was first found in the sluice boxes at the lower end of the creek, and later the float was discovered farther up and traced to its source. On the east branch of Charley Creek, at a point about 1,000 feet from the forks and at an elevation of 950 feet above sea level, two parallel quartz veins appear near the stream bed and have been found to carry the bismuth. These veins are about 12 inches and 8 inches in thickness and are separated by 16 to 18 inches of schist. They occur in strike joints dipping 50° to 60° N., and may be traced on the surface for only a short distance because of the covering of loose slide rock. At one place they are offset about 8 to 10 inches by a small fault. The percentage of bismuth seen in the veins is small, but some bowlders found in the stream below show a larger amount. Attempts to interest capital in the development of these veins have not been successful and up to the present time little has been done toward prospecting them.

ANTIMONY.

A quartz vein carrying the sulphides of iron and antimony was lately found on Manila Creek. The vein is located on the hill slope west of the upper end of the creek and as traced by surface float has a length of about 3,000 feet. It has an elevation above sea level of approximately 800 feet at its southwest end and 1,200 feet at its northeast end. Apparently it dips at a moderate angle toward the northwest. The thickness is not known, since at the time it was visited by the Survey party no exposure of the vein in place had been made and all information concerning it was derived from loose material on the surface, part of which may of course be considerably removed from its source. Pieces of the float, however, indicate that locally the vein reaches a width of 2½ feet, but that its average width is much less, probably about 8 or 9 inches. The best ore occurs as bunches or irregular streaks through the quartz and usually shows the reddish color resulting from partial oxidation or a stain of iron oxide. A prospect hole, supposedly on the dip of the vein, has been driven for a distance of 60 feet into the hill, but the vein was not visible at its lower end. The hole was located in loose surface material and schist bed rock considerably broken and so much displaced that it was not possible to make any reliable observation on the ore body. Besides antimony the vein carries some gold.

GOLD.

As yet no gold-bearing veins of proved value are known in the Nome region. The occurrence and character of quartz veins have been previously described, together with some general statements regarding them, and it was pointed out that the more highly mineralized veins are the small ones such as are numerous in the schists of the Anvil-Glacier Creek divide or the region north of Rock Creek. There was some prospecting on gold-bearing quartz veins in this vicinity during the summer of 1906, principally on the west side of Anvil Creek, above Specimen Gulch.

GRAPHITE.

Graphite occurs abundantly in portions of the schists included in both the Nome and Kigluaik series, but is not known in commercial amounts within the area covered by the Nome and Grand Central sheets. Just north of the Grand Central area, however, in the upper valleys of Grand Central River and Windy Creek, and especially in the vicinity of the divide between these two streams, there are graphite deposits of considerable size. Their occurrence, as well as that of the graphite to the west of Cobblestone River on the north side of the Kigluaik Range, has been known for a number of years, but so far no effort has been made to develop them.

Rising to the south from the saddle between the Grand Central and Windy Creek is a sharp ridge made up of biotite schists striking east and west and cut by dikes and sills of intruded coarse granitic rocks. Some of the schists are highly graphitic, the graphite appearing as abundant small scales on the cleavage surface and much of it not distinguishable from the biotite on casual examination. Locally graphite is segregated in beds of much flattened lenticular masses lying in the cleavage of the schist and reaching thicknesses of 6, 8, or even 18 inches. Thin beds of schist with numerous large garnets are included and quartz is nearly everywhere present. When compared with the higher grades of graphite the raw product of this locality is seen to have a much greater weight, owing to the included quartz.

As stated, the biotite schists are cut by sills and dikes of pegmatite. These also contain graphite, which is associated with them in such a way as to suggest that the intrusives and the graphite are closely related. Graphite seems to be an original mineral in the pegmatite and also occurs in close association with it in the schist. At one place about 8 inches of solid graphite was included between a pegmatite sill and the overlying schist. The steep slopes of the mountain are strewn with the loose fragments, which, owing to the fact that they are much lighter than either the schist or pegmatite, appear more abundantly on the surface. One block with dimensions of approximately 7 feet, 6 feet, and 30 inches consisted of about equal thicknesses of schist and apparently almost pure graphite.

These graphite-bearing schists extend eastward beyond the east fork of Grand Central River and westward across Windy Creek and the head of Cobblestone River to the region south of Imuruk Basin, where, if the reports of it are true, the graphite is present in greater quantity than in the locality just described.

The quality of this graphite is such as to prohibit its use where the better grades are required, although it might be of value for some purposes. With the present price of the mineral, however, it is doubtful if it can be now handled and placed on the market with profit.

PLACER DEPOSITS AND MINING.

To those who year by year have followed the development of mining in the region adjacent to Nome it is a noticeable fact that during the summer of 1906 the attention of mining men was largely given to operating within the area of the Nome tundra. This is a condition which may probably continue for some years, until the gold of the beaches begins to fail or until all the available ground is opened up. If, in addition to the operations on the tundra, those of Glacier Creek, Anvil Creek, and Grass Gulch are included, all the most important workings will have been taken into account, although elsewhere within the area shown on the Nome and Grand Central maps minor

operations were conducted on a few scattered streams, probably the most extensive being on Buster Creek.

At present the buried beaches of the Nome tundra occupy the center of the mining stage, and the efforts of all operators have been given to the exploitation of old placers or the search for new. Litigation touching the rights of property, however, has seriously obstructed the development of much of the most valuable ground, and may be expected to continue to do so as long as the present methods of acquiring and holding mining property are in force.

Mining is carried on most actively just now along the two ancient shore lines whose locations and principal features have already been described, but there has been more or less work on different streams, such as Dry and Bourbon creeks, and extensive drilling in various other parts of the tundra. On the first or present beach practically all work was suspended. Along the second beach many of the old properties were worked and some very good new ground was discovered in the vicinity of Otter Creek. The third beach is the principal producer of the region.

The third beach was discovered in the late fall or early winter of 1904, but when the summer closed in 1905 operations were confined to

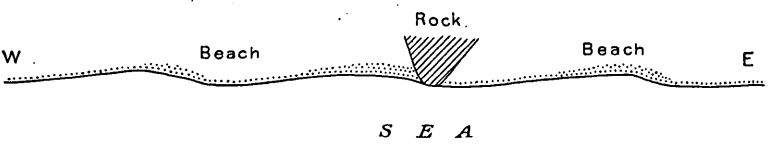

FIG. 7.—Diagram showing the manner in which gold is concentrated north of Nome in shallow depressions or on sides of cusps of the third beach.

the immediate vicinity of Little Creek. An account of this locality has been published elsewhere.[a] During the winter of 1905–6 the eastward continuation of the beach was located to a point within a short distance of Nome River. Between Moonlight Creek or the railroad and McDonald Creek it is traced continuously. To the west and east of these localities it is not definitely known. Remarkably rich ground was exploited near Little Creek and between Holyoke and Bourbon creeks, and nearly all the claims between Little and Dry creeks have shown good values in gold. East of Dry Creek less work has been done, but most of the shafts have struck good pay. Nevertheless, some claims or parts of claims are of little value with the present cost of mining, for while the beach gravel deposits are continuous the pay in them is not so. There are intervals along the line where gold is present in small amount or is almost lacking. These places are sometimes referred to as "blanks." Further, the gold is not evenly distributed through any of the gravel. The writer was informed that in the shallow depressions such as occur at intervals along the beach a much greater concentration of gold took place on the east ends (see fig. 7), and that

[a] Moffit, Fred H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 134.

in one or two places where low ridges or rolls of bed rock reached the surface and projected slightly beyond the ancient beach exceptional amounts of gold were found on their west sides, a position of maximum concentration corresponding to that in the indentations just mentioned. This would indicate that the distribution of gold in the gravels was largely influenced by the prevailing direction of the ocean waves and currents. It is probable also that very rich deposits, such as occur at Little Creek and Bessie Bench, are due to their nearness to the source of gold or to streams which brought it to the sea. The character of both the gold and the gravel accumulations would indicate the same thing. On the western part of the beach the gold is, on the average, much coarser than at the east end, where it resembles in appearance and approaches in fineness that of the present beach. The gravels of the west end are more variable in character and exhibit a larger amount of coarse angular stream wash than those toward the east, showing that the conditions under which the western gravels accumulated were less uniform—at one time stream deposits, at another sea deposits, being laid down.

Some ideas concerning the eastward and westward continuations of the third beach are suggested by an examination of the topographic map. The shore line must formerly have extended from the hills west of Cripple River to Cape Nome, and if one may judge by the portion now known it had the form of a broad arc of fairly uniform curvature, like the present beach, but with smaller radius. It is the belief of not a few miners at Nome that the third beach did not, like the first and second beaches, keep to the seaward of Cape Nome, but that it passed to the north through the broad, low depression between Saunders Creek and Flambeau River, thus forming an island of the Cape Nome granite area. The elevation of the depression between Cape Nome and Army Peak is only 115 feet, and the possibility of the cape being an island at the time when the third beach was formed can not be refuted by any evidence now at hand, although it appears improbable. Bed rock is traced northwestward from Cape Nome for a distance of nearly 5 miles, and in the low rounded hill between Hastings and Saunders creeks has an elevation of 297 feet. Between this point and the Army Peak schist mass, still farther to the northwest, is an interval of about 3 miles across a broad, low saddle where no rocks are exposed. As stated, the elevation of this flat at its lowest point is about 115 feet, but the depth of gravel is unknown. If it has a thickness of 40 or 50 feet it is possible that the third beach passes through. It seems far more probable, however, that the controlling influence in determining the coast line here was exercised by Cape Nome, since it must have been a factor in directing the ocean currents and consequently the accumulation of sands and gravel. To judge

from present conditions, it appears more likely that the sea would have built a connecting bar between Cape Nome and Army Peak rather than wash between them. At any rate, the force of the waves due to southerly and southeasterly winds would have been greatly diminished through the protection offered by Cape Nome, and the amount of concentration would have been thereby decreased.

Another idea which is maintained by some and may lead prospectors astray is that wherever bed rock can be found at an elevation of 79 feet above sea level the third beach will be present. The fallacy of this idea is immediately apparent when it is remembered that, so far as known, the old beaches were not laid down on a cleanly swept, somewhat uneven rock floor, but were formed over a surface whose inequalities had already been reduced by a filling of gravel and sand. This is shown by the fact that in many places they do not rest on bed rock, but are underlain by a variable thickness of loose deposits.

Further evidence of a somewhat negative character is afforded by the fact that neither the third beach nor either of the others is known to have formed reentrants at such places as their intersections with the valleys of Snake and Nome rivers, but rather that in each place where the river valleys lie below the beaches at such intersections the beaches end abruptly, for the present valleys through the loose deposits have been cut since the beaches were formed.

Another fact which must not be lost sight of in prospecting for the third beach is the possibility of recent warping. When formed, a beach is at sea level, and if raised uniformly throughout its length all parts will continue to have like relations to the sea. But changes of level do not always nor even usually take place in a uniform manner throughout all portions of an affected area. One part may be raised or lowered more than another, or one part may even be raised while another is sinking. It does not follow, therefore, that because one point of the beach has an elevation of 79 feet all other parts will have the same elevation, although in a small area such as this it is probable that they will not differ greatly.

Since, however, we now have no evidence that warping of any consequence has taken place, and since so far as we know it the third beach does maintain a fairly constant level, it is not to be expected that it will be found in any locality whose surface elevation is less than 75 or 80 feet above tide, even if such an area lies directly between or in line with points where it is known to be present.

Some probabilities concerning the distribution of gold in the known beaches or in others which may be found are gained from a consideration of its distribution in the gravels so far exploited. The richest gold-bearing gravels mined in the Nome tundra have been found in that portion of it which lies between Nome and Snake rivers. This

corresponds also with the richest part of the first or present beach, whose greatest values were taken from the neighborhood of the mouth of Snake River and from sands to the east toward the mouth of Nome River. This area lies directly south of the mineralized area from which it is believed that the gold has been chiefly derived, and it is the locality toward which weathered material from the near-by hills may properly be expected to migrate, since it lies immediately between them and the sea. There appears, therefore, to be warrant for the assumption that in the future, as in the past, the most valuable placers will be found within the limits given. One apparent exception is to be noted in the old beach placers of Hastings Creek. There is a possibility, however, that these may be the result of more than one concentration, that they may contain the gold of several old beach lines converging toward Cape Nome, and that the gravels from which they were derived may not originally have carried any very notable amount of gold.

GENERAL DEVELOPMENT.

Some improvements affecting in greater or less degree nearly the entire region were carried on during the summer and merit notice. Among them is the extension of the railroad formerly known as the Wild Goose, later as the Nome Arctic, and now as the Seward Peninsula Railway. In 1905 this road was extended from a point east of the summit of King Mountain into the low saddle north of it, near the part of the Miocene ditch known as the "Ex." In 1906 the road was continued northward and eastward through the valleys of Nome River and Salmon Lake and thence down the east side of Kruzgamepa or Pilgrim River. When the Survey party left Nome in October the roadbed was completed and the tracks were laid nearly as far as Lanes Landing, on Kuzitrin River. During the coming summer (1907) the road is expected to reach Kougarok River, thus opening for development a region which to this time has been one of the most difficult of access on Seward Peninsula.

The construction of the Seward and Pioneer ditches, which were begun in 1905, was carried forward in 1906, so that now both deliver water on the tundra north of Nome. The Seward ditch, the upper of the two, has an elevation of about 275 feet on Dry Creek. The Pioneer ditch is about 60 feet lower. There are, then, three ditches, the earliest being the Miocene, which supplies water on Glacier, Anvil, and Dexter creeks, bringing water from the upper Nome River drainage area to the vicinity of Nome.

A wood-stave pipe line to carry water from upper Grand Central River into the Nome River basin is under construction by the Wild Goose Company. The greater portion of the trench in which the

pipe is laid between the intake at Crater Lake and the Nome River-Grand Central divide is completed and about 1 mile of pipe put together. Part of the material for the remainder is on the ground, and more is being taken in this winter (1906–7). This line, if carried to Nome, as is now intended, will furnish water with greater head than any of the ditches yet constructed.

Construction work on the power plant at the outlet of Salmon Lake was interfered with by litigation between rival claimants for the dam site and water supply, but will doubtless be taken up again as soon as the question of ownership is settled.

GOLD FIELDS OF THE SOLOMON AND NIUKLUK RIVER BASINS.

By PHILIP S. SMITH.

INTRODUCTION.

While the area drained by Solomon River and the Niukluk and its tributaries was visited by the writer for only a few days, it has seemed desirable to make a brief statement of some of the more important developments that have been under way since the progress report for 1905 was published.

SOLOMON RIVER BASIN.

DREDGING.

In the Solomon River region few new developments were in progress. The most active work was being conducted at the dredge near Rock Creek and at the Big Hurrah mine. Outfits of one to ten men have been engaged along the river and its main tributaries, but last summer was so dry that most of the smaller operators could work only intermittently.

The dredge on Solomon River has previously been fully described.[a] During the last season work has gone on uninterruptedly and, as far as could be learned, in a manner highly satisfactory to the owners. Much ground has been handled at a low cost. The dredge seems to be efficient in cleaning gold from the bed rock. This was a matter of a good deal of importance when the availability of a dredge was first discussed and is one of the vital points which should be thoroughly considered by anyone who contemplates undertaking dredging operations. Too much emphasis can not be placed on the preliminary investigations which should always precede the construction of a dredge, since the neglect of these considerations has often resulted in financial failure. It is not only necessary to have efficient management, but it is also of prime importance that the ground should be thoroughly prospected before a dredge is built. A dredge is a

[a] Moffit, Fred H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906 pp. 136-137.

very costly machine, and unless an area of sufficient size and richness to repay the cost of the dredge and pay interest on the investment is obtained it is better not to consider this form of mining. It may seem a waste of time to state so self-evident a fact, but the number of abandoned dredges which have not paid for themselves in different parts of Seward Peninsula bears ample testimony to the neglect of this most simple precaution.

LODE MINING.

Work at the Big Hurrah mine on Big Hurrah Creek has continued during the past year on practically the same scale as formerly. No new developments had occurred at the time of the writer's visit. This mine still continues to be the only productive lode-gold mine in the entire district. About forty or forty-five men are employed at the mine and at the stamp mill, which is close to the mine.

PLACER MINING.

During the winter of 1905–6 work in the Solomon River region was carried on much more extensively than during the previous winter. It was recognized that the lower wages paid during the winter, coupled with the fact that the walls in deep gravel cuts stand better than when the frost is out of them in the summer and caving takes place, allowed the most economical development of many of the properties. From reliable sources it has been ascertained that approximately forty men were employed on Solomon River and its tributaries during the winter of 1905–6. Though no accurate figures could be obtained, it is estimated that about $75,000 was taken out during the winter. The figures for the production during the last summer are too vague to permit even an approximate statement.

NIUKLUK RIVER BASIN.

The areas in the Niukluk basin in which minerals of economic importance have been worked during the last year may be described according to their geographic position on the different tributaries of the river. The main productive tributary streams from the mouth of the Niukluk toward the head are Fox River, Melsing, Ophir, Goldbottom, and Elkhorn creeks, and Casadepaga River.

BENCH GRAVELS OF THE NIUKLUK.

In the whole region there are practically no winter mines, and this has a very detrimental effect on the growth of the district. The miners are driven to some of the other camps which offer winter work; and those who are faithful and industrious are retained in the field to which they have gone, and only those of lesser ability drift

back, after the break-up, to the summer work in the Niukluk region. This criticism applies only to the laboring men and is not intended in the least to reflect on the prospectors and miners who are developing their own ground or holding responsible positions with any of the larger companies.

To meet this annual exodus many of the more foresighted business men are attempting to develop winter workings which shall give employment to a more permanent population. Explorations with this end in view are being carried on in the deep gravels that occur along the Niukluk between Ophir and Camp creeks. This work has not progressed sufficiently to prove the value of the ground, but from the returns so far obtained further outlay is justifiable. During the last summer two men sunk a shaft 40 feet through these gravels. A section of this shaft is of interest not only as giving the succession of sands and gravels, but also as indicating the frozen conditions. The ice, on melting, so undermines and caves a shaft that its preservation during the summer is extremely expensive. The section in the shaft is as follows:

Section of bench gravels on Niukluk River between Ophir and Camp creeks.

	Feet.
Vegetation and muck	2
Pure ice	10
Sand and ice	15
Rock fragments, etc.; much mica	$\frac{1}{6}$
Sand and ice	1
Frozen gravel, carrying values	12

Up to the close of last summer no rich pay had been found in the benches along the Niukluk. Summer work in these benches will be costly and should be abandoned in favor of winter work.

FOX RIVER.

On Fox River some mining had been in progress during the past year, especially on I X L Gulch, a small tributary to Fox River 8 or 10 miles from Council. The rocks in the neighborhood are almost entirely schists and greenstones, but near Horton Creek there is a massive limestone member which forms a prominent topographic feature. The contact between the limestones and schists was not examined in detail and it is not known whether it is mineralized or not. The output from Fox River will be rather small, as the number of workers is limited.

MYSTERY CREEK.

On Mystery Creek, a small tributary of the Niukluk from the north, a small amount of gold has been won, but the work was conducted on a small scale.

BEAR CREEK.

The gravels which form the broad flat through which the Niukluk flows were prospected in the winter of 1905–6 on Bear Creek. Two shafts were sunk to a depth of about 50 feet, and fine sand, which was reported to be in many respects similar to beach sand, was found. The excitement attendant on the finding of old beaches in the Nome region has so stimulated the imagination of many of the prospectors that they see beach sand in all kinds of gravel. The so-called beach sand was not seen by the writer, and so no definite report can be made on the statement, which, if true, is of considerable importance in unraveling the complex history of the gold-bearing portions of Seward Peninsula. The scanty information at hand, however, leads to much doubt of the sea-beach origin of these sands. The reason for the doubt rests largely on the shape and size of the basin that would result if the whole region were depressed so as to bring the so-called beach down to sea level. Such a change would result in a narrow estuary, nowhere much over 4 miles in width, and in some places—as, for instance, 6 miles north of White Mountain—not over three-fourths of a mile. In such a body of water, wave and current action, the predominant activities in beach formation, would be very ineffective, and muds, silts, and river wash would be much more characteristic than clean beach sands. In this connection it is perhaps desirable to point out that the presence or absence of gold is in no measure dependent on sea beaches except under certain special conditions such as exist around Nome. The United States has a shore line composed of thousands of miles of beaches, and yet not 1 per cent of this entire length is auriferous in economic quantities. The idea, therefore, that old beaches and rich gold deposits are necessarily interchangeable terms should be discarded

MELSING CREEK.

On Melsing Creek, which was formerly one of the most productive streams in the district, not very much gold has been taken out during the last season. This was largely due to the extremely unfavorable weather conditions. It was so dry that only in the latter part of the season could enough water be obtained for mining purposes. When it did rain, so much water came down that it could not be handled by the miners, and consequently much of the rich ground was flooded. At the time of the writer's visit the only work in progress was near the junction of Basin and Melsing creeks. At this place the course of the pay streak, which lies only a few feet above the present stream level, is very sinuous and suggests that these gravels were laid down by a stream of relatively small size meandering widely on a flat slope. A feature of some interest was the occurrence of large granite and

quartzite bowlders, reaching 18 inches in diameter, in a layer of muck and decomposed vegetable matter lying above the gravels. The granite is but slightly decomposed and the bowlders are rather angular. These facts suggest a different transporting agent than running water. Associated with the auriferous gravels are in many places thin strata of cemented gravels in which the cementing material is mainly calcite. The cemented character prevents the separation of the gold in the sluice boxes, so that if much of this sort of gravel should be encountered recourse to some method of crushing would be necessary.

On Melsing Creek a method of preparing the sluice boxes which has not been seen in any other part of the peninsula was noted. This consisted of nailing a strip of canvas or cocoa matting on a plank slightly narrower than the bottom of the sluice box. On top of the canvas a strip of galvanized-iron screen, with about one-fourth inch mesh and the same width as the plank, was fastened. In use, this plank was placed in the bottom of the sluice box and the riffles laid on top, thus holding it in position. To clean, the plank was taken out of the sluice box, turned upside down, and pounded with a hammer or mallet. Although no comparative figures were available to prove the added efficiency of the sluice boxes thus equipped, the operator was completely satisfied with the results, as he was convinced that the additional saving of gold was very great. It is of course not necessary that every box in a set should be equipped with such a false bottom. Individual practice and study will determine the most effective number for different kinds of gold.

OPHIR CREEK.

Ophir Creek still continues to be the most productive of the tributaries of the Niukluk. The development of the placer claims along its course and on its main tributaries—such as Dutch, Crooked, and Sweetcake creeks—has constantly demanded additional water supply with greater head. To meet this demand high-level ditches have been constructed, but it was early recognized that even under the most favorable circumstances Ophir Creek could not be relied on to meet the growing demands. Consequently it has been necessary to lead water from other drainage areas into the Ophir Creek basin. The largest operation of this kind has been successfully carried out and undoubtedly permitted mining which the dry weather of last summer would have otherwise prohibited. This ditch takes water from Pargon River at Helen Creek, a small tributary about 2 miles north of the summit of Mount Chauik. The ditch is 11 miles long, and in many places, where the slopes are excessive, flumes have been constructed. The water is led around the eastern flank of Mount Chauik and thence across the divide into the Ophir Creek basin. In order to obviate additional ditch construction, the water is discharged

into Ophir Creek and taken up again lower downstream by one of the existing ditches. It was estimated that about 8,000 miner's inches of water were available from the Pargon, but during the dry period of last summer only about 500 inches were delivered by the ditch.

Another project for leading water from Pargon River to Ophir Creek is under way, but as yet actual ditch construction has made little progress. Up to the present time the work of the company has been devoted mainly to surveying the course for the ditch, making preliminary observations, and acquiring rights of way. The proposed ditch will take water from a point considerably below the completed one, and for that reason should have more water available.

The operations on Ophir Creek during 1906 were carried on less by individuals and more by large companies than in previous years. The most active work had been done by the dredge at the "Portage," by elevators near Sweetcake and Dutch creeks, by derricks a little above Dutch Creek, and by shoveling in near the mouth of Crooked Creek. Above Crooked Creek no work has been done on Ophir Creek during the last summer. In regard to the tributaries it may be said that a little mining has been done on Sweetcake Creek, but the values do not seem to extend much more than a mile above its mouth. On Dutch Creek a little mining has also been done. The small stream joining Ophir Creek near claim "19 above" has been prospected, but does not seem to carry values above its mouth. Along Crooked Creek for a distance of 2 miles the creek has been worked continuously all summer by parties ranging in size from 2 to 14 men. The fact that almost all the side streams carry gold has led to an enrichment of the main-stream gravels. Practically every one of the bonanzas of Ophir Creek has occurred in the main stream at the junction of a side stream. The recognition of this feature, which also prevails on many other streams, should be of some assistance in prospecting undeveloped regions.

RICHTER, CAMP, AND GOLDBOTTOM CREEKS.

Richter Creek, the first tributary of the Niukluk from the southwest above Ophir Creek, although the goal of one of the stampedes that took place a few years ago, seems now to be exhausted and its output is negligible. Camp Creek has been worked by prospectors during the last summer, but the locations have been made mainly on the gravels near the Niukluk. The mine described on page 148 may be cited as an example of this kind of development. Goldbottom Creek and its branch, Warm Creek, tributary to the Niukluk a little above Camp Creek, have produced some placer gold during the last summer. Activities, however, have not been pushed with as much vigor as in previous years, only two or three small parties having been working on these creeks.

ELKHORN CREEK.

Elkhorn Creek has also been a small producer during the last year. The operations have been carried on for a distance of about 2 miles along the stream, but the largest amount of work has been done near the mouth. The section exposed in pits at the junction of the Niukluk and Elkhorn Creek is as follows:

Section at junction of Niukluk River and Elkhorn Creek.

	Feet.
Vegetation	2
Clay and muck	4
Sands and gravels	4

The lowest member showed considerable cross bedding in the sands associated with the gravels, thus indicating the variable character of the water by which they were deposited. Numerous pieces of wood in a more or less decomposed condition were found in the gravels. The surface form and internal structure suggest that the deposit is an alluvial fan of Elkhorn Creek rather than the flood plain of Niukluk River. Work on this creek was abandoned before the last week of September and, owing to the absence of miners, no estimate of the production or tenor of the gravels could be obtained.

CASADEPAGA RIVER.

MOUTH TO BONANZA CREEK.

The general impression of the mining which had been done along the Casadepaga in 1906 was that the work had been carried on more by prospectors than by active settled companies. As a result of this method of work the production from the stream and its tributaries will probably be small. On the lower course of the river as far as Bonanza Creek no mining had been in progress. Near Bonanza Creek two camps had been established to work the low bench gravels of the Casadepaga. These camps, however, have employed only two to five men each, so that not much work has been accomplished. A little work had been done on Bonanza Creek, but it was not visited.

BONANZA CREEK TO PENELOPE CREEK.

From Bonanza Creek to Penelope Creek the river gravels have been extensively prospected during the summer by a drill with a crew of six men, with the aim of determining the character of the ground. No statement as to the results of this work can yet be made. One peculiar feature noted in drilling below the mouth of Penelope Creek was that on certain of the river bars gold occurs on the surface and not on bed rock. There is no false bed rock of clay at these places and the surface concentration is due to the washing away of the gravels

of the bars during periods of flood, the particles of gold previously contained in the gravels being left behind because of their greater weight. On Big Four Creek, a tributary of the Casadepaga from the south between Bonanza and Penelope creeks, only assessment work has been done during the last summer. On Birch Creek, which flows into the Big Four about 5 miles above the Casadepaga, two camps have been engaged in working creek gravels below Shea Creek.

At Dixon Creek, 2 miles above Big Four Creek on the Casadepaga, there has been some development work. The bed rock at this place is schist and limestone, the creek appearing to follow the contact more or less closely. As this contact is in many other places the locus of mineralization it would seem desirable to further investigate the gravels of this creek and of the Casadepaga near its junction.

PENELOPE CREEK TO MOONLIGHT CREEK.

Penelope Creek is now the terminus of the Council City and Solomon River Railroad and by this line is about 32 miles from Solomon. There have been two camps on this creek, one near the mouth and one about a mile above. The upper camp has been the most active during the last summer. Four men have been employed and the gravel has been handled with horse scrapers. A short ditch has been constructed at a low level, but, as in other parts of the peninsula, considerable difficulty has been experienced from lack of water.

On Goose Creek only two men have been mining during the last summer and according to local reports not much more than wages has been produced. Three-fourths of a mile above Goose Creek there is a broad bench of gravels trenched by the Casadepaga which shows good values. Mining on this flat, however, has been inactive, pending the completion of a ditch from Moonlight Creek. (See p. 154.)

No mining except assessment work was done in 1906 on Canyon Creek. On Banner Creek also work was practically at a standstill. It is reported that all the gravels on the latter creek have been turned over and that the only values left are those that have been lost by the primitive methods in vogue when the creek was first worked. Certain claims are, however, held by annual assessment work, but the yield is seldom more than wages.

Willow Creek, which is noted on some of the Survey maps as Left Fork, is locally known as Lower Willow in order to distinguish it from Upper Willow Creek, also a tributary of the Casadepaga. Upper Willow Creek enters the river from the south about a mile west of Johnson Creek, while Lower Willow Creek has its mouth nearly opposite Ruby Creek. At the mouth of Lower Willow Creek two men have been working all summer. A mile above the mouth two men have been at work, but have been much hampered by the

lack of water. A mile above the forks of Wilson and Lower Willow creeks two men have been doing some work, but operations were suspended late in the season to allow the installation of a California grizzly. About 1½ miles above the fork of Wilson and Lower Willow creeks two men had been employed all summer. They stated, however, that the claim had been previously worked out, and their operations this summer consisted merely in saving some of the values that had been lost in the earlier mining. A short ditch at a low level takes water from the upper part of the creek and carries it to the discovery claims, a distance of about 2 miles. The geology of the region at the forks of Willow Creek is complex, the bed rock consisting of limestone and both chloritic and graphitic schist. The gold of this part of the stream has probably been derived from a near-by source. Mineralization is evident in at least two places at the schist and limestone contacts on the south side of Lower Willow Creek. At one place sulphides were recognized in a quartz vein, and numerous copper stains on weathered vein stuff were found on the summit of the divide between Lower Willow Creek and the Casadepaga near the head of Ptarmigan Creek.

On Ruby Creek two parties have been at work during the last summer, but the creek is now exhausted. It is said that the values have been more completely extracted from the gravels of this creek than from those of any other stream in the Casadepaga drainage, so that reworking these gravels in the future will not be remunerative.

On Moonlight Creek the main activity during the last two years has been ditch building. This creek heads in a series of bare limestone hills with steep slopes, so that the run-off is high. The ditch has an intake at an elevation of about 500 feet. It is proposed to carry the ditch across Canyon Creek to the broad bench of Casadepaga River about three-fourths of a mile southwest of Goose Creek. The water supply from Moonlight Creek will be augmented by a ditch line from Upper Willow Creek with its intake at such a level that it delivers water to the ditch at Moonlight Creek at an elevation of 500 feet. It is estimated that the ditch will have an average delivery of 1,500 to 2,000 inches of water.

An eighth of a mile below the junction of Moonlight Creek and the Casadepaga there has been some slight exploration of the bench gravels that occur a few feet above the level of the river. The gravels seem to be typical river gravels, but the floor on which they rest is rather uneven. Old channels have been reported in this district, but the rumors could not be investigated. Above Moonlight Creek there have been no mining operations on the Casadepaga during the last season.

AURIFEROUS LODE DISCOVERIES.

During the last few years there has been a noticeable increase in activity in the search for lode mines, with the result that several veins of promising character at the outcrop have been located. As has already been stated, the Big Hurrah mine is the only gold-bearing lode mine in operation in the district at the present time, but this condition can hardly prevail long.

DESCRIPTION OF LOCALITIES.

A very promising ledge of quartz has been located on the divide between Goldbottom and Ophir creeks near the head of Crooked Creek. The lode occurs near the contact of limestone and schist, and specimens show considerable free gold. It is reported to run nearly $40 to the ton, but it is not known how the sample was collected. This discovery seems to be very significant in connection with the fact that the gold in many parts of Crooked Creek is very sharp and angular and much of it has quartz fragments attached. A specimen of gold seen near the mouth of Crooked Creek, derived from a placer deposit at that place, was of such fragile shape and crystalline form that it seemed impossible for it to have been carried more than a few feet from the vein from which it was derived.

Another lode which has recently been found is located about half a mile southeast of Post Creek, a tributary of the Niukluk from the north. This vein has quartz as the gangue mineral, occurs at the contact of a schist and limestone, and is about 8 feet in width. According to reports it shows considerable free gold, and the values obtained by crushing and panning indicate that the vein would run nearly $35 to the ton. No responsibility is assumed for this statement, as it is not known how the sample was collected. It is an interesting speculation whether or not the vein on the divide at the head of Crooked Creek and this vein near Post Creek are connected.

Still another lode has been located on the south side of the Niukluk near the head of Camp Creek. No specimens were seen from this vein, and the descriptions were meager. They sufficed, however, to make it certain that a quartz vein carrying free gold in visible quantities has been found at this place and that developments are being pushed as efficiently as a small force and funds permit.

In addition to these well-authenticated finds, there are numerous rumors of other lode locations. These reports seem to indicate clearly that more and more attention is being paid to the search for lode deposits throughout the district.

ASSOCIATION OF LODES AND CONTACTS.

In view of the fact that all the lodes so far discovered are in close proximity to the limestone-schist contacts, it may be interesting to point out that Brooks, Collier, and Hess, in a manuscript which has not yet appeared in print, have suggested that these contacts may be zones of weakness along which ore-bearing solutions could most easily penetrate. If this suggestion is verified by subsequent closer inspection of a large number of examples, it will be of immense importance in directing the prospector to the more likely places of mineralization. It must be remembered, however, that in making so broad a generalization it is not intended to assert that in every place where a contact is found a deposit of economic importance will occur. The statement simply means that a valuable ore deposit is more likely to occur at such a place than at any other. If, however, the shattered and easily pervious condition which is so commonly associated with these contacts is duplicated elsewhere, ore deposits are just as likely to occur in those places as in the contact zone.

SILVER-LEAD ORE.

On Omalik Creek, a branch of Fish River, which is a tributary of the Niukluk, a silver-bearing galena lode has long been known. This vein was the first lode discovered in Seward Peninsula, and its discovery dates back to 1881. Since that time it has been worked more or less intermittently without producing much metal. During the last summer renewed attempts were made to reopen the vein. The mine was not visited by any member of the Geological Survey, but from the current reports it seemed to be the intention of the company to spend the summer months in taking in supplies, but active mining operations were not to be commenced until the freeze-up occurred. The high cost of supplies and labor makes this undertaking one of great expense.

GEOLOGY AND MINERAL RESOURCES OF IRON CREEK.

By PHILIP S. SMITH.

INTRODUCTION.

Iron Creek, one of the largest tributaries of the Kruzgamepa, joins that river near the great bend about 11 miles east of Salmon Lake. Although really continuous, Iron Creek bears three names in different parts of its valley; thus from its mouth to Left Fork, a distance of 7 miles, the stream is called Iron Creek; above Left Fork as far as Eldorado Creek, a distance of 1 mile, it is called Dome Creek, and from Eldorado Creek to the divide it is called Telegram Creek. This confusion of names is due to the interpretation of the mining laws which permits the staking of additional claims on different creeks—i. e., creeks having different names. There are four main tributaries, the three largest being from the south and the fourth and smallest from the north.

Owing to the fact that some errors occur in the reconnaissance map of 1900,[a] the only map prepared by the Geological Survey of this region, it has seemed advisable to correct such inaccuracies as were noted in a hasty trip along the stream in 1906. Much assistance in platting the district was afforded by the transit notes of a ditch survey made by J. M. Love, of the Gold Beach Development Company. A corrected map of the Iron Creek basin is shown in fig. 8. It will be noted that this basin is roughly triangular. The western side of the triangle forms the divide between the drainage of the Kruzgamepa and that of Iron Creek. The southern side of the triangle in the western part separates the Iron Creek drainage from the headwaters of Gassman and Venetia creeks, both tributaries of Eldorado River. The divide from Venetia Creek is low, being only about 800 feet above the mouth of Iron Creek, or 1,000 feet above the sea, so that it affords a good route for a road to Nome. The eastern portion of the southern side of the triangle forms the divide between the Iron Creek and Casadepaga drainages. A low pass, with an elevation of about 1,000 feet, permits a good wagon road to run up Telegram Creek and down Lower Willow Creek to the Council City and Solomon River Railroad, a distance from the junction of Iron and Canyon creeks of 13 miles.

[a] Reconnaissances in Cape Nome and Norton Bay regions, Alaska, in 1900; a special publication of the U. S. Geol. Survey, 1901, pl. 17.

Now, however, that the Seward Peninsula Railway from Nome to the Kougarok has been completed beyond the mouth of Iron Creek, it is probable that with reasonable freight rates the use of the wagon roads will decrease, though freight is now delivered at Iron Creek by winter hauling from Nome for only 2 cents a pound. The northern side of the Iron Creek drainage basin forms the divide from Sherret Creek and several smaller streams which flow northward into the Kruzgamepa.

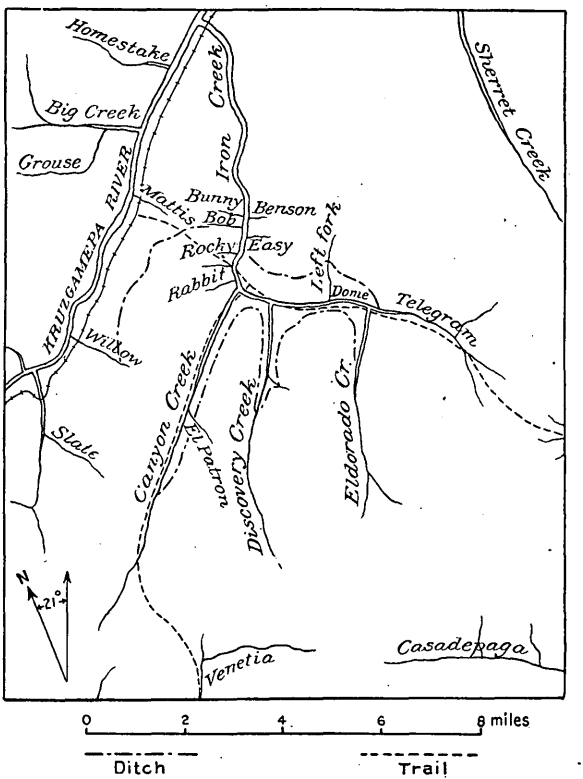

FIG. 8.—Sketch map of Iron Creek basin.

PHYSIOGRAPHY.

STAGES OF VALLEY CUTTING.

The physical features of the district are complex, and only the more striking facts can be presented here. An older topography, in which the present stream is intrenched, is preserved in the upper slopes of the valley walls. In this portion the bed rock is so covered over that exposures are practically wanting. This is due to a period of erosion and the accumulation of a heavy mantle of waste that reaches nearly to the top of the divide. The higher portions of the divides are generally bare, consisting of fantastically curved pinnacles of rock from

which taluses with steep slopes, practically uncovered by vegetation, descend, gradually merging with the smoother moss-covered slopes of the middle portion of the valley walls.

The streams in their lower courses flow in rock-walled canyons. In tracing any one of the streams headward the canyon is found to decrease in height and to merge gradually with the older topography previously mentioned. The history of these features suggests that the former topography of gentle slopes and wide, open valleys was produced by the long-continued erosion of rivers and weathering. Subsequently uplift of the region renewed the down-cutting power of the streams, so that canyons were carved in the floors of the old valleys. This erosion allowed rapid reassortment of the old gravels and waste and thus effected the concentration of any gold or other heavy minerals which may have been contained in the gravels.

The canyon cutting ceased, however, before it had progressed beyond the lower portions of the streams. The interruption was produced either by a movement of the land or, as is more probably the case, by a climatic change which decreased the amount of water transported by the streams. Such a change may have also been responsible for the disappearance of the local glaciers which were formerly present in the Kigluaik Mountains. Whether the climatic change had anything to do with the retreat of the glaciers or not is, however, of slight importance in this discussion. Some change must have occurred, for the streams are no longer down-cutting but actually building up the floors of their valleys. The reason for believing that the change must have been one which affected the rainfall rather than the elevation of the district with respect to sea level is based on the shape of the rock canyon. The canyon has a broad, swinging course which is so symmetrical that it could not have been produced by the straggling present stream, which occupies only a small portion of the floor between the rock walls. Many other streams in different parts of Seward Peninsula show this same feature. The extensive development of this phenomenon suggests a widespread cause, such as climatic change, rather than a local cause, such as uplift.

EVIDENCES OF GLACIATION.

Another feature of some theoretical interest is the presence of granite bowlders on the divide near the low sag at the head of Mattis Creek. In the rapid reconnaissance it was impossible to examine the district with sufficient care to make a final statement as to the origin of these bowlders. It is known, however, that there is no granite of similar character south of the Kigluaik Mountains. Furthermore, the granite bowlders are unweathered, showing that they have not been in their present position a very long time geologically. Although the question has not been carefully studied in the field, it is suggested that possibly

these bowlders have been brought by glaciers from Kigluaik Mountains and carried into their present position by ice blocks floating on a lake formed by glacial obstruction of the drainage. This suggestion is to be regarded only as a working hypothesis, but it fits in with the known facts, which may be summarized as follows: The angular, unweathered form and foreign character of the granite and the presence of shore lines at considerable elevations. Lakes of this type are common in regions that are at present glaciated, and evidences of such lakes have been recognized in many places where glaciers have now disappeared.

GENERAL GEOLOGY.

The bed rock of the district belongs to the Nome series. It consists of a series of much faulted and contorted limestones and schists and some greenstones. The greatest development of limestone occurs in the lower part of Iron Creek, but a great number of thinner beds interlaminated with schists are encountered even up to the headwaters. It is believed that the numerous alternations of schist and limestone are indicative of the source of the Iron Creek gold. Although no extensive proof of mineralization at the limestone-schist contacts has been found in this locality, the fact that such contacts are the loci of mineralization has been very well established in other parts of Seward Peninsula.

The rocks of the Iron Creek district trend northeast and southwest and dip toward the southeast, but there are numerous exceptions to this general direction, as the rocks are complexly folded and faulted. The deformation and consequent shattering that the rocks have undergone has undoubtedly resulted in the formation of zones of pervious rock in which mineralization has taken place. The streams also have taken advantage of the northeast-southwest structure and practically all the tributaries are arranged parallel to this direction.

In lithologic character the rocks are similar to the Nome series as described for other parts of the field. The schists present two main lithologic facies, namely, graphitic and chloritic. No boundary between the two can be drawn at the present time, although it is believed that detailed study would solve their interrelation and structure. The chloritic schists are most extensively developed in Iron Creek below Telegram Creek. They are thinly laminated, with wavy cleavage, and rusty brown to greenish gray in color. Chlorite and quartz are the only minerals distinguishable in the hand specimen. Graphitic schists are most abundant on Telegram Creek above Eldorado Creek. These rocks are in general but slightly schistose and would better be described as dark, nearly black, graphitic quartzites, with here and there schistose phases. Hand specimens show considerable quartz and a little chlorite. The other constituents are not distinguishable by the eye, though the presence of graphite is recognized

by its soiling the hands. Here and there some sulphides are found, especially in the places where dislocations occur.

The greenstones which occur in the Iron Creek region have not been studied in detail, but seem to be similar to those found in the adjacent country nearer Nome. If this correlation is correct, they are mainly of intrusive origin. Rumors were heard of an extrusive flow of greenstone south of Iron Creek, but neither was it found in place nor was any float of an extrusive greenstone seen, so that doubt is felt about the occurrence of a surface flow.

MINING DEVELOPMENTS.

GENERAL CONDITIONS.

Mining on Iron Creek has been much retarded by the inaccessibility of the region, but this obstacle is now disappearing with the building of railroads and wagon roads. Freight from Nome can now be delivered by the Seward Peninsula Railway at the mouth of Iron Creek, but the schedule of rates was not learned. It has already been noted that in winter supplies can be brought in by team at a cost of 2 cents a pound. The cost of summer hauling by team to Iron Creek is now, owing to the good condition of the road to Nome, but little higher than the winter rate.

DITCH CONSTRUCTION.

In 1906 work on Iron Creek and its tributaries had almost ceased at the time of the writer's visit in the latter part of September. With one exception the work for the season seemed to have been carried on by small outfits of only one to five men each, and a liberal estimate of the output of the creek and tributaries for the year would not exceed $50,000. The most important work during the last season has been ditch construction, about 13 miles having been built. One ditch taps Eldorado Creek at a point 1 mile above its junction with Telegraph Creek and leads the water along the south wall of Iron Creek to a penstock near the junction of Discovery and Iron creeks. A second ditch takes water from Canyon Creek 5 miles above its mouth and leads it along the east wall of Iron Creek, thence following the south slope of the valley to the west side of Discovery Creek, along which it runs southward to a point 2 miles above the mouth of the stream, where it crosses and extends along the east side of the valley to the penstock previously noted. Another ditch on the north side of Iron Creek, which takes its water from the junction of Telegram and Eldorado creeks, is also being constructed by the same company. Between sixty and seventy men at a time have been employed in the construction of these ditches. They were not completed until the latter part of September, so that water for washing the gravels was available for

only about two weeks. The ground operated at present by the company is on Iron Creek at the mouth of Discovery Creek. A hydraulic elevator has been installed to handle the flood-plain gravels, and active mining operations will be conducted during the coming year.

MINING ON MAIN STREAM.

Between Discovery Creek and Left Fork on Iron Creek there is a fractional claim which has been worked for the last two years on a small scale. From one to five men have been employed on this claim all summer. The gold is coarse and easily saved. Both rusty and bright gold are found. The values occur in a thin pay streak on limestone and in the cracks and crevices of this bed rock. The small amount of ground in this claim has prevented any large-scale developments.

At the junction of Left Fork and Iron Creek three men have been continuously employed all summer working creek gravels. The method of working these gravels has been by means of a bed-rock drain and sluice boxes. Several nuggets worth $30 or $40 each have been found in this place. The bed rock is a much shattered limestone with thin bands of chloritic schist both above and below it.

A short distance upstream from Left Fork the largest nugget recorded from Iron Creek was found. This nugget weighed over 30 ounces and was valued at $600 on the assumption that the gold was worth $18.50 an ounce. It is a fact of some significance that upstream from this point, which is about half a mile above Left Fork, the gold is all rusty, whereas below both rusty and bright gold occur. The reason for the absence of bright gold above is believed to be that this point marks the place where the older and newer valleys merge. In other words, upstream the creek flows in the nearly unmodified old valley, while downstream it has cut below that level. The result of the down cutting has been to wear some of the gold and expose fresh, shiny surfaces; whereas the gold that has been practically unmoved has a rusty coating.

Between Left Fork and Eldorado Creek only one camp was in operation in 1906. Five or six men have been at work at this place, but as it is understood that this portion of the creek has already been worked over three times it is doubtful whether subsequent work will be remunerative. The gravels are apparently similar to those already noted.

Above Eldorado Creek the main stream, as has been previously stated, is called Telegram Creek. One man only has been at work on this stream during the last year. This claim is located at a point about a mile from the divide. The bed rock is mostly graphitic schist with some thin limestone and schist bands. Several nuggets, worth as much as $100 apiece, have been found on this claim, and it is reported that very coarse gold is found even on the crest of the divide from Willow Creek. The water supply of Telegram Creek is small,

especially in a dry year, such as 1906. Often this lack has hindered or in large measure prevented exploration of the gold gravels that have been found by prospectors in this part of the Iron Creek basin.

MINING ON TRIBUTARIES.

On the tributaries of Iron Creek but little work has been done. Bunny Creek, the fifth stream which enters from the west below Canyon Creek, is not over three-fourths of a mile in length. Two men have done a little work on this stream last summer, but it probably produced not more that $100 or $200. On Bobs Creek, the next small stream south of Bunny Creek, the only work done during the last season has been on the upper part. This claim has been worked with water brought over the divide from Willow Creek, the first tributary of the Kruzgamepa east of Rock and Slate creeks. Considerable trouble has been experienced with the ditch, as a large part of it is built on frozen ground, which melts under the water. This ditch carries only about 400 miner's inches of water. Even this small amount is more than is yielded throughout the season by Willow Creek, and it is proposed to extend the ditch next year 3 or 4 miles to Slate Creek.

Easy Creek, which enters Iron Creek from the east opposite Bobs Creek, has shown good values in the lower portion. Three men were at work at this place last summer, but it closed down rather early in the season owing to the drought. Little more than assessment work has been done on the other claims along Easy Creek. The next small stream to the south is Lulu or Benson Creek. Four men have been operating on this creek the entire summer. On Rapid, Rocky, and Rabbit creeks, the three other small tributaries of Iron Creek from the west below Canyon Creek, little more than assessment work has been done during the last season, although they are completely staked.

Except on Canyon Creek, no work has been done on any of the larger tributaries of Iron Creek. On a little tributary of Canyon Creek called El Patron Creek, about 3 miles above the junction with Iron Creek, one man has been at work all summer. However, but very little gold has been produced owing to the lack of water. It is expected that with the completion of the Canyon Creek ditch water may be purchased, so that work will be pushed with greater activity in the coming summer.

SUMMARY.

In summarizing the Iron Creek region it may be said that the gold is mostly coarse and easily saved; that it has been derived from a relatively local source; that water for the economic development of the placers is at hand, and that the questions of freighting and transportation are rapidly being effectively and satisfactorily settled.