RECENT DEVELOPMENTS IN SOUTHERN SEWARD PENINSULA.

By Philip S. Smith.

INTRODUCTION.

The purpose of this paper is to describe the new work which has been undertaken, the previous work which has been recently completed, and the projects and tendencies which have been noted in the southern part of Seward Peninsula. As an account of the earlier developments has been given in former Survey publications,[a] a repetition of the facts there set forth is unnecessary.

In trying to cover so large an area as the southern part of Seward Peninsula, the writer has unavoidably overlooked many enterprises and given to many minor features undue prominence because they fell more directly under his observation. The mention of various properties is therefore not to be taken as evidence that they are the most important. In fact, many of the largest producers will not be referred to at all, for they are only continuing work previously described in some of the reports already cited, and their developments have thrown no new light on the larger problems of Seward Peninsula geology and ore deposits. On the other hand, some prospect hole without enough mineral exposed to warrant staking the ground may be significant as suggesting an important economic truth.

PRODUCTION.

Figure 18 shows in diagrammatic manner the estimated production of Seward Peninsula from 1897, the first year when any notable amount of gold was won, to the end of the open season of 1908.

[a] Brooks, A. H., Placer mining in Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 19–24.
Moffit, F. H., Gold mining in Seward Peninsula: Bull. No. 284, 1906, pp. 132–141.
Moffit, F. H., The Nome region: Bull. No. 314, 1907, pp. 126–144.
Smith, P. S., Gold fields of the Solomon and Niukluk River basins: Idem, pp. 146–156.
Smith, P. S., Geology and mineral resources of Iron Creek: Idem, pp. 157–163.
Brooks, A. H., The Kougarok region: Idem, pp. 164–179.
Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., Gold placers of parts of Seward Peninsula: Bull. No. 328, 1908.
Smith, P. S., Investigations of the mineral deposits of Seward Peninsula: Bull. No. 345, 1908, pp. 206–250.
Knopf, A., The Seward Peninsula tin deposits: Idem, pp. 251–267.
Knopf, A., Mineral deposits of the Lost River and Brooks Mountain region: Idem, pp. 268–271.
Knopf, A., Geology of the Seward Peninsula tin deposits: Bull. No. 358, 1908.

These estimates are based on statements from the different banks, post-offices, express companies, and custom-houses, and replies to schedules sent out by the Geological Survey. Unfortunately, the last-named means of acquiring information has not been very successful in Seward Peninsula, owing to the lack of cooperation on the part of some of the producers. It is hoped that in the future more of the miners will respond to the request of the Survey for information; otherwise the production which should be credited to Seward Peninsula may be attributed to some other district. In this way a wrong impression may be gathered by outsiders of the mining activities in this region.

As is represented by the diagram (fig. 18), the gold production of Seward Peninsula has shown a marked decline from that of 1907, being about $5,000,000 in 1908. This amount is about the same as that for each year from 1900 to 1905, inclusive—in other words, prac-

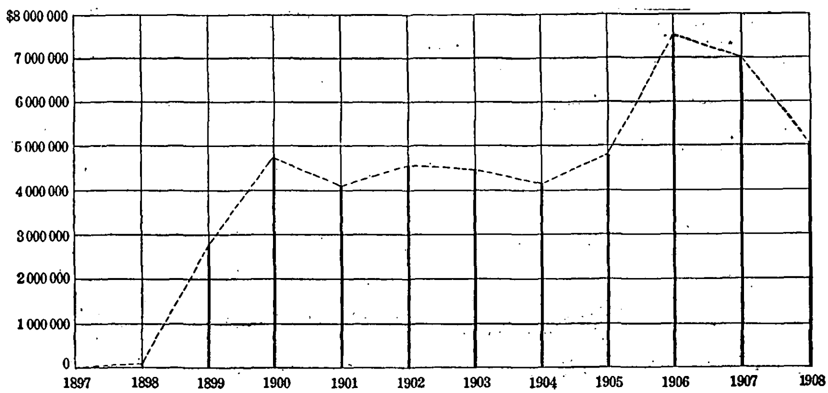

FIGURE 18.—Gold production of Seward Peninsula from 1897 to 1908.

tically the same as before the ancient beaches were discovered. Undoubtedly, many explanations could be advanced for this great falling off in the production of last year. Outside of more or less local reasons, there are three causes which have affected the region as a whole—the unsettled financial condition in the States, the mining out of the known bonanzas, and the unfavorable climatic conditions. Of these the second and third were the most important. The financial crisis had only a slight effect on the production of Seward Peninsula in 1908, but its influence will perhaps be felt more in the coming year, for the inability to start new enterprises in 1908 will be a decided drawback.

As placer mining progresses, the bonanzas that have given rise to the establishment of a camp become exhausted. It is inevitable that the production should show a decrease after a few years unless prospecting work keeps always ahead of the actual developments so that new deposits are discovered. After a camp has become well established, a uniform production from medium-grade placers is likely to replace the fluctuating production characteristic of the early bonanza stage. There can be no doubt that large deposits of low-grade gravel that can be economically exploited by competent management still remain in Seward Peninsula. The need of the region as a whole seems to be adequate prospecting and the development of the different enterprises on a sound business basis.

The unfavorable climatic conditions which prevailed in 1908 probably had a greater effect on the production than either of the other factors that have just been discussed. The unfavorable conditions were of two kinds—small precipitation and low temperature. An idea of the small amount of precipitation is afforded by a comparison of the stream discharges measured by Mr. Henshaw and Mr. Barrows in 1907 and in 1908, as stated on pages 370–401. All the streams show a marked decrease during the last year. But the figures themselves are not so impressive as the statement that practically no rain fell until the last week of July, and then the amount was rather small. Never, since the beginning of mining in the peninsula by whites in 1897, has so dry a year been reported. Many of the streams ceased flowing, and water, even for camp use, was often hard to find. Tundra fires were common, and everywhere along the railroad the sparks from the engine were starting new blazes each day. Thousands of the railway ties were burned and in places even the bridges over the creeks were destroyed. The aridity was not confined to any one section but was widespread throughout the peninsula. Its effect on mining was least marked in those places where the ditch systems derive their supplies from some large permanent source. Even in these places, however, it was not possible to work a full force. It should be pointed out, however, that a large part of the gold from the peninsula is won by winter mining, and that water for sluicing the winter dumps is generally snow water or is pumped by power.

Mining was retarded also by the fact that the opening of the season—that is, the arrival of boats from the States—was much delayed. It was the 15th of June before the first boat arrived, and one boat did not get in until the middle of July. Many of the mining operators were thus delayed several days in commencing work, and even a day's time in so short a season as that of Seward Peninsula may mean a marked reduction of output. However, a considerable proportion of the production is derived from winter work and was therefore not affected by the late arrival of the boats. It should also be noted that the season was not very late on land, but that the streams were flowing as early as usual and only the unusually heavy ice pack prevented the boats getting through. In addition to the time lost during the first part of the season, many more days were lost at the close on account of an early freeze-up. By the middle of September many of the smaller operators had stopped work owing to the freezing of the streams, and by September 22 or 23 all the large ditch lines that bring water from the interior to the vicinity of Nome had closed for the season. This year the ditches stopped delivering water at the earliest date that has ever been known in Seward Peninsula, except in the fall of 1905. The shortness of the season necessarily affected the production of the region, but just how much can not be determined.

NOME REGION.

GENERAL CONDITIONS.

Placer mining in the vicinity of Nome has been conducted on practically the same lines as in the past. No new bonanzas have been found during the year and much of the formerly known rich ground has been worked out. Nome, however, still leads the peninsula in gold production and the amount won probably exceeds that from all the other parts of Seward Peninsula put together. The causes which led to a great dropping off in other localities were not so strongly marked near Nome, because the large companies have already installed long ditches or mechanical devices for supplying water at a good head and in large volume. Nevertheless, none of the mines were able to work with full force all summer and the early closing of the ditches cut several days from the length of the working season. The snowfall near Nome was only about half that of other years, so that the supply of snow water for sluicing was available for only a few days.

To distribute the gold production of this region among the various types of placer deposits is impossible, owing to the fact that few replies have been received from the miners in response to schedules sent out by the Geological Survey. From the slight amount of information at hand it seems probable that about two-thirds of the entire production from the Nome region has been derived from the beaches and the other third from the creek and bench placers. The probable decrease in the ratio between beach and creek production for the year is believed to be due in a measure to the curtailment of work on the creek deposits by the shortness of the season and the lack of water. It should be remembered, however, that in actual amount the yield of the beach deposits has decreased proportionally more than that of the creek gravels. This falling off is due mainly to the low tenor of the beach deposits, because the conditions which affected the creek mining had only a slight effect on beach mining. This is true, first, because most of the beach is mined during the winter and therefore climatic conditions do not interfere, and, second, because the dumps from even the largest mines are sluiced in a very few days during the early part of the summer.

BEACH PLACERS.

Mining on the ancient beach lines has not undergone any notable reduction in costs during the present year. In fact, there has been a general tendency to mine more and more difficult ground, and this tendency has had the effect on the whole of increasing the costs. In one mine in particular work was being carried on by underground stoping in places where a perfect deluge of water was pouring through the roof. So much water was coming into the drifts that it could be kept down only by the use of very large pumps. Under such conditions a large part of the profits were consumed by fuel charges. At another mine the management, after having installed successively larger and larger pumps, finally decided to suspend operations, for the cost of working exceeded the income from the placer.

Most of these difficulties with water are encountered in ground where there is no permanent frost. There are many such areas which do not show any definite or constant relation to the present topography. Clumps of willows are taken as surface indications of thawed ground, but the more sections are exposed by prospecting the more irregular appears to be the distribution of the ground that is not permanently frozen. The presence of willows seems to serve little more than to point out the places where thawed ground is more likely to be encountered than elsewhere. They seldom grow on frozen ground, but on the other hand they are lacking in many places that are underlain by thawed material. Carefully drilled holes are probably the most effective and cheapest method of exploring an area to determine the physical character of the gravels in advance of actual developments.

A new beach placer or line of beach called the "submarine" has been discovered during the past year, and active operations have been conducted on it in at least two mines where large dumps were taken out during the winter of 1907–8. No accurate data on the value of the gravels were obtained, but it seems certain that the tenor is not nearly so high as that of the "third beach line." As this beach is a new discovery, and has not been described before in the reports of the Geological Survey, more space may be allotted to it than its output would perhaps warrant.

The easternmost of the properties on this beach is located on the coastal plain just west of Snake River and almost directly south of the pumping plant, a quarter of a mile north of the present beach. The ground has been opened by means of two shafts, the eastern of which has a depth of 69 feet and the western of about 65 feet. At this place the pay streak is 19.6 feet [a] below sea level and for that reason the beach is called the "submarine." The pay gravels in the

[a] Determined by Arthur Gibson, of Nome.

western part of the claim rest upon a true bed rock. Wherever this was seen it was a bluish-gray, somewhat calcareous schist, similar to that occurring in many other parts of the Nome district. The bed-rock surface slopes slightly toward the east, so that in the eastern part of the claim the values are found in material resting on a false bed rock of clay. The workable gravels have usually had a constant thickness of 3 feet. Not enough development work has been done to determine the direction or width of the auriferous gravels, but from the slope of the floor it is possible that their trend may be more nearly north and south than the present beach. Such a direction seems highly improbable, however, and it is much more likely that this slope is due to later deformation. Until the blocking out of the ground has gone further it seems unwise to accept any of the present deductions as to the direction in which the pay streak runs. As will be shown later, the occurrence of a similar layer of gravel at practically the same elevation on the adjoining claim to the west would strongly suggest that the general trend was east and west rather than north and south.

The unconsolidated deposits at this place consist of irregularly distributed alternations of gravel and sand, the latter usually forming the base of the section. Many of the sandy layers show abrupt terminations which seem to have been formed by faults, but none of these dislocations could be traced into the gravel lenses. In the gravel beds pebbles of all kinds of rocks were found. Numerous fragments of black slate, similar to that occurring in places as the bed rock of the "third beach" and in the hills back of Nome, were seen, as well as various schist and limestone pebbles. Feldspathic schist and greenstone fragments, however, form only a small percentage of the deposit. It is interesting to note in this connection that several blocks of granite were also found in the gravels. The significance of this lies in the fact that the granite fragments are similar to the granite of the Kigluaik Mountains, and the conclusion is practically inevitable that they must have been derived from this source. In the gravels some large blocks of quartz were found, some of them 2 feet in longest dimension. Their general outline was more or less angular, but their corners were well rounded and they had all the appearance of having been waterworn. No constant direction of the shingling of the gravel deposits was observed, and it would appear that deposition was effected by strong variable currents such as would be expected to occur near a shore line.

In the west end of the southern drift a series of ramifying streaks of a black peaty material cut in irregular directions across the layers of sand and gravel. Because of the difference in color these bands are far more noticeable where they cut across the light-brownish sand, but a careful search shows that they are almost equally numerous in the coarser gravel layers. Pebbles showing well waterworn outlines are scattered irregularly but not abundantly in these peaty seams. When first examined it was believed that they represented cracks which had been subsequently filled by material from the surface. Similar cracks are observed at the present time in many places where the melting of the ground ice allows settling and cracking of the deposit previously formed. In the light of more careful study, however, such an interpretation seems inadequate, for many of the seams taper off toward the top as well as toward the bottom, so that a connection with the surface is not indicated. It is believed that their occurrence is due in some way to the settling of the ground subsequent to the formation of a part at least of the gravel deposits, but the information concerning these seams is as yet too meager to allow an explanation of their origin. Although as the matter now stands an explanation of these seams does not appear to be directly connected with the economic problems, it is believed to be important, for everything which throws light on the physical conditions under which the coastal-plain deposits were formed should assist in determining the factors which led to the deposition of the economically valuable placers in this area.

In the north end of the eastern drift a layer of sand with a few pebbles scattered irregularly through it lies underneath a gravel deposit, only the base of which is exposed in the drift. This sand bed is interesting because it contains numerous shells that can be used in determining the relative age of the gravels at this point. The most abundant of the shells is one that is large and clamlike, but numerous other fossils also abound. All the shells occur in the sand layer, none being found in the overlying coarser gravel. The physical condition of these shells is interesting and, it is believed, throws some light on the relative age of this beach and the earlier known and previously described beaches. Practically none of the shells show water rounding or other evidence of having been subjected to the pounding of surf, but in spite of this almost all are broken into small bits or are so decomposed that it is almost impossible to remove them from the layers in which they occur. Such a condition would seem to indicate that they have undergone a large amount of decomposition and fracturing since they were laid down. When it is remembered that the shells found on many of the beaches farther inland, such as the "intermediate beach," are practically undecomposed, the suggestion that the "submarine beach" is much older than the others receives considerable support from the physical character of the fossils.

About a dozen species of fossils collected from the "submarine beach" at this place by E. M. Kindle and the writer were submitted to W. H. Dall for determination. From their resemblance to fossils whose geologic positions have been determined, he stated that these forms mark undoubtedly the oldest horizon that has been found in the unconsolidated deposits of the Nome coastal plain. This coincides closely with the decision that had been reached by the writer on entirely independent grounds, namely, the relation of the gravels containing the fossils to the overlying deposits and the greater amount of decomposition that had affected the shells. No final statement can as yet be made regarding the precise geologic age of the fossils from the "submarine-beach," but there seems little room to question that they are at least as old as the Pliocene.

As far as exploration and development of the ground at this claim have gone, all the gravels are permanently frozen and therefore lend themselves to development by underground methods such as are in use in flat-lying consolidated deposits. Unfortunately, however, the contact between the sand and gravel layers is a plane of weakness, and frequently great pieces of the roof flake off along these division planes and bad accidents are likely to occur without warning. Practically no timber is used save in the main lines of underground communication. The shafts are well timbered and are equipped with power hoists. The ground is so dry that it requires very little expenditure for draining.

As is usual at the deep placer mines in Seward Peninsula, a dump is taken out in the winter and the gold is extracted during the early weeks of the open season. As the present operators are not the owners of the ground, they propose working throughout the year. In the winter of 1907–8 more than 10,000 yards of auriferous gravel was mined and hoisted to the surface. Foresight on the part of the operators caused them to place sluice boxes in position at the place where they proposed to make the dump of pay gravel. In this way, when the dump was sluiced in the spring it was necessary only to turn a hydraulic nozzle against the pile and the gravel was washed directly into the sluice boxes. This method resulted in a considerable saving in the cost of extracting the gold from the gravel and should be much more generally applied. Water for sluicing is furnished by means of a gasoline engine, which pumps water from Snake River, only a few hundred yards away. The tailings from the boxes are dumped over the steep bank which has been cut by Snake River into the coastal plain on which the shafts are located, so that an economical handling of the gravels is effected.

Only a small quantity of the gold won from this claim was seen and generalizations concerning its character may require modifications in the light of fuller knowledge. Most of the gold is fine, but the pieces average two or three times the size of those from any of the other beaches that have so far been discovered. It is of a bright color, practically no rusty pieces having been found. In spite of its bright appearance, however, it is not readily amalgamated. It is reported to lose considerable weight on melting, and this loss is attributed to the presence of arsenic. In the concentrates collected with the gold, magnetite and ilmenite form but an insignificant portion. Garnets are common. Sulphides are much more abundant than on any of the other beaches, and pieces of quartz with both iron and arsenical pyrite are common. The physical characters of the gold are such as to suggest that it has been derived from a near-by source.

Adjoining this claim on the west is another in which gold-bearing gravels have been found at practically the same elevation and are similar in all other essential respects to those of the claim just described. Because of this similarity it is supposed that the general trend of the pay streak is east and west rather than more or less north and south, as was suggested by the slope of the bed-rock surface, but in neither claim had the true direction been clearly demonstrated. No statement as to the value of the gravels per cubic yard was obtained, but it seems certain that it does not anywhere approach that of the "third beach" bonanzas.

The gold which is obtained from this claim is nearly the same as that from the one farther east, except that it is slightly coarser. So far as could be learned the largest piece of gold from this ground was worth between $10 and $12. Most of the pieces are flat, but some nuggets up to a dollar in value are found which have quartz attached and show, by their form, that they have not traveled far from the parent ledge. It is clear that the average of the gold is much coarser than that on the third beach. It is usually of a bright-yellowish color, but it is said to be greasy, so that it is not easily affected by mercury. On smelting it loses considerable weight, owing, it is said, to the large amount of arsenic. According to the owners the banks pay for the gold at the rate of $16.53 an ounce. Among the concentrates magnetite and sulphides form a considerable proportion. The sulphides are both iron and arsenical pyrite. Many large fragments of vein quartz and calcite in the tailings show abundant crystals of both of these sulphides. An assay by Ledoux & Co. of some of this vein material showed a gold value of nearly a dollar a ton. Garnet forms but an insignificant part of the concentrates.

The method of working the deposit is similar to that in use elsewhere in the underground mines of the coastal plain. Water for sluicing is delivered from Snake River by a gasoline pump, which is used for half a day by this claim and for the other half by the one to the east. The tailings are dumped directly from the lower sluice box over the bluff to the Snake River flood plain. None of the concentrates are saved, although it seems probable that the sacking of some of them would repay the additional cost. Seven men were employed in shoveling the winter dump into the sluice boxes, so that the cost of the spring clean up was much higher than on those claims where the dump is washed with hydraulic nozzles directly into the boxes.

Owing to the finding of values at this level 20 feet below the sea, prospecting has been carried on still farther west. It is reported that about an eighth of a mile beyond the last-described claim a beach has been found at the same level and that it carried some gold, but work at this place stopped so early that it is hard to believe that satisfactory indications were obtained. An eighth of a mile beyond there is still another shaft, but not enough work had been done here to indicate the value of the ground. It is said that the next drill hole that shows the presence of workable placers is about a mile beyond this point. According to current reports, however, even this place does not show a very encouraging deposit, and beyond this shaft no values have yet been found.

Another supposed line of ancient beaches, although it has furnished no production, is interesting as throwing further light on the complex movements that have affected the coastal-plain province, at least, and probably a large part of Seward Peninsula. Not enough is known as yet concerning this line, which has been prospected in a few widely separated places, to determine whether it is really a beach or not. Its supposed course nearly parallel with the present beach and the fact that the gravels of which it is composed seem to be of marine origin are the main features which have given support to the theory that it is a beach. This beach lies 300 to 1,000 feet inside the present one and may be called the "outer submarine beach" to distinguish it from the beach previously described, which may be called the "inner submarine beach." Around Nome both of these beaches are popularly called the "submarine," and the use of the terms inner and outer is suggested only to permit ready reference in the present paper. The elevation of the outer beach is reported to be 34 feet below mean sea level. No work was being done on this beach, so it could not be studied, but it is said to be rather crooked. The values obtained by the prospectors are low, but from their reports it appears that the ground can be worked. The pay streak rests on a false bed rock of clay at a depth of 60 to 70 feet, depending on the configuration of the surface, or at a nearly uniform depth of 34 feet below sea level. At a depth of 4 to 12 feet below the false bed rock, according to local conditions, is found the true bed rock on which, so far as is known at present, no values have been concentrated.

As there has been no production from this beach line the character of the gold has been determined only from small samples taken in panning. These samples are bright and, as a rule, finer than the gold from the "inner submarine beach." It is a fact of universal experience, however, that the samples obtained by panning are finer than the average found in the sluice boxes when the deposit is mined, so that a final statement as to the relative coarseness of the gold is not possible at this time. Perhaps one of the most notable features connected with the pay streak from this beach is the large amount of concentrates. It is roughly estimated that from a small clean up yielding a little less than 4 ounces of gold at least 6 pounds of heavy concentrates were obtained. A large proportion of these were sulphides. Arsenopyrite in perfectly formed crystals which have sharp outlines and are not waterworn forms a large part of the sulphides. Iron and copper sulphides are also abundant. Magnetite and ilmenite form a small proportion of the concentrates. Garnet, although represented by numerous fragments ranging in color from pink to deep red, does not form a notable part of the concentrates. None of the sulphides at this place have been proved to carry values in gold, but from their similarity to sulphides from near-by areas that have been assayed it seems probable that a considerable amount of gold may be locked up in these minerals, so that if sufficient quantities are obtained they should be saved for treatment.

OUTLINE OF THE HISTORY OF THE BEACHES.

Including the newly discovered inner and outer submarine beaches, there are now at least six beaches which have been recognized in the vicinity of Nome. Though data are not yet at hand to permit a detailed account of each of these beaches and their interrelations, it is certain that they represent marine conditions and mark periods of stability between successive movements of the land relative to the sea. It has been shown that the six beaches have the following elevations with respect to sea level: The "outer submarine beach" is 34 feet below sea level; the "inner submarine beach" is about 20 feet below sea level; the present beach is, of course, at sea level; the "intermediate beach" has an elevation of about 22 feet; the "second beach" has an elevation of 38 feet; and the "third beach" has an elevation of about 78 feet. Figure 19 shows in diagrammatic manner the position of these different beaches, both vertically and horizontally, relative to the present beach. Although there have been many oscillations the details of which are lacking, it seems certain that the so-called "second beach" is the next older than the present beach, because it is the only one showing by the topographic forms associated with it that it has not been subsequently covered by the sea.

From the present evidence it would seem that the earliest event recorded definitely in the history of the region is the formation of the "outer submarine beach." What the condition of the region was prior to this incident is not known, but it is probable that older coastal-plain deposits had been formed and were eroded by the waves to form this beach. After the outer beach had progressed to a certain stage, gradual depression with respect to the sea brought the shore line at the level of the "inner submarine beach." The amount of this depression must have been about 14 feet. Still later, further subsidence of about 42 feet brought sea level to the elevation of the "intermediate beach." The movement continued and the land sank with respect to the sea about 56 feet, so that the shore line was on the level of the "third beach." After remaining for some time in this position further depression took place and the sea attacked the schist and limestone bluffs which rise steeply about half a mile north of the "third beach." While each of the beaches was being formed by the sea, deposition was taking place on the sea floor, and sands and gravels brought down by the rivers and worn from the cliffs by the waves were covering the earlier beaches, thus producing a surface such as the sea floor of the present day might show if it could be examined.

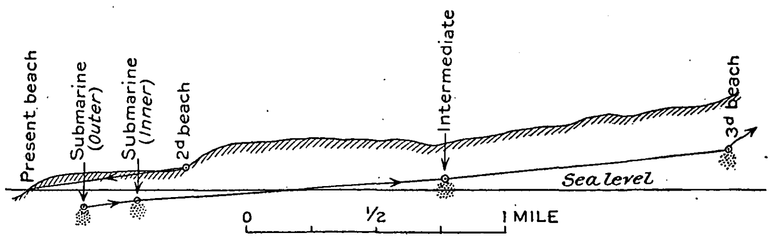

FIGURE 19.—Diagrammatic cross section showing beaches near Nome. Vertical exaggeration about 12 times.

After the shore line had taken a position landward of the "third beach" a change in the progressive depression of the land took place, and uplift began. The result of the uplift was to cause more and more land to emerge from beneath the sea. The uplift seems to have gone on at first without any interruption, for there are no signs of long halts and the accompanying formation of beaches on the surface of the coastal plain. At length, however, when the shore line was some distance south of the "second beach," a period of relative stability ensued and the sea gradually cut back into the coastal-plain gravels until a cliff, in places nearly 75 feet high, towered above the beach. This feature can be most plainly seen in the vicinity of Rocker and Martin gulches, a little east of Nome. When this stage of cutting had been reached an uplift of about 38 feet brought the shore line to a short distance seaward of its present position and then, in a period of stability, the sea renewed its cutting on the shore and formed the low cliff which rises from the present beach.

According to this interpretation the recognizable portion of the history of the coastal plain shows an earlier series of depressions amounting to between 100 and 200 feet, followed by an uplift of about 34 feet less. That there were oscillations in these movements can not be doubted, but that the sum of the changes of level was of the character noted seems obvious. The absence of all surface topographic forms characteristic of beaches, save in connection with the present, the "second," and the most inland beaches, seems to indicate conclusively that these three were the last ones formed and have not been subjected to marine erosion since their formation. Furthermore, the condition and character of the fossils already described would seem to substantiate this conclusion.

Even this interpretation of the past, however, is very incomplete, and the more remote history should be studied in order to understand the reason for the peculiar distribution of gold in the ancient beaches. It is suggested that the "third beach" is richest because there the greatest concentration was effected. It is highly probable that an earlier concentration may have been brought about in the vicinity of the "third beach" by former stands of the sea, and the reworking of this older deposit by the sea at the time of the formation of the "third beach" may have been the reason for the irregular distribution of the rich ground. That there has been greater reconcentration at this place is strongly suggested by the fineness of the gold. It is a well-known fact that the gold from the "third beach" is in smaller pieces than that on any of the other beaches except that of the present day.

CREEK AND BENCH PLACERS.

The lack of water has had a deterrent effect on the exploitation of new ground, and even the previously productive camps have been forced to curtail operations and work on a less extensive scale. During the season of 1908 creek and bench placer mining was done in practically the same areas as in the past. For this reason the region around Dexter, including by this term Dexter, Anvil, and Glacier creeks, is still the most important producer of gold from placers of these types. The result of this work, however, has not shed much new light on the geologic conditions at these places, and as the previously known facts have already been assembled and published, repetition here is not necessary.

Some new mining work has recently been undertaken on Osborn Creek, a tributary of Nome River from the east, 5 to 10 miles east of Nome. This region has long been known to be auriferous, but the tenor of its gravels had not been sufficiently well established to tempt extensive developments. A ditch was completed during the season and under normal climatic conditions a much greater production would have been expected than was actually achieved in 1908. Above Osborn Creek on Nome River a number of small outfits were mining. Not only was work in progress on the gravels of the main stream and its benches, but also almost all the larger side streams showed renewed prospecting. The production from this source, however, was small owing to the unfavorable season, but the activity seemed to point to a resumption of creek diggings.

In the Snake River basin the greatest mining activity was in the Anvil and Glacier creek basins. Creek and bench placers were being worked also on the tributaries above the junction of North Fork, where a number of outfits were employed. The most notable of these streams were Goldbottom and Grouse creeks, where several camps had been mining as uninterruptedly as the scarcity of water would permit. The production, however, was small.

On the other rivers practically nothing has been done except prospecting. On Stewart River two or three camps have been established above the mouth of Mountain Creek, but only a few men were employed at each and the amount of work accomplished was small. A little mining was done on Flambeau River, but the season was not profitable owing to the drought. A ditch started several years ago on this stream was continued for several miles this summer, but it was not used to any great extent.

LODE PROSPECTS.

In a summary of the lode developments up to the close of 1907 [a] the various veins which had been more or less prospected were enumerated. Only three of the number, however, were being actively exploited at that time. During 1908 work was continued on but one of these three properties, though one of the others was closed down because of lack of funds rather than absence of leads. Only two or three new localities of promise were brought forward. No producing ore bodies have been developed and the claims are simply in a prospect stage.

The prospect on which development work was continued last summer was a quartz vein carrying native gold located on the divide near the head of Goldbottom Creek. Earlier work at this place has already been described [b] and few new facts were gathered from the later work. At the time the prospect was visited the work of timbering the shaft was in progress and the underground developments could not be studied. The type of mineralization, so far as could be seen from the surface exposures, seemed to be that characteristic of the black graphitic slates rather than that of the limestone-schist contact. It is true that the limestone contact lies only a short distance east of the main shaft, but the rocks, although somewhat schistose in places, are, as a rule, slates of dark, nearly black color.

[a] Smith, P. S., Investigation of the mineral deposits of Seward Peninsula: Bull. U. S. Geol. Survey No. 345, 1908, pp. 231-234, 240-242, 244-245.

[b] Smith, P. S., op. cit., p. 233.

They are much jointed and veins and stringers of quartz are abundant but seem to have been formed later than or coincidently with the fracturing of the rocks. The veins, therefore, belong to the series which has been termed the later veins. Although the characteristics of this type of mineralization are its wide extent and the small thickness of the great number of small veinlets, there are many places along lines of movement where veins 2 or 3 feet thick are found. Such veins occur at the head of Goldbottom Creek, where the main lead on which the shaft has been sunk stands at a steep angle and seems to occupy a faulted zone in the rocks. The evidences of movement are very strong in the mirror-like slickensided slabs that are abundant on the dump. In fact, the main difficulty to be anticipated in developing this deposit will come from the dislocated character of the country rock.

Lithologically the vein quartz shows in places a little sulphide mineralization, but ordinarily sulphides are lacking and the quartz is milky white to glassy in color, with here and there darker bands that seem to be due to inclusions of the wall rocks. From the absence of sulphides or other sources of gold in samples which assay well, it is to be argued that the gold occurs primarily in native form. No accurate samples have been taken of the entire width of the vein, and, inasmuch as many of the specimens that have been assayed contained visible particles of native gold no approximate estimate of the value of the vein has been made. It seems evident, however, that it is to be classed as a low-grade ore body which will probably run below rather than above $10 in gold to the ton of rock.

No production has yet been made by this property. Apparatus for gold extraction was installed, but it has been taken up and will require modifications before it can be successfully operated. At present it is proposed to hoist the ore directly from the shaft and to dump it on the upper floor, whence it will be fed through a crusher and then pass to storage bins. From the bins the ore will be automatically delivered to the battery of gravity stamps and will then pass to a buddle or slime table. The tailings will be carried off by a sluice and then allowed to settle in a settling pond. A small amount of ore has been treated in this way, but as the underground developments have not reached the stage where a constant supply of ore could be delivered, the table has been removed and the mill is not now running. It would not, however, take long to put it into working condition.

From the surface indications it seems probable that the region is so faulted and the veins so greatly disturbed, that considerable expense will be involved in mining. This is perhaps the main difficulty to be anticipated for the immediate future, but mineralization is so widely distributed throughout the belt of black graphitic slates that even without a definite continuous vein it might be possible to mine the country rock with its network of small veinlets and crush and treat the whole material. If this is done, however, the presence of a large amount of carbon is likely to render the saving of the gold difficult. In other prospects carrying the same kind of material which have been brought nearer to the productive stage, it is found that the presence of graphite interferes greatly with the recovery of gold.

A new location that was reported last summer lies at an elevation between 400 and 500 feet on Newton Gulch. Several holes have been put down and some of them have penetrated for nearly 100 feet into a much-decomposed material lying close to the contact of a dark siliceous schist and the heavy limestone which forms the lower slopes of Newton Peak. The underlying rock that occurs most abundantly east of Newton Gulch is a dark graphitic schist; on the west of this gulch the underlying schist is silvery and micaceous. The dip of the rocks is northerly or into the hill, but they show intense crumpling and accurate interpretation of the structure is not possible, owing to the scarcity of outcrops.

Two or three men have been employed on this group of claims all summer, and it was proposed to do still further work in the winter of 1908–9. At the time of the writer's visit it was not possible to go underground in any of the deeper shafts, and a fall of several inches of snow so obscured the surface features that many of the facts which it was desired to learn could not be determined by direct observation. The mineralization that was seen showed abundance of sulphides now decomposed into limonite. All of the material thrown out on the dump was so badly decomposed as to afford little indication of its original condition. It seems probable, however, that the gold content is low, but only careful sampling can establish this matter and determine whether the deposit carries sufficient values to be profitably exploited.

A short distance above Specimen Gulch, on the western slope of the Anvil Creek valley, at an elevation of 25 to 30 feet above the stream, several holes have been sunk on a vein carrying a considerable amount of stibnite, or antimony sulphide. The rocks in this part of the valley are much dislocated and sheared. As a result of these movements fractures have been produced and many of them have been subsequently filled with minerals. In certain places veins 18 inches wide, consisting of stibnite nearly unmixed with other minerals, have been found, but as a rule the stringers are much narrower. Most of the stibnite is in rather massive aggregates, but in a few places radiating groups of the mineral show by their perfect crystal form and the unbroken lath shape of the separate plates that they could not have been subjected to any considerable amount of dynamic disturbance. This conclusion substantiates the previously expressed opinion that the mineralization has taken advantage of the fracture zones produced by an earlier period of diastrophism. No systematic work has been done at this place, but the surface indications warrant further development in order to allow more complete examination. From the fact that the vein filling has taken place after the period of great deformation, it seems probable that the difficulties of mining should be much less here than in the great number of Seward Peninsula veins that have been fractured and dislocated by these movements. The cost of treating antimony ores is so high and the market for the metal so well controlled, however, that it is questionable whether the ore can be worked unless it carries accessory values in gold. No assays of this ore have been made, but from the evidence afforded by samples taken from other antimony veins in the vicinity it seems highly probable that the ore does carry gold.

In other parts of the Nome region ledges showing mineralization have been brought to the attention of the Survey during the past season, but none of them have been developed by more than shallow pits that give but slight insight into the character of the leads. The two types already enumerated [a]—those in which the gold is free and those in which it is chemically combined with sulphur or some other element—seem to be the only ones which have been recognized, and of these only the veins which have been formed subsequent to the period of maximum deformation seem to be of sufficient economic promise to warrant much prospecting. Every year brings to light more and more evidence of the fact that throughout Seward Peninsula mineralization is very widespread, but it is this greatly diffused character which will reduce the number of workable ore bodies. It would seem that lode mines will be developed only in those places where especially favorable geologic conditions have prevented the diffusion of the mineralizating solutions and have confined them within certain narrow limits. That such places will be found can not be doubted, but that many failures are bound to precede the location of each productive mine is inevitable.

SOLOMON AND CASADEPAGA REGION.

COASTAL-PLAIN DEPOSITS.

The successful location of beaches in the Nome region has induced attempts to find other areas where similar conditions exist. In the Solomon region a coastal plain, in many ways similar to the one at Nome, stretches from the shore line to the foothills, a distance rang-

[a] Smith, P. S., Investigations of the mineral deposits of Seward Peninsula: Bull. U. S. Geol. Survey No. 345, 1908, p. 230.

ing from practically nothing at Topkok Head to 4 or 5 miles near the mouth of Bonanza River. Exploration for ancient beaches has been carried on at a number of points on this plain, and systematic work has been done between Spruce and Magnet (or Lillian) creeks, as already described.[a] In 1908 work on a small scale was continued, but the results, so far as finding placers of economic value was concerned, were not satisfactory. It seems clear, however, that marine material forms a large part of the coastal-plain deposits and that beach accumulation has taken place. The absence of gold may perhaps be due to the character of the bed rock that forms the old land from which the coastal sediments were derived. This rock is distinctly different from that back of the coastal plain at Nome, where abundant heavy limestones approach close to the old coast line. It is believed, however, that search for beaches in the Solomon region has been unrewarded so far because of the expectation that they will occur at levels identical with those at Nome. In the light of the complex history suggested on pages 277–278 for the Nome beaches, it is evident that discordance instead of accordance of elevation is to be expected.

In the winter of 1907–8 some prospecting was done 4 or 5 miles farther west, with a view to locating ancient beaches in the vicinity of Rabbit Creek, one of the many tributaries of Pine Creek. One shaft has been sunk at an elevation of about 200 feet on Rabbit Creek, a short distance above the point where the flume that leads water from the upper part of Uncle Sam Creek to Rock Creek crosses the stream. The bed rock at this place is reported to have been schist, which was encountered about 30 feet below the surface, or at an elevation above the sea of over 150 feet. The material in the upper part of the shaft is more or less shingly creek gravel, but lower down well-rounded quartz pebbles and sand indicate formation by marine agencies. The gold that was found in this lower gravel is bright and although all the pieces that were recovered by panning were very fine, none of them seemed to be very much worn and many had the spongy appearance of crystalline gold. No quartz or country rock was found attached to any of the pieces, but their form strongly suggested that the gold had not traveled far from the veins from which it had been derived. As the ground had been prospected only by this one pit no adequate idea of the tenor could be obtained. It was reported, however, that one 4-pan bucket had yielded 36 cents in gold. The gold, however, is irregularly distributed and the values found do not encourage development.

Farther up Rabbit Creek is a shallower hole in which the gravels are not as well rounded as in the lower pit and seem more like creek wash than beach or marine deposits. These gravels rest on a mica schist bed rock which is slightly calcareous and has a salmon color,

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[a] Smith, P. S., op. cit., pp. 219–221.

owing to the stains due to the decomposition of the iron minerals. Some of the gold is rusty, as if it had not been subjected to recent movement. The rusty color undoubtedly is due in part to the character of the bed rock on which the gold has accumulated, for evidence of a considerable circulation of iron-bearing waters could be found at numerous places in the gravels. The gold occurs in thin plates, many of them with the edges bent over. Only small fragments were recovered in pan tests, the largest being worth about 1 cent. On the whole, the gold does not appear to have traveled far from its place of derivation and its shape is very dissimilar from that of characteristic beach gold, such as is found on the present beach at Nome or at other points in the peninsula.

West of this last-described hole, on the valley slope a little above the creek, at an elevation of approximately 250 feet above sea level, a hole 45 feet deep has been sunk without reaching bed rock. Thawed ground was encountered and the miners were driven out by the water. Northeast of this hole, on the eastern bank of Rabbit Creek near its head, two holes, 20 and 30 feet deep, were sunk to bed rock. In both, near the bottom, well-rounded beach wash was found. A section of one shaft showed in the upper part more or less angular slide or river wash, followed by sand and rather poorly rounded gravel, and near the bottom well-rounded gravel. In one of the holes the pebbles consist almost entirely of black graphitic slate, similar to that forming the country rock of Uncle Sam Mountain, but in the other the pebbles are almost all of white vein quartz. These pebbles, as a rule, are about an inch long and half an inch in the other dimensions. Under the gravels is a rather thin sand layer that rests upon a much-decomposed schist bed rock.

The values at this place occur in the sand underlying the well-rounded gravel and in the upper part of the decomposed bed rock. A selected pan from this material yielded 40 to 50 colors which together were worth about a cent. Some of the gold was iron stained, but most of it was bright. Apparently the gold derived some of the iron with which it is stained from the decomposition of the iron minerals contained in the black quartzitic slate pebbles. Not enough iron is present to form a cement at this place, but a short distance downstream another hole 36 feet deep passed through several layers of cemented gravel. Too small an amount of gold was seen from the upper hole to permit a final opinion of the character of the sand layer as a whole, but it would seem that the gold is much finer and in the main much more worn than that from any of the other holes already described. Although nearly all the ground is frozen, thawed areas are occasionally encountered so that the conditions of developing any productive deposit will be essentially the same as those surrounding the deposits of similar types near Nome.

CREEK AND BENCH PLACERS.

In the Solomon River basin the past season has been marked by greater activity in dredging work than in any of the other methods of mining. The dredge near the mouth of Johnson Creek has continued operation during the open season, a new dredge of nearly equal power has been constructed a short distance farther upstream, and an abandoned dredge near the mouth of Quartz Creek has been again put into commission. Along Shovel Creek the dry-land dredge is still in operation on West Creek and the steam shovel with its unique gold-saving device is working on the main stream near the mouth of Cadillac Creek.

A description of the dredge near the mouth of Johnson Creek on Solomon River recently published [a] gives some figures regarding the output of this dredge and its operating expenses that have not been heretofore available. According to this article the dredge cost originally $118,000 and was modeled after Exploration No. 2 dredge at Oroville, Cal. It has a capacity of 3,700 cubic yards a day, and the estimated cost of operating is about 10½ cents a yard. The total cost, however, including not only the actual operating expense but also items to cover depreciation, maintenance, and amortization of the capital, is 18 cents a cubic yard.

Although this statement of the costs of handling the gravel is of great interest, it seems wise to give a word of caution against the too general use of these figures for all dredging enterprises in Seward Peninsula. It should be remembered that such low operating expenses are possible only under particularly favorable physical conditions. All of the ground to be dredged was carefully tested in advance of actual mining and the area and extent of permanently frozen ground outlined, so that it could be avoided. Most of all, however, sufficient acreage was obtained to outlast the life of the dredge. By attention to this last detail the annual amortization charges were greatly reduced, for it is evident that such charges are much lower where the installation has a life of ten years than where only enough ground is available to support the industry for five years. The company working the dredge just described controls, according to Rickard, 4,000 acres, of which less than 100 have been dredged out in the three years that the company has been operating. Still another factor that has contributed to the success of the work at this point is the fact that the bed rock over the larger part of the area is schist, and is much more easily excavated than the hard limestone, which can be handled only by very powerful dredges.

The high cost of fuel is one of the most expensive items to be considered in dredging. At the plant just described more than 10 tons

[a] Rickard, T. A., Dredging on the Seward Peninsula: Min. and Sci. Press, vol. 97, 1908, pp. 734-740.

of coal are required daily. Where transportation is difficult it is evident that the success or failure of an enterprise may be decided by this factor alone. It was planned to build a ditch from Solomon River near the mouth of East Fork and to use the water thus derived to generate electric power for operating the dredge. Unfortunately this scheme was blocked by a controversy as to the ownership of the water right and has been, at least temporarily, abandoned.

Just upstream from this dredge another, operated by a different company, was installed last summer in the short space of about seven weeks. It is not new, having been originally in use near Hope, on Kenai Peninsula, but it has seen so little service as to be practically as good as new. Almost all the first part of the summer was occupied in assembling the dredge, and was thus unavailable for actual productive work. Mining began early in September and continued until the close of the open season, about the end of the third week of October, a large amount of gravel being moved. The opportunity of comparing this dredge, which is of the Risdon type, with the modification of the Bucyrus dredge farther downstream is exceptionally good and should afford considerable data for a determination of the efficiency of each type.

In operation the 5-foot buckets raise their load of gravel to the level of the upper deck of the dredge and dump upon an inclined plate which directs the material into a revolving trommel. The oversize from this trommel is discharged into flat pans which form a bucket conveyor, and the tailings are stacked at the rear of the dredge. The finer material that has passed through the screens is fed to tables covered with cocoa matting, on which are laid expanded-metal riffles. No quicksilver is used. Most of the gold is caught in the upper part of the tables, but the lighter material, after it has left the tables, is carried in a sluice with riffles, and a small additional saving may thus be effected. According to Rickard [a] the actual operating expense at this dredge, without allowing any charges for depreciation, interest, or amortization, is a little over 14½ cents per cubic yard. The ground had not been carefully prospected in advance of mining, so that no statement of the average tenor of the gravels is possible. It would seem, however, from the fact that the gold lies mainly in the lower layers and on bed rock, that the financial success of the enterprise depends on the efficiency of the dredge in cleaning bed rock.

Near the mouth of Quartz Creek an old dredge, which for the past two years has been lying abandoned near the mouth of Big Hurrah Creek, has been recently placed in commission. It is a small affair with 4-pan buckets. Power is furnished by a gasoline engine, the water being pumped by a 10-inch and a 3-inch pump. The larger

[a] Rickard, T. A., op. cit.

pump delivers the water for the main line of sluice boxes; the smaller is used on the so-called "slough over" from the bucket line. Hungarian or pole riffles are used in the boxes and most of the gold is caught in the upper half of the string. Unfortunately the machine is not strong enough for the work it is called upon to do, and more than half of the season was lost in making repairs. The bed rock in the eastern part of the claim is limestone, but in the western part schist predominates. Most of the mining is being done on the western part, for the dredge is not capable of cleaning the hard limestone. It is estimated that this dredge can handle 400 yards of gravel a day, but this maximum is seldom attained.

The fourth dredge in the Solomon-Casadepaga region is of a dry-land type and is in use near the mouth of West Creek, a tributary of Shovel Creek, which in turn joins Solomon River. Mining at this place was conducted on practically the same scale as in former years. The dredge is small, having a capacity of about 200 yards in ten hours, with not sufficient power to handle the large slabby pieces of limestone that are frequently encountered. This plant shows a rather unusual feature in that the sluicing water is carried by means of hydraulic hose to the dredge, where the gravels are washed, the tailings being discharged over the opposite side of the machine. It is not usual at this place to take up much of the actual bed rock, as the best paying material is found on a decomposed layer several inches above. It is expected that considerable values still remain in the bed rock, but according to the management it is not profitable under present conditions to attempt further recovery.

A short distance above the mouth of Jerome Creek, on Solomon River, some low bench gravels were mined to a small extent during 1908. The bed rock at this place is a few feet above the level of the river and is of a yellowish color and a somewhat limy character. It is overlain by about 12 feet of well-rounded, waterworn gravels, the largest pebbles of which are from 6 to 8 inches in diameter. All of the gravels are frozen except where exposed by surface stripping. Throughout the greater thickness of these gravels valuable, heavy minerals are almost entirely lacking. Near the base there seems to have been a slight concentration, and some gold-bearing gravel that can be profitably mined is found. Together with the gold in the concentrates is a large amount of magnetite and ilmenite and a small amount of garnet. Water for the development of this ground is delivered from the ditch on the east side of Solomon River, having an intake on Big Hurrah Creek, and is carried from this ditch by hydraulic pipe to the point where it is used. This place is interesting as giving an insight into the character of the gravels that form notable deposits along Solomon River as far upstream as Quartz Creek.

On Moran Gulch, a few hundred yards from Solomon River, a party of two men has been hydraulicking bench gravels which seem to be more closely allied to Solomon River than to Moran Gulch. In thickness they show considerable local differences, but the average is about 9 feet. The unconsolidated material consists, in the upper part, of muck and vegetation; this is underlain by layers of more or less clear ice mixed with muck, and this in turn by 3 or 4 feet of well-rounded gravels resting on a decomposed schist bed rock. Exploitation has failed to reveal any rich ground, but it is a question whether the slight returns may not be due to the mining methods practiced. No drain has been carried up to the workings, and it is frequently the custom to pipe the gravels into the sluice boxes through a large pool of standing water. Furthermore, bed rock is cleaned only with the hydraulic nozzle. It seems highly probable that owing to these two methods of work a share of the values is not recovered. Water is delivered to this ground from the ditch on the east side of the Solomon River valley, the intake being on Big Hurrah Creek. Work was in progress at this place only during the latter part of the season.

Between Shovel Creek and the mouth of Quartz Creek on the main river four camps have been working during the summer. One party of only two men was mining low bench gravels about a quarter of a mile above the mouth of Shovel Creek. Water for sluicing was delivered by a gasoline pump. The values of this ground are reported to be low and the returns, therefore, were probably small. Farther upstream, only a short distance above the mouth of Penny Creek, another party has been mining bench gravels west of the river. The gravels are about 10 feet deep and all of the upper gravel is well worn, so that the cobbles are smooth and rounded. Bed rock, so far as exposed, is limestone, which is much fissured as well as dissolved. In one place a pothole at least 8 feet deeper than the average level of the bed-rock surface has been dissolved in the limestone. Attempts to prospect this pothole have not yet been successful in reaching the bottom, but so far as it has been opened it has failed to reveal any gold. For the first 100 feet or so from Solomon River the gravels were entirely thawed and it was only after getting in about 150 feet that frozen ground was struck. So far as could be determined the upper gravels contain so small an amount of gold that for practical purposes they may be considered barren. Near the bottom, however, a pay streak of 1 foot of sand and gravel was encountered. The values are not limited to this thin layer, for gold has been found penetrating the cracks and crevices of bed rock to a depth of at least 4 feet. It is the practice at this place to sluice off the upper gravels and then to wash the pay-streak gravels and take up by hand from 1 to 4 feet of the bed rock. The pay streak is not only thin, but narrow, for its width is generally not more than 30 feet, and 15 to 20 feet would probably be about the average width. Water for sluicing is furnished by the ditch on the east side of Solomon River.

Half a mile below the mouth of Quartz Creek a party of five men has taken advantage of the exceptionally dry season to carry on mining in the bed of Solomon River. The river has been turned aside and small areas have been surrounded with sod dams covered with canvas to keep the water out. Bed rock in the eastern part of the claim is limestone, but toward the west side of the valley floor it is schist. The gravels are thin, nowhere exceeding 3 feet in thickness, and are probably more or less thoroughly set in motion each year by the stream. In consequence the values occur almost entirely on or within bed rock, so that it is necessary to take up by hand from 1 to 3 feet of the limestone to recover the gold. All of the gold from this ground is coarse and shows but slight evidence of having traveled far. In 1907 a $150 nugget was found and last year one worth $70 was taken near the bed-rock surface. The gold of the latter was not very bright and had a great deal of quartz and schist attached. From the character of the material associated with the gold it was evident that the nugget had been derived from one of the older series of much contorted quartz veins occurring in the chloritic schist which forms a part of the Nome group. The smaller pieces of gold are almost invariably bright and show no tarnish or rust. This character is in part due to the kind of bed rock on which they occur, for it is a notable fact that in a region where limestone forms the country rock the gold is, as a rule, not discolored.

East of the small dredge near the mouth of Quartz Creek, previously noted, bench ground has been developed on a small scale. Bed rock is limestone, in places much brecciated. The gravel here and there is 10 feet thick and this has given rise to some winter work by drifting. No well-worn gold is found on this ground, all the pieces being chinky and many of them of considerable value. The largest piece was worth $250. This heavy gold seems to occur near the contact of the heavy white limestone and the chloritic schist. At this locality part of the bench gravels are cemented. Both lime and iron form the cementing material and in a few places some placer gold has been found in the midst of the cement. Owing to the cemented character of a part of the gravel some gold is undoubtedly lost in sluicing, for no attempt to break up the agglomerate is made and so the pieces roll through the sluice boxes. Although the greater part of the gold on this claim is bright, much of that occurring in the places where iron-bearing solutions are prevalent is rusty and will not amalgamate.

Farther up Solomon River, between Quartz and Big Hurrah creeks, a bench deposit to the east of the river is being mined. Three men are engaged at this place in drifting from a vertical shaft. Water for sluicing is furnished by a small gasoline pump which takes water from Solomon River. The gold-bearing gravels are hoisted by a gasoline engine and the bucket is dumped by the man attending to the sluice boxes. Bed rock is a heavy white limestone, much fissured. In order to recover the values it is necessary to take up the bed rock to a considerable depth. No values are found in the upper part of the overlying gravels and as the ground is solidly frozen the drifting method is applicable. No statement could be obtained as to the tenor of the ground, but from the fact that the work has been continued at this place for several years it would appear that the results were satisfactory.

Hydraulic work has been continued on Big Hurrah Creek near its junction with Solomon River, but the unusual dryness of the season hampered mining to a marked degree and not so much was accomplished as was expected. On this ground there are three elevators, but only one is in use at a time. The bed rock for the first half or three-quarters of a mile above the railroad consists of black, somewhat graphitic, very siliceous slate, breaking into more or less rectangular blocks. A few narrow black limestone beds occur, but they are of slight extent. The bed rock is cleaned only with the hydraulic nozzle and is not hand picked. While this plan undoubtedly saves expense, there must necessarily be a considerable loss of gold. It is reported that the gold from this part of Big Hurrah Creek is bright and medium coarse. The greater part of it is flaky, but some small nuggets are found. Most of the values occur along the south side of the present creek floor. The northern part of the valley bottom is said to show only a small amount of gravel, the material for the most part being slide that carries but low values.

Few other localities in the Solomon River basin were actively mined during the past summer and the production from them may be considered as practically negligible. Outfits of one to four men each were working during a part of the season on Butte, Mystery, Kasson, and several of the other small creeks, but the lack of an adequate water supply caused suspension of mining until late in the season and the early freeze-up stopped work early in the fall. No new discoveries were made and what little mining was accomplished was along the same general lines and at approximately the same places that have been described in earlier reports of the Survey.

In the Casadepaga drainage basin the effects of the abnormal season were felt even more keenly than in the Solomon basin, for in the former few ditches have been built except from small local basins, so that no continuous water supply was afforded. When the region was visited in July no work was in progress, and later accounts from credible sources indicate that but little work — and that mainly of a prospecting nature—was done during the season in the whole Casadepaga region. Many miners who had been busy installing machinery during the previous season were forced to abandon operations and await more favorable conditions. A few additional notes on the Casadepaga and adjacent regions are given elsewhere in this volume, in a report on the Iron Creek region (pp. 333–337).

LODES.

For a long time the Solomon-Casadepaga region has been notable because in it was located the only productive lode mine in Seward Peninsula. Unfortunately a series of difficulties have arisen which compelled the suspension of operations at this mine during 1908. The closing down was not at all due to the quality or other characters of the ore, so that there is no reason to believe that work has been given up for good. Until the questions of management, etc., can be definitely settled, however, there is little prospect of work being resumed. It would seem that the developments already made justify a continuation of the work.

Practically nothing has been accomplished in this region during 1908 in the way of lode developments. Nearly all the lode prospects and exploratory work noted in a previous report[a] have received but scanty attention, and in many places not even the annual assessment work has been performed. A little new exploration has been undertaken on the north side of Big Hurrah Creek at a considerable elevation above that stream, but no shipment has been made. It might be possible by low freight rates to bring in supplies at a sufficiently low cost to allow the profitable development of some of the properties near the railroad. It should be remarked, however, that the diffused character of the mineralization throughout the various rocks suggests that only by a careful search for those places where the mineralization has been localized will a successful mine be established. That there are such places can not be doubted, for the Big Hurrah mine affords a conclusive example, but that many of the locations are on small stringers without any continuity in depth and without sufficient width to allow profitable mining must also be evident to anyone acquainted with this region.

COUNCIL REGION.

In the Council region the same adverse conditions that have already been noted as prevailing in other parts of the peninsula caused a great falling off in the production. This region was visited during the early part of July and a most discouraging impression of its activities was gained. From the data gathered at that time and from later

[a] Smith, P. S., Investigations of the mineral deposits of Seward Peninsula: Bull. U. S. Geol. Survey No. 345, 1908, pp. 234–238.

reports it seems certain that the production from this camp fell off nearly 50 per cent from that of the preceding year. The rich bonanzas that made the region famous in the early days have been more or less exhausted and no new ground has been opened by prospecting. That there are many rich spots still remaining, even on the known creeks, can not be doubted. It is believed that most of these places are those that have been overlooked in the earlier work and that they are not extensive. There are, however, many streams as yet practically untouched which would seem to warrant prospecting with good hopes of high returns. Rich ground must be found or a material reduction in operating expenses must be made if the future of Council is to be assured.

Of all the streams in the vicinity of Council, Ophir Creek still continues to be the most productive. Although this valley shows marked proof of failing to yield as much gold as formerly, nine-tenths of all the gold that comes from the Council region is derived from it. On one of the lower claims a dredge which has been located here for several years continued operations during 1908. Figures concerning the yield of the ground and the operating expense have recently been published by Rickard,[a] who states that the original cost of this dredge was $28,700 and that the annual charges for repairs are about $5,000. An interesting portion of Rickard's article referring to the work of this dredge is as follows:

> During the season of 1907 this dredge worked for 110 days. The actual running time represented 69 per cent of the total time. The ground excavated represented 98,718 cubic yards. The total expenses were $31,672, and the value of the gold extracted was $83,144. Therefore the average yield was 84 cents and the average cost 32 cents per cubic yard. The season of 1908 will show about the same costs, but a better yield of gold. The fuel consumed is wood at the rate of 10 cords per day, at $10 per cord delivered. The total costs as given above include all repairs, equipment, and general expenses.

These figures are interesting as indicating the higher cost of dredging in a region not so easily accessible as the Solomon and Nome regions and for a dredge not of modern construction, but handled by an efficient management. Frozen ground is encountered more or less irregularly, and thus decreases the amount of gravel handled and materially increases the cost for repairs.

During the past season the largest organization operating on Ophir Creek, the Wild Goose Company, has moved its headquarters camp from its old position near the junction of Dutch and Ophir creeks to Discovery claim near the mouth of Sweetcake Creek. This change marks the beginning of the closing stage of the operations of this company on the upper part of Ophir Creek and is not a favorable sign for the district as a whole. Work was continued on several of the

[a] Rickard, T. A., Dredging on the Seward Peninsula: Min. and Sci. Press, vol. 97, 1908, pp. 234-240.

claims held by this company, but the main work was on the claims near Discovery. The unusual dryness of the season affected these claims less than it did those of the small operators who had not such extensive ditch lines. In spite of these long ditches, however, not enough water could be delivered to permit continuous mining and for a long time actual productive work was suspended. During these periods some prospecting was done, but no new developments of importance were recorded.

A short distance up Ophir Creek, on the same claim where, in 1907, an unsuccessful attempt had been made to use a dry-land dredge, a camp was established in 1908, and it was reported that the most productive work of the season was carried on there. Mining was done with scrapers and derrick, and a large crew of men was kept busy. No accurate data are available for a statement of the production from this claim, but it is believed that the success of the venture was not due to the richness of a small amount of ground, but to the fact that a large volume of medium low-grade gravel was handled economically. Some gravel of high tenor was found, but if previous explorations are to be trusted the rich areas were not extensive. The success must be attributed in large measure to efficient management.

Four or five other parties were more or less continuously engaged in mining above this claim all the way to the canyon of Ophir Creek. Many of these were using horse scrapers, but others were simply shoveling in. Near the mouth of Crooked Creek, however, a new enterprise that will be watched with considerable interest was started during the summer. This was the installation of a dry-land dredge similar in many respects to the dredge built on one of the claims nearer the mouth of the stream in 1907, but of much stronger pattern. The original intention was to use the dredge on Melsing Creek, and it was designed for the depth of gravels on that stream. For various reasons, however, it was decided to erect the dredge on Ophir Creek about 7 or 8 miles above the mouth. The gravels were reported to have a little higher tenor on this claim, but their depth was considerably greater than the dredge was originally planned to handle. A large part of the season was lost in getting the machinery which was shipped in from the States installed and in running order, so that it was in operation for only a short season. From all accounts the dredge seemed to be working satisfactorily. A dredge of this type, however, has yet to demonstrate that it can handle hard bed rock, and until this is proved it seems inexpedient to attempt mining of this sort except where the physical conditions are favorable. Fortunately the bed rock where this dredge is located is a much decomposed schist that can be easily picked up by the buckets.

Few other creeks in this region showed any notable production. On Melsing Creek work was in progress at the mouth and near the junction of Basin Creek, but there were few who gained much more than wages. Mystery Creek, which joins the Niukluk 5 miles east of Council, was the scene of some activity early in the season, but the long, continuous drought discouraged the operators and little was accomplished in the way of actual production. Above Ophir Creek little work was done on any of the tributaries of the Niukluk. A small production was reported from Warm Creek and also from Camp Creek, but the operations were not nearly so important as in previous years. The Casadepaga basin, which forms part of the Council precinct, has already been briefly discussed on page 292 of this report. It will be seen that the production from this area is not commensurate with its size and probably not with its latent resources.

KOUGAROK REGION.

Few of the claims in the Kougarok region were mined in 1908. This region is, even under most favorable conditions, hampered by lack of water, and when this normal character is exaggerated by unusual drought, mining is brought to a standstill. Though none of the larger companies have taken out much gold, many prospectors forced to earn a "grubstake" for the winter have gone back to the primitive rocker and were taking out a little gold. The amount won in this way was, however, too small to have a marked effect on the production. In consequence it may be said, without any disparagement to the future output of the region, that the amount of gold won in 1908 was far below that of preceding years.

On Quartz Creek and its tributaries, Dahl and Coffee creeks, some winter work was done, and the dumps were sluiced with the early run of snow water. Outside of this production little was accomplished. Mining on Dahl Creek was limited to three claims, and all of them were worked on a small scale. On Coffee Creek three outfits were located, but the work was mainly of a prospecting character. It is reported that a short distance up Kougarok River from the mouth of Quartz Creek some dredging ground was prospected, but no attempt was made to develop it. Although the summer was a failure in this drainage basin, the number of boilers that were placed in position at the close of the season promised considerable activity in winter mining. At least five parties were planning to sink shafts and prospect their claims on Dahl Creek.

Farther upstream, the next place where mining was done in 1908 was on Windy Creek, which joins Kougarok River from the west. Two claims were being developed on a small scale. The most interesting project on this stream has to do with gaining a water supply. The upper part of Windy Creek heads in a region of heavy limestone with practically no surface water. Lower down, however, near the contact of this limestone and the schists, numerous springs return to the surface the water that has been carried by underground passages in the limestone. These springs do not carry enough water to supply the needs of miners throughout the season. It is proposed, therefore, to dam up the springs and to allow them periodically to overflow during the winter. In this way a thick body of ice will be formed, which on melting during the summer will give a continuous flow. This experiment will be watched with interest, as it is practically the first attempt of its kind. Snow storage has not been successful, and it remains to be demonstrated that ice storage of this sort will fulfill the requirements. On Windy Creek there is also an enterprise on foot to build a ditch to Dahl Creek. A start on this ditch was made during 1908, but it will not be completed until the season of 1909.

Mining on the North Fork of Kougarok River has been carried on at three different camps. Most of the values that have been found occur in the benches on either side of this stream. The benches near the mouth of the creek seem to carry better values than those farther up the valley. Near the mouth of Eureka Creek bench ground showing a good gold tenor has been mined. One of the most interesting discoveries on Harris Creek has been the location of placer gold in limestone. Samples of this material were given to E. M. Kindle, of the Survey, by Mr. Kennedy, and have been examined by the writer. Though no minute study of these samples has been made, it seems certain that gold in particles that have all the appearance of placer gold occurs in the midst of the limestone. This rock is a dark, somewhat brecciated limestone, consisting mainly of calcite, but containing in addition rolled garnet grains and flakes of gold. The shape of the gold precludes the possibility that it was originally formed in the limestone in the condition in which it now appears.

Coarse Gold Creek is reported to have been mined by one outfit during the past summer. As there was no water until the first of August and as the freeze-up came about the first of September, no considerable production was to be expected. A few cuts were made and the gravel was sluiced, but it will be another year at least before any notable output is made from this stream. On Arizona Creek, which enters the Kougarok a mile and a half above Coarse Gold Creek, two men spent the season in prospecting. It was reported that minable gravels had been uncovered on the bench on the west side of Kougarok River near the mouth of Arizona Creek. The bench gravels lie at an elevation of about 70 feet above the stream.

Below Taylor Creek, on the main river, the past season has been spent mainly in preparing for future work. Considerable progress has been made in stripping and crosscutting the benches on both sides of the river, and everything seems to be in good condition to carry on mining actively when a normal season affords sufficient water. On Taylor Creek practically no work was done. The hydraulic elevator at no time had sufficient water, consequently it remained idle all the season, and no other work was started. On Homestake Creek some prospecting was done, but there was no productive mining. Above the Homestake Creek camp all the work was done on creek-bed claims. Five camps were operating claims on this part of the river, and several others were prospecting. The camps had crews ranging in number from 2 to 12 men each. No figures as to the production are available, but it seems probable that more than wages was made by the different outfits. The total production was probably greater than from any other summer diggings on the Kougarok. Prospecting on Macklin Creek is reported to have shown the presence of some minable gravels, but water for sluicing was lacking.

Developments on the tributaries to Noxapaga River that have been productive during former seasons were practically at a standstill during 1908. Prospecting work only is reported to have been done on Boulder Creek, and its production, therefore, can be considered as little more than wages. On none of the other streams in this section have there been any mining developments. In one place, however, plans have been perfected for more active work during the coming season.

PORT CLARENCE REGION.

PLACERS.

Gold mining in the Port Clarence region is confined largely to the valley of Bluestone River and its tributaries. There is also an extensive equipment on Sunset Creek and at a few other points in the region, but in the number of men employed and amount of production the valley of the Bluestone is the most important. When, however, this whole region is compared with the Nome or even with the Solomon region, its production is small and its industries seem to be on the decline. Such decrease is not to be accounted for entirely by the remoteness of the region. Supplies can be landed at Teller, the largest town, at even less expense than at Nome, and the routes into the interior are not much more difficult from one place than from the other.

A camp has been established on Bluestone River near the mouth of Ruby Creek, but little work was in progress except on some low benches on the west bank of the river. All of this ground is frozen and facilities for sluicing are lacking. A long ditch line has been projected, but its feasibility has not been demonstrated. It has also been proposed to build a ditch from the upper part of Ruby Creek, but when this creek was visited in the middle of August there was no water in the upper 2 miles of its valley. No other mining was in progress on any other part of the Bluestone proper below a point less than a mile from its junction with Right Fork. At this place the unusually dry season allowed work to be carried on for a short time in the actual river bed, which under ordinary conditions is inaccessible because the narrow canyon prevents turning the river aside. A small pocket of coarse gold was found and practically exhausted before the rains raised the river to such height that the miners were driven away. It is reported that all of the gold from this ground was coarse and chunky, fine gold being practically absent. In a lot of gold worth over $1,000 almost all the smaller pieces were shotlike in form and uniformly bright in color. Some wire gold was also seen, one piece being nearly 2 inches long. The largest nugget that was found was worth $72 and was roughly triangular in form. None of the gold showed signs of long travel and several pieces could have come only from near-by localities. It is not believed that the gravels in which this coarse gold was found are very extensive and the mode of occurrence would suggest local concentration caused by the peculiar physical conditions. There are strong indications of several levels of stream erosion on the walls of the canyon near this claim, and a detailed study of the evidence they afford would be necessary to determine the past history of the river.

Between the mouth of Right Fork and Alder Creek a little desultory prospecting on some of the bench deposits of the Bluestone was done. Hydraulicking of some of the bench gravels of the small stream north of Alder Creek resulted in a small production, but scarcity of water prevented any large scale operations. Above Alder Creek, on the tributary of the Bluestone known as Gold Run, several camps were established. A low channel on the west side of Gold Run was worked with a small force and productive ground developed. The material from the surface down to a depth of 5 to 10 feet is a dark slaty-colored muck showing in places distinct lines of stratification. It is solidly frozen and is reported to carry no values. Below this muck is gravel ranging from a few inches to several feet in thickness. This member and the underlying bed rock carry the gold. The bed rock is a dark schist much softened and decomposed on its upper surface. The gold is ordinarily bright, but tarnished and rusty pieces are by no means uncommon. Few large nuggets are found, but none of the gold is very fine. Pieces worth from 1 to 5 cents show but slight water rounding, though the finer gold is in general fairly well worn. In the concentrates ilmenite predominates over magnetite and there is very little garnet. Mining is done by ground sluicing off the overburden and piping the gravels through a series of bed-rock boxes. The tailings are discharged into Gold Run. A low ridge of rock separates the channel that is being mined from the present stream.

Southeast of the last-described property another outfit has been developing somewhat similar gravels. It is not to be inferred, however, that these two deposits are continuous, and as a matter of fact it seems probable from the difference in elevation that one succeeded the other only after a lapse of time. A section at the upper claim shows silts overlying the gravel deposits, but the stratification is not so clearly marked as on the lower claim. The pay streak rests on a somewhat calcareous schist that ranges in different parts of the exposed area from a foliated chloritic schist of greenish-gray color to a dark, nearly black siliceous slaty schist. The gold is coarse and several nuggets worth from $20 to $40 have been found. There is in addition a good deal of fine gold, but all is easily distinguished without the use of a lens. The actual mining operations are mainly hydraulic in character. Two nozzles are directed against the face of gravel and silt, caving the material, which is then washed into sluice boxes where the gold is recovered, the tailings being discharged into the main stream. Apparently sufficient water is available to meet the ordinary needs of the operators.

These are practically the only productive properties on Gold Run, but several prospectors on tributaries of this stream and the Bluestone are testing the gravels and producing a small amount of gold. On the head of Gold Run one prospector has continued the work of previous seasons on a small scale, owing to scarcity of water. On Bering Creek, a small tributary of Igloo, itself a tributary of Right Fork, a camp much handicapped by lack of water has taken out some good values considering the length of time devoted to mining. On Right Fork near the mouth another camp was engaged more or less actively in prospecting. On the divide between Gold Run and Canyon Creek the deep shaft mentioned by Collier[a] was visited last season and it is reported that further exploration work will be undertaken in the near future. From the character of the gravels, which at the base are made up largely of well-rounded granite bowlders derived from the Kigluaik Mountains, it seems probable that the old channel must have been formed by a river heading in those mountains before the glacial obstruction formed the divide between the Canyon Creek and Gold Run basins. It is believed that if this is the case the chances of finding economically important placers in this channel are not good.

Of the many small streams entering Port Clarence and Grantley Harbor from the north, Sunset Creek is practically the only one on which mining was conducted during the summer of 1908. Even at this place, which is equipped with a long ditch, not enough water was available to allow continuous work. In the winter of 1907 a shaft was sunk west of the creek and the gravels found were reported to be of low grade. The bed rock is a schistose greenstone, but farther east it is a dark-colored, somewhat calcareous schist. An open cut was also driven to the east of the creek with a view to prospecting

[a] Collier, A. J., and others, Gold placers of parts of Seward Peninsula, etc.: Bull. U. S. Geol. Survey No. 328, 1908, p. 279.

the bench gravels. The bed-rock surface rises rapidly away from the stream, but well-rounded gravel continues to an elevation of about 60 feet above Sunset Creek. The country rock at this place looks like black graphitic schist, but it is not quartzose and does not break into more or less rectangular blocks, and it gives a slight lime reaction. In places this schist is cut by greenstone and feldspathic schists. Mining has been done on Sunset Creek all the way from the mouth as far as Lombard Creek, the second small tributary from the north. After the first mile ledges appear in the valley slopes almost all of the way to the head. In places, especially near the mouth of Lombard Creek, the surface gravels are heavily iron stained.

At the present time the only work is being carried on about a mile from the beach. A hydraulic elevator was used, but the low gradient of the creek caused trouble in disposing of the tailings, and it may be necessary to use horse scrapers to clear away the accumulation at the lower end of the boxes. The gold is rather coarse, and the large pieces are dark colored. In the upper layers of the gravel some bright gold is found. Out of a collection of nuggets worth between $200 and $300 only one piece with quartz attached was found. Most of the gold does not have sharp outlines. No clue as to the origin of the gold has been discovered. Veins are common in the schists, and there is a good deal of heavy quartz float all along the creek, but none of it shows any mineralization, and assays that have been made indicate but a very insignificant gold tenor.

LODES.

In the Port Clarence precinct the lodes of especial interest are those in which the valuable minerals are cassiterite or wolframite. Investigations of the various localities where tin or tungsten has been found in Seward Peninsula has been recently summarized by Knopf.[a] None of the properties were examined by the Survey during last summer, so that there is no new information concerning recent developments. It is reported that near Tin City prospecting work was resumed early in the season. The placer-tin properties north of York were not in operation until late in the season. In the Lost River and Brooks Mountain region three locations were more or less prospected last season, but no ore was commercially extracted. As a whole, the prospecting for tin lodes was less actively pursued than for several years past.

Lodes of another class have been developed to some extent in the Port Clarence region on the north side of the Kigluaik Mountains, near Imuruk Basin. These are the graphite prospects. Mention has

[a] Knopf, A., Geology of the Seward Peninsula tin deposits, Alaska: Bull. U. S. Geol. Survey No. 358, 1908.

been made in another report[a] of the deposits of this mineral at many places in these mountains, and it has been shown to be of widespread distribution. Unfortunately, however, the graphite is so intimately mixed with grit and impurities that its extraction is difficult. Two or three separate outfits were engaged more or less continuously in developing the leads on the small gulches that lead to Imuruk Basin west of Cobblestone River. The graphite occurs in bands in a series of biotite schists rather closely associated with granitic intrusions. Dislocations and fractures make the stoping out of the ore more or less dangerous, and none of the holes have been run in more than a few feet. After the ore is broken from the ledge it is cobbed and hand sorted. In this sorting less than 25 per cent of the material is retained. This is sacked and slid down the steep slope of the mountains on sleds, made like a stone boat, to the flats surrounding Imuruk Basin. The sacks are then transported by horses to the shore, where they are put aboard a boat and taken to Teller for shipment to the States. Only a few tons of ore have been produced from this property. There can be no doubt that enormous quantities of graphite are present in the rocks in the Kigluaik Mountains, for large slabs have been found in the float all the way from a point east of Grand Central River to the head of Tisuk Creek, but it has not yet been proved that it can be separated from the accompanying grit and transported economically. In addition, the dislocated character of the rocks throughout the greater part of the region will make the following of the leads expensive when actual mining is commenced.

[a] Smith, P. S., Investigations of the mineral deposits of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 345, 1908, p. 250.

THE IRON CREEK REGION.

By Philip S. Smith.

INTRODUCTION.

In 1905 and 1906 parties from the Geological Survey mapped in detail the geology of a rectangular area extending from Norton Sound on the south to the crest of the Kigluaik Mountains on the north and from the meridian of Cape Nome on the east to a meridian 2 miles west of Nome on the west. In 1907 and during a few weeks in the early part of the field season of 1908 the mapping of the geology of another quadrangle was completed. This area is bounded on the south by Norton Bay, on the north by Niukluk River and the flats between that river and the Kruzgamepa, on the west by a north-south line 2 miles west of the town of Solomon, and on the east by the meridian of Topkok Head. Between these two regions only reconnaissance studies had been made. With the completion of the detailed investigations it became desirable to connect the two separated regions by study in the intervening area in order to see whether the various groups of strata could be correlated. Not only was such a closure desirable from the standpoint of the geologist, but it was recognized that the mining industry had developed in this area gold-bearing gravels that were similar to those in other parts of Seward Peninsula, and it was hoped that a study of these gravels might assist in explaining the origin and distribution of the gold gravels of the peninsula as a whole. This intervening area includes a large part of the basins of Bonanza, Eldorado, and Iron creeks, of which only the Iron Creek basin has been important as a placer region. It was not possible to complete the mapping of the geology of more than the Iron Creek basin and the northern part of the others, though some additional data were procured on the adjacent areas. Valuable notes were furnished by A. H. Brooks and F. H. Waskey and have been used in this report without specific acknowledgment, but the writer desires to express thanks for the assistance thus afforded, which can not be measured by reference.

Although it is the intention in this paper to direct the discussion mainly to the mining industry of the Iron Creek basin, it becomes necessary, in order to establish certain broader generalizations, to include portions of the Casadepaga River and American and Sherrette creek drainage basins on the east and portions of the Eldorado and Kruzgamepa drainage basins on the west and north. This rather ill-defined area lying between the Casadepaga and Grand Central quadrangles, bounded on the north by Kruzgamepa River and on the south by Casadepaga River, is described here under the inclusive term "Iron Creek region."

Although situated only 40 to 60 miles from Nome, this region has not been extensively developed, and the number of miners who have exploited it has not been commensurate with the promise the area held out to the gold seeker. Even as early as 1900 gold had been found on the main stream and several of its tributaries, but the high cost of freight and the lack of adequate water supply discouraged permanent location. During the past year, however, the opening of a store, where supplies can be obtained at a rate of only a few cents a pound more than in Nome, and the completion of a large mining enterprise near the mouth of Iron Creek have assisted in the development and attracted attention to the district. The railroad which runs from Nome to Lanes Landing, or Shelton, as the inland terminus is called, has rendered the region easily accessible, and the high freight rates that prevailed when supplies had to be brought by team or dog sledge from Nome have been very sensibly reduced. In the early days, freighting of supplies often cost 25 cents a pound. The rate was reduced later to about 10 cents, and this price continued practically until the railroad was completed. Now, however, with a biweekly train service, freight, even in less than carload lots, is delivered from Nome at a cost of only 2 cents a pound.

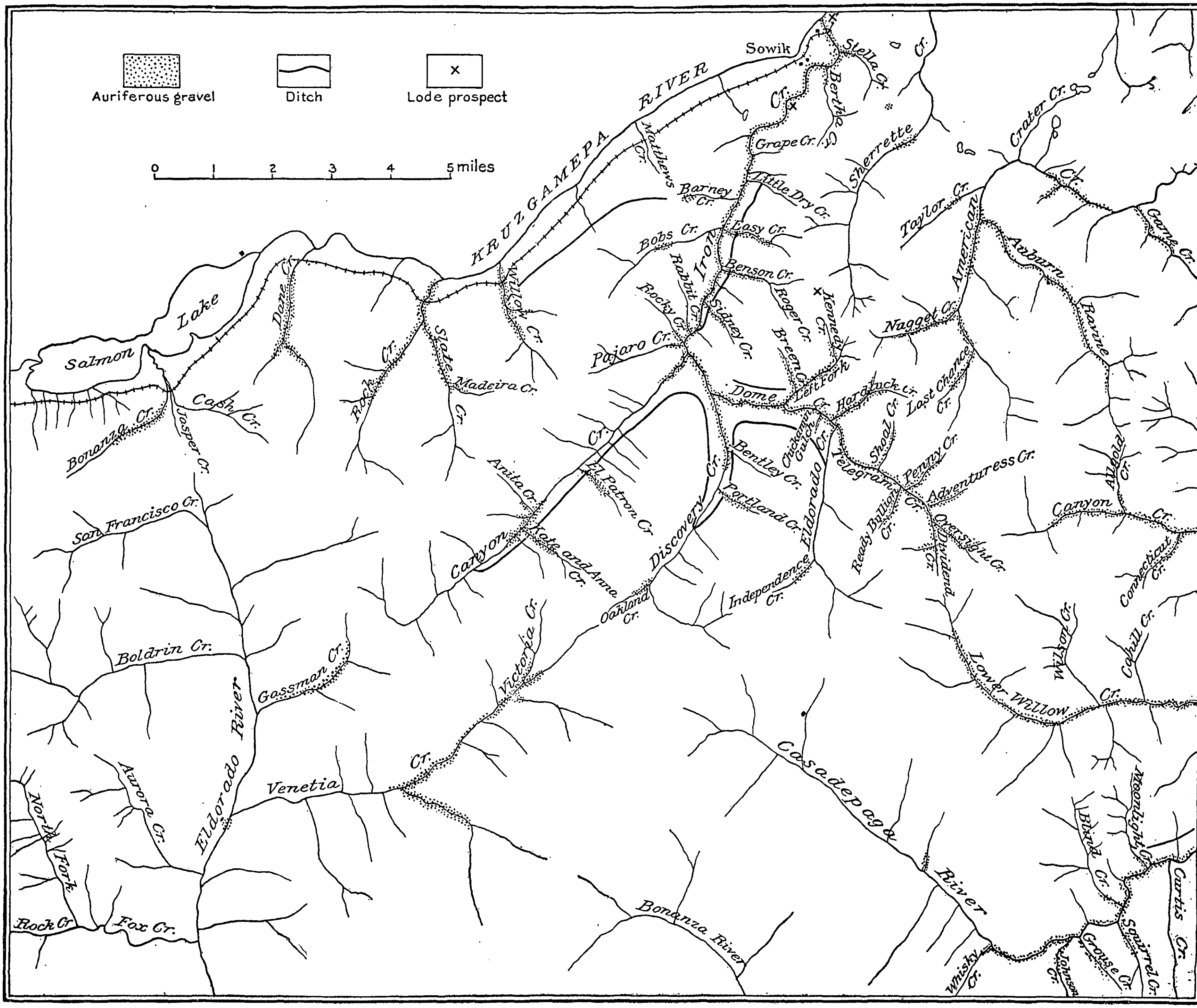
In addition to the railroad there is a wagon trail connecting Nome and Iron Creek. The trail is long and hard, crossing five divides and winding from sand bar to sand bar as it follows the various creeks. Since the railroad was completed the wagon road has been practically abandoned, for it is a three days' trip, and as there are no road houses the traveler is forced to carry his own supplies or burden the prospectors along the line with his support. This road has not been laid out or graded; each succeeding team followed the wheel marks of its predecessors until an unusually soft stretch of ground impelled the driver to choose a new route. It is entirely feasible to make a good road for much of the distance; thus the traveler to interior points could avoid many of the vexatious delays and high charges incident to the often-traveled route along the beach to Solomon before striking inland.

GENERAL GEOGRAPHY.

The general geography of the region may be best understood by reference to Plate X. The Iron Creek basin is a triangular area whose divides form the watershed between the Kruzgamepa drainage, which flows westward into Imuruk Basin, the Niukluk drainage, which flows eastward into Golofnin Sound, and the drainage of Bonanza and Eldorado rivers, which flow southward into Norton Sound. In places the divides between the different rivers are sharp and well defined, so that the area belonging to the different systems is sharply delimited and easily recognized from afar, but in other places the divides are obscure, and one is uncertain of the course of the streams until they have been actually followed. Undivided drainage is particularly characteristic of the broad flat lying between Kruzgamepa and Niukluk rivers and shows an intricate past history which will be considered in more detail in a later portion of the report.

As already defined, the Iron Creek region includes the entire basins of the streams entering the Kruzgamepa from the south, from Dane Creek to Iron Creek. It also includes the headward portion of Sherrette Creek, which joins the Kruzgamepa 2 miles below Iron Creek, and the headward portion of American Creek, a tributary of the Niukluk. The eastern and a part of the southern boundary of the region are formed by the Casadepaga and its tributaries, the largest of which are Lower Willow and Canyon creeks. Eldorado River, with its numerous tributaries, forms most of the western boundary of the region, the extreme northwestern corner being formed by Bonanza, Cash, and Jasper creeks, which are tributary to Salmon Lake. At the heads of nearly all the larger streams are low, broadly open saddles that lead from one drainage basin to another.

The relief of the region is not great, few of the higher summits rising more than 2,000 or 2,500 feet above the sea. Viewed from a distance, the sky line is uniform and but few points project much above the general level. When the divides are studied in detail, at close range, however, the uniformity is not apparent, and though the suggestion of earlier writers that these divides represent an old erosional surface has not been disproved, it is not supported by any known facts. For instance, the tops of the ridges are practically devoid of gravels or deeply weathered rock, and the history of the surface that now forms the upland is undecipherable, because of the extent to which it has been changed by more recent activities. It would seem better, therefore, from the evidence now at hand, to attribute the present character of the sky line to headward erosion of subequally spaced streams. Such an interpretation would not preclude the possibility that the old surface in which these streams are intrenched was a



MAP SHOWING DISTRIBUTION OF MINERAL RESOURCES IN IRON CREEK REGION, SEWARD PENINSULA.

nearly base-leveled plain that has been uplifted, but would indicate that such an explanation has not been made out from the existing features.

Although the relief is not very great, the slopes are by no means gentle, and descents of 1,000 to 1,500 feet from the ridges to the streams are not uncommon. The slopes show great variations in different parts of the area. Some of these changes are attributable to differences in the rocks, but many of the benches and abrupt descents are the result of the various movements that the crust has undergone—each bench or terrace representing a period of relative stability and each steeper slope a more active period of degradation. Many of the more resistant rocks may be traced for long distances by their topographic expression. The most resistant of the rocks are the greenstones and the limestones. Of these the limestones are particularly striking, for, because of their better drainage, they do not support vegetation well, and therefore their white color and steep slopes make them noteworthy landmarks.

Differences in the rocks have also an important effect on the streams of the region, for where the valleys are cut in a limestone bed rock the water seeps underground and is carried off in subterranean channels, so that running water is absent on the surface. One of the best examples of this condition is afforded by Auburn Ravine, a tributary of American Creek. For nearly 2 miles the valley is entirely devoid of surface water, except during periods of heavy rain. When this creek was visited, in July, there was not even enough water for camp use, and it was necessary to carry a supply from a small stream cutting across the limestone-schist contact. It is easy to see that under such conditions mining ventures which depend for success on a water supply are seriously hampered, if not entirely out of the question.

Even in those places where little of the rainfall is carried underground, the climate is such that water must be carefully conserved if it is to be used for mining purposes. No accurate data extending over a long period are at hand concerning the rain and snow fall of the region, but it has been shown [a] that the rainfall at Salmon Lake in 1906 was about 12 inches, from June to September inclusive, or about twice as much as at Nome. If the same proportion holds true during the rest of the year, the rainfall in the Iron Creek region is not over 20 inches, or about that of Wyoming or Colorado. It is evident, that under such conditions, this region should be classed as semiarid. As the precipitation comes mainly in the form of rain and during the four summer months, it gives the impression of being greater than it actually is.

[a] Henshaw, F. F., and Hoyt, J. C., Water supply of Nome region, Seward Peninsula, Alaska, 1906: Water Supply Paper U. S. Geol. Survey No. 196, 1907, pp. 9-10.

GENERAL GEOLOGY.

It is impossible to treat adequately the geology of the Iron Creek region without reference to many contiguous areas, and therefore in this report only the broader features of the subject will be described, the more detailed description being reserved for further discussion elsewhere.[a]

The geology of the region may be taken up under two broad subdivisions—the geology of the consolidated deposits, or, as they are sometimes called, the hard rocks, and that of the unconsolidated deposits, such as the sands and gravels. From the standpoint of the placer miner the latter class is, perhaps, more important than the former, but the question of the origin of the mineralization and the physical features which affect gold concentration are so closely associated with the geology of the hard rocks that a study of them must not be neglected. It should be noted that in this subdivision it is not proposed to include the cemented gravels under the term consolidated deposits.

CONSOLIDATED DEPOSITS.

There are a number of kinds of rocks in the Iron Creek region which differ from one another not only in physical character, but in age and mode of origin. Some, with more or less similar physical characters, differ in origin and age. It is not proposed to go in this paper into any great degree of refinement in the differentiation of the various rocks, but it may be broadly suggested that all the rocks were formed either as sediments or as the result of igneous activity. In many cases, however, it is difficult to assign a particular rock to its appropriate group without the most minute study. The changes have gone so far in many rocks that a determination of their original character is impossible and the decision as to the group to which they belong must be based on analogy or left unmade.

SEDIMENTARY ROCKS.

Of the unquestionably sedimentary or water-deposited rocks the limestones are the most abundant. Their distribution is somewhat irregular and affords many problems in correlation. Commencing near Solomon and extending in a slightly west of north direction is a heavy limestone which appears in the mapped area in the hills south of Casadepaga River in which Squirrel and Grouse creeks head. This limestone is cut by the Casadepaga and forms the ridge between that stream and Lower Willow Creek. To the north it persists as a

[a] This matter will be treated at some length in a report on the geology and mineral resources of the Solomon and Casadepaga quadrangles and adjacent regions, which is in preparation.

ridge separating Lower Willow Creek from the Canyon Creek of the Casadepaga drainage basin; farther north it separates the American Creek basin from that of Telegram Creek and, still farther north, Sherrette Creek from the tributaries of Iron Creek. Throughout this distance the limestone is practically continuous, and though it has been dislocated and fractured, its course is not interrupted. It forms a ridge except where it is cut across by one of the larger streams, such as Casadepaga River or Lower Willow Creek. Owing to the numerous fractures and the porosity of the limestone most of the water that falls upon it sinks underground and is carried by submarine channels so that the surface is dry. For this reason and also because of its steep slopes vegetation does not grow upon it and the bare white hills form striking topographic landmarks. Where this limestone is cut across by Iron Creek it forms a canyon of considerable ruggedness and the stream changes from its nearly due north course to one approximately northeast. Nowhere does this limestone appear to be less than 400 feet thick and in some places, where dislocation makes the structure difficult to interpret, an even greater thickness is indicated.

Apparently joining this limestone and continuous with it is a thick limestone which forms the ridge separating the Iron Creek drainage from that of Kruzgamepa River. It forms high hills on either side of Matthews Gap and cuts across the lower part of Willow, Slate, and Rock creeks as far as Dane Creek. In this part of the area its obvious continuation ceases, owing in part to the deposits of recent alluvium which mask the bed-rock exposures in the headward portion of Jasper Creek and Eldorado River. There is, however, another heavy limestone that continues from a point near the mouth of Bonanza Creek and forms the scarp south of Salmon Lake, where it may be regarded as the westward continuation of the limestone just described. There are few places in this distance where a thickness of less than 600 feet can be assigned to the limestone. No fossils have been found in it, and its stratigraphic position is assigned only on the basis of its areal relationships.

In addition to the nearly continuous heavy limestones there are other bands less regular in their distribution and ranging from beds only a few feet in thickness up to beds of several hundred feet. Some of the heavy limestones are probably the infolded equivalents of the limestone already described. A limestone of this character forms the ridge near the eastern margin of the mapped area, east of Allgold Creek, and extends westward, forming the divide between Auburn Ravine and Game Creek and being represented by the low limestone knob between the head of Stella and Bertha creeks and Sherrette Creek. Another heavy limestone of essentially the same character forms the ridge between Rock and Slate creeks and

Canyon Creek west of Anita Gulch and extends westward to the head of Gassman Creek. Smaller beds appear at various places along the middle and upper portions of Iron and Dome creeks.

Usually the thicker beds are but little metamorphosed, and the determination of the original characters is not difficult, but in certain places the various movements that the region has undergone have changed or metamorphosed the rock. In such places mica and other minerals have been formed and a schistosity or foliation has been developed, so that the original limestone becomes a calcareous schist. All gradations of these changes may be traced in selected localities up to those where the process has gone so far that the original character of the rock is lost and it is a schist with entirely new features. The passage from a true limestone to a calcareous schist can be seen on the hill forming the divide between Canyon and Eldorado creeks and Venetia Creek. Calcareous schists occur also on Dome Creek, where their relation to the limestone may be clearly seen and the intergradation between the two types recognized.

A second type of rock of sedimentary origin occurring within the region is a black, very quartzose rock that is in places graphitic or carbonaceous. It has a thick slaty cleavage and usually breaks into more or less rectangular blocks, owing to the jointing. Nowhere is a great thickness exposed, but it seems to have a course nearly parallel to the thick limestone that forms the eastern boundary of the Iron Creek basin. It is somewhat dislocated, but can be traced from the mouth of Sidney Creek southeastward to Hard Luck, thence more nearly southward to the mouths of Ready Bullion and Adventuress creeks, and thence into the Lower Willow Creek basin, where it forms notable outcrops for a couple of miles below the head of that stream. It continues southward along the west side of Blind Creek, and the last seen of it in the mapped area is on Johnson Creek; but it actually extends southward to the point where it is overlain by the coastal-plain deposits near Solomon. It contains numerous veins of quartz that have been formed in the joint and fracture planes. It appears that this rock has not suffered as great metamorphism as the others, and consequently, instances of a gradation from the quartzitic phase to a schistose phase are not common.

There are many other places in which rocks of similar character are found, but their relationships have not been thoroughly worked out, and it is not possible as yet to determine whether they represent the same or different horizons. Thus on Canyon Creek, a tributary to Iron Creek, black quartzitic slates occur near the mouth of Anita Creek, and float of the same rock is found on the divide between Kate and Anna creeks and Oakland Creek, a branch of Discovery Creek. It is also present on Boldrin Creek, 3 or 4 miles above the junction of that stream with Eldorado River, and on the hill separating Aurora and Boldrin creeks, as well as on the southwest side of Aurora Creek. In all these places this rock seems to have been brittle, and where subjected to stress it was fractured rather than sheared.

Underlying the less metamorphosed sediments are schists of different character and chemical composition. Some of them have been proved to be of sedimentary origin through investigation with the microscope, and the origin of others has been disclosed by their relations to other known sedimentary rocks. Their relations to other rocks and their physical characters show that these schists are among the oldest rocks of the region. They form the bed rock over the larger part of the area, and if the overlying sediments could be removed they would cover a still larger surface. Their composition differs in different parts of the field. In some places the schists are highly quartzose; in others the quartz component is relatively small and the larger part of the rock is calcareous. Chlorite is universally present in these schists and gives the greasy greenish color which is so characteristic of these rocks. Original structures have almost entirely disappeared, but under exceptionally favorable conditions an older structure different in direction and character from the more recent structure induced by metamorphism can be recognized. According to the earlier workers in Seward Peninsula geology, these schists form the Nome group, which is pre-Ordovician in age and probably younger than the rocks that form the Kigluaik Mountains to the north. To this group have been referred all the highly metamorphosed rocks of sedimentary origin. As the original character of the rocks in many places is impossible to determine, the group doubtless contains some rocks of igneous origin as well.

IGNEOUS ROCKS.

The igneous rocks of the Iron Creek region are all of basic type. Granites and other acidic rocks, although abundant only a few miles to the north, are not found within this area in place. In composition these rocks are high in alumina, iron, and soda and low in silica. The igneous rocks may be roughly divided into two main classes—schistose and nonschistose. The nonschistose igneous rocks, as the name implies, are rather massive rocks that are somewhat jointed and fractured, but not cleaved or foliated. Though having affinities with different kinds of rocks, they may all be grouped under the general term greenstones. Because of their massive character the greenstones form prominent knobs and ridges. The minerals usually visible in hand specimens are garnet, amphiboles, and lath-shaped feldspars. The microscope shows that the amphiboles usually consist of the soda-rich hornblende allied to the glaucophanes and that the feldspars belong to the plagioclases rich in soda and lime, having a composition about that of oligoclase. In areal distribution the unsheared greenstones are irregular but occur throughout the region in small masses. Where contact relations are clearly shown the greenstones appear to form dikes and sills in the sedimentary rocks. Greenstones are most abundantly developed in the ridge between Eldorado and Iron creeks which extends southward, separating Casadepaga River from the headward branches of Lower Willow Creek. Rocks of this type are abundant in the divide south of Slate and Willow (tributary to the Kruzgamepa) creeks. They are also widely distributed in the hills west of Eldorado River, forming prominent peaks and ridges south of Fox Creek, in the divide north of Aurora Creek, and between San Francisco and Bonanza creeks. They are among the latest rocks in the region, lying on top of or cutting the older formations.

Another series of rocks forming considerable areas of the bed rock in this region are the schists that show numerous feldspar crystals, which give the rocks a speckled appearance. Some doubt is felt as to the precise origin of many of the rocks of this character, but there seems to be small room to question that some are of igneous origin. In favorable localities it is possible to trace the gradational stages between the unsheared greenstones and the sheared feldspathic schists. It is therefore believed that in such localities the schists have been produced by the shearing and metamorphism of the igneous rocks. Though this explanation can not apply to all the feldspathic schists, it seems probable that a considerable part of them have been formed in this way and should therefore be separated from the schists of sedimentary origin. If this is the correct interpretation, these schists are younger than the others and the areal relations are very different from those that would be shown if they formed part of the sedimentary sequence. Feldspathic schists predominate near those places where greenstones are most abundant. There are many places, however, where although feldspathic schists are present few greenstones occur. This condition might be explained by the suggestion that in such places shearing has gone on to such an extent that none of the original greenstone is preserved.

Although the question of the origin of all the feldspathic schists can by no means by regarded as settled, it is unnecessary in this paper to pursue the details further. It remains only to point out the areal distribution of this group of rocks. It is a common occurrence that the feldspathic schists form the upper parts of the ridges and are absent in the valley bottoms. This suggests that they overlie unconformably or cut the sedimentary rocks. Such a condition is shown by the bed-rock geology between Canyon (tributary to Iron Creek) and Discovery creeks. Feldspathic schists are also commonly developed in the divide north and east of the Casadepaga and in some of the hills at the heads of Rock and Slate creeks. The ridge between the headward portion of American Creek and its tributary, Auburn Ravine, is made up in large part of the feldspathic schists. West of Eldorado River also there are many areas of feldspathic schist; especially in this region are they near the knobs of greenstone.

VEINS.

The veins of the Iron Creek region are of different ages and character and each type occurs under different physical conditions. On the basis of age the veins may be divided into two main groups, the older and the younger veins. These terms are purely relative, but roughly suggest the relation of the veins to the great period of metamorphism that affected the region. The older veins antedate this period; most of the younger veins were formed during or after it. The difference in age has caused many of the differences in physical character. Thus the older veins are knotted and irregular lenses and stringers, whereas the younger veins are more or less continuous. Moreover, the vein filling in the older series is smashed and recemented, but in many of the younger veins the filling shows well-formed original crystals.

The contorted and irregular veins are most typically developed in the chloritic or sedimentary schist series. They are younger than that series, for they cut across the structure, but they seem to be older than the heavy limestone, for as a rule they do not occur in it. Practically none of these veins are present in the areas occupied by the feldspathic schists and greenstones. Usually the older veins consist entirely of quartz with no sulphides or other visible metallic minerals. Assays, however, of samples showing no metals have yielded values in gold, so that this mineral undoubtedly occurs in them. Secondary minerals have been developed in some of these veins and show by their presence that the contents of the veins have received additions and subtractions of material in the long periods since their formation. Owing to the folding and deformation to which they have been subjected they are not continuous and few of them can be traced for any great distance.

The veins of the second or younger series usually have quartz for vein filling, but some contain calcite instead. The quartz veins are of two types, one showing sulphide mineralization while the other does not. The sulphides are usually iron pyrite, but here and there copper pyrite is found. The nonmetallic filling in such veins is almost invariably quartz. In a few localities the quartz forms perfectly terminated crystals with the sulphides nearer the wall rocks. The more common type of younger veins, however, does not show sulphides, the filling consisting entirely of quartz. Such veins are particularly abundant in the black quartzose slates, but they cut all the other rocks of the region, though as a rule they are relatively few in the areas where greenstone or feldspathic schist forms the country rock. Assays of these veins show that they, too, like the older veins, carry values in gold. It is evident, therefore, that the introduction of the gold that has formed the gold placers of Seward Peninsula took place at more than one period of geologic time. As the younger veins have not been so much deformed by the later movements, they are more continuous than the older veins and some of them can be traced for a considerable distance. The younger calcite veins are confined almost entirely to the large limestone areas, being as a rule absent from the adjacent schists. No well-formed calcite crystals have been reported and the filling appears to be material squeezed into the fissures caused by the deformation. So far as known no minerals of economic value have been found in veins of this type.

UNCONSOLIDATED DEPOSITS.

TYPES AND AGE RELATIONS.

The gravels and unconsolidated deposits of the Iron Creek region are of four main types—the present creek gravels, the bench creek gravels, the glacial deposits, and the gravel-plain gravels. While in many places the types are distinct and unmistakable, there are gradational phases between them which make the boundaries ill defined. In age the unconsolidated deposits range through a long time, but geologically they are very recent. The fossils that have been found throw no light on the age of the oldest of these deposits, but it is probable that none of them antedate the Pliocene. The absence of definite criteria prevents any statement as to the relation of the gravels of the Iron Creek region to those of the coastal plain with its ancient beaches, near Nome. Such a correlation could probably be effected by tracing the various deposits along the Kruzgamepa and Kuzitrin valleys until the coastal-plain province was reached. This correlation, however, would be more of theoretical than of practical value.

PRESENT CREEK GRAVELS.

The present creek gravels, as the term used in describing them implies, are those gravels which are now practically in process of formation by the existing streams. The materials which are being handled by the streams are of two sorts—those formed from the bed rock of the region and those made from the previously formed unconsolidated deposits. A stream that flows on older gravel deposits may be working on materials which are foreign to its drainage basin, and whose origin must be sought by reference to the previous history of the region. As an example of gravel of this type, formed by the intrenching of a stream in gravels of an older stage, may be mentioned the lower course of Sherrette Creek, which for a couple of miles above its junction with Kruzgamepa River flows on the unconsolidated deposits of the gravel plain, described on page 316. The gravels of Sherrette Creek are formed of rocks which do not constitute the bed rock of the creek valley, but which have been brought to their present position by a preceding series of activities and are being treated by the present stream as if they were deposits in place.

On the whole, however, the streams over the southern and larger part of the area are flowing on gravels that are made up of the same material as the bed rock of the basin. This is especially the case in the headward portions of the smaller streams, where it is evident that the gravels are directly derived from the underlying bed rock. As has already been pointed out, the region contains rocks of many different types, namely, the various limestones, black quartzites, greenstones, and chloritic, feldspathic, calcareous, or quartzose schists. In each area of a certain kind of bed rock pebbles of that kind of rock predominate in the gravels. This characteristic is in many places so strongly marked that the position of the contact between different formations may be closely approximated by noting the changes in the character of the gravels.

Almost all the present creek gravels are relatively shallow, few of the sections exposing more than 3 or 4 feet of material. Owing to the fact that these gravels are more or less constantly affected by the streams, decomposition has not proceeded far and the separate fragments are usually fresh and show but little effect of chemical decay. In shape the fragments vary much. The usual form, however, is the flat shingle so characteristic of normal creek wash; but this is typical only of the laminated rocks. Greenstones and the more massive limestones rarely exhibit the flat thin phases, but form pebbles whose different axes are more nearly equal.

Though the creek gravels are usually loose and unconsolidated, here and there, where the presence of water carrying large amounts of material in solution permits the process, the gravels are cemented. The two most common cements are lime and iron, and in the upper part of Iron Creek, near the black-slate contact, the iron cement is abundant. The iron of these cements is derived mainly from the decomposition of the sulphides that have been formed near the contact of the black slate and the thin-bedded limestones. Lime cement was seen in several parts of the field, but is of less importance than the iron cement, for it occurs at only a few places in the gold-bearing gravels and therefore does not cause as much trouble to the miner.

BENCH CREEK GRAVELS.

Bench creek gravels, the second type of gravel deposits occurring within the area, are of similar origin to the present creek gravels, but they have no longer their old relation to the stream by which they were formed. As a class these deposits, except under favorable conditions, are difficult to separate from the so-called gravel-plain deposits that form the fourth class. There are, however, many bench deposits which show so clearly their mode of origin that there can be no reasonable doubt that they have been formed by streams in the past. Since their formation movements of the earth's crust have permitted the ancient streams to cut down their valleys, and thus portions of the former flood plains have been left as benches on the valley walls.

Because the bench creek gravels and the present creek gravels have been formed under practically the same conditions, their general characters are the same, but the difference in topographic position shows that the bench gravels have been affected by certain activities to which the present creek gravels have not been subjected. The most notable difference is that of age. The bench gravels were formed at an earlier stage than the present creek gravels and it is by no means uncommon, in some of the older benches, to find many of the pebbles more or less decomposed and their soluble constituents leached out. The amount of leaching, however, is not at all commensurate with the amount that takes place in similar gravels in temperate latitudes, for the frozen condition of the ground and the absence of much ground water make the rate of decomposition slower than in a warmer, moister climate.

Benches occur along the lower courses of almost all the streams and many of them can be traced for considerable distances. In elevation they are in places a hundred feet or more above the streams. Although some benches occur at very much greater elevations, the creep of the surface cover and the greater length of time that they have been subjected to degradational processes render their form more and more obscure. So, although washed fragments of gravel are occasionally found high up on the hillsides, the deposits from which they came have been so commingled or rearranged that identification is almost out of the question.

None of the ancient bench creek gravels show any fragments of rocks foreign to the drainage basins in which the deposits occur, except in those places where gravel-plain or glacial deposits have been laid down and reworked by the streams that formed the bench deposits. Certain cases of this sort will be referred to elsewhere in this report (pp. 316–319). Though the bench deposits are numerous, sections are difficult to obtain except where mining operations have furnished fresh cuts. Interpretation of the sections thus afforded shows that in recent times the region has suffered a number of modifications, of which some were probably due to movements of the crust, but others were undoubtedly due to climatic changes that affected the conditions of precipitation.

None of the larger streams and few of the tributaries fail to have benches in portions of their courses. Instrumental leveling might give some clue as to the movements of the crust in the recent past, but no such work has yet been done, and widespread correlation of the benches at different elevations has not been attempted.

GLACIAL GRAVELS.

Glacial deposits form noteworthy superficial features in the Kruzgamepa Valley. There are two distinct types of these deposits—one in which the material was laid down by ice and the other in which, although the material had been carried by glaciers, the actual deposition was effected by streams or in bodies of quiet water, such as lakes. Each type is distinct and can be recognized by the usual criteria that apply to ice-laid or water-laid deposits. Although details of the history have not been worked out, it is definitely known that at a period not geologically remote glaciers occupied many of the valleys of the Kigluaik Mountains and extended into the Kruzgamepa Valley. In places the ice sent tongues through the low passes south of the valley, and, melting, discharged the water into the Norton Sound drainage area. Such a condition is clearly to be made out in the low divide at the head of Eldorado River, where morainic material and topographic forms due to glaciation are prominent.

The most striking of the morainic deposits are those which mark the closing stages in the period of glaciation. Consequently, the upper limit of ice advance is not well defined. It seems certain, however, that the region has not been entirely covered by ice at any recent time, for the character of the gravels and of the topographic forms affords conclusive evidence that the ice was more in the form of valley glaciers than of regional ice sheets. The deposits of a morainic character are usually formed of angular, unwaterworn fragments of rock that vary greatly in size, some of the larger blocks being several tons in weight. That the center from which the glaciers proceeded was the Kigluaik Mountains is clearly demonstrated by the lithology of the deposits formed by the ice. In these mountains the rocks are characteristically biotite schists and granites, whereas south of the mountains neither of these kinds of rock occurs in place. A good opportunity is thus afforded to differentiate the gravels that have been brought into the area from the north from those of local origin.

Though not all the material from the north has been brought by glaciers, almost all of it has been subjected either to the direct action of ice or to the indirect effect which the ice had on the previous drainage of the region. The intricate relation between the distinctly ice-laid and the fluvioglacial deposits makes the differentiation of the deposits to be assigned to each class nearly impossible, without artificially prepared sections.

GRAVEL-PLAIN DEPOSITS.

A consideration of the purely glacial deposits is intimately associated with that of the deposits of the gravel-plain type, and though the two are not always to be directly connected they present many points in common. Gravel-plain deposits are most characteristically developed in the Kruzgamepa Valley and in the broad flat which forms the northern border of the Iron Creek region between Kruzgamepa and Niukluk rivers. Very little is known about the gravel-plain deposits or about the floor upon which they rest, but from the few facts now available it is certain that their history is intricate, and that a number of factors must be considered in arriving at an adequate explanation. Natural sections of the gravel plain are extremely unsatisfactory, and but few artificial sections have been made. The few holes that have been sunk show that the gravels of which these deposits are formed are in places very deep. Near Sherrette Creek there has been a good deal of exploitation by the drill, and though the records are not complete they indicate a depth of gravel in places of more than 180 feet. A shaft sunk on Sherrette Creek a short distance above the first mapped tributary from the east showed a depth of gravel of nearly 70 feet. The section at this place consists of gravels containing heavy blocks of granite and other material from a foreign drainage basin, associated with limestones and schists, which occur within the Sherrette Creek basin. The bed rock exposed in this shaft was limestone and schist, the schist lying to the east and the limestone to the west, the shaft apparently striking the contact between the two rocks. The floor upon which the gravels were deposited seems to rise toward the west and to slope downward toward the east, or toward the center of the gravel plain. No data were available with regard to the slope in feet to the mile, but from the distribution of outcrops it seems certain that the gradient is high.

Elsewhere the same gravel plain seems to be a thin veneer of gravels over a high bed-rock surface. This condition is well illustrated by the flat between Iron Creek and Sherrette Creek near Kruzgamepa River. In this part of the area the main stream flows in a rock-walled canyon intrenched 50 to 100 feet below the surface of the gravel plain, and Iron Creek itself cuts across the plain in a canyon which in almost all places shows bed rock projecting in angular ledges that are covered by only a few feet of gravel and silt.

Here and there, however, ancient channels, whose depth exceeds that of the present streams, are found in the gravel-plain deposits. The most interesting of these ancient stream channels is well exposed by a tunnel that has been driven for mining purposes from Iron Creek to the Kruzgamepa near Sowik. Most unexpectedly the tunnel went for this entire distance through gravel. Four shafts were sunk to furnish ventilation and means of access, the collars being situated as follows:

Location of shafts near Sowik.

Shaft number—	Elevation above Kruzgamepa River.	Distance from Iron Creek.
	Feet.	*Feet.*
1	92	250
2	87	550
3	64	850
4	26	1,160

The following sections give the thickness and character of the various beds which were passed through in shafts 1, 2, and 3, from the surface downward:

Sections of shafts 1, 2, and 3 near Sowik.

SHAFT NO. 1.

	Feet.
Gravel, muck, and bowlders	40
Clear ice	2
Gravel	5
Sand	4
Gravel	9
Sand	4
Gravel	4
Sand	1
Gravel	8
	77

SHAFT NO. 2.

Sod	5
Clear ice	30
Gravel	2
Muck containing fragments of wood	8
Gravel	8
Loose sand	37
Gravel with large bowlders	28
Sand	2
Gravel	3
Sand	1
Gravel	4
Gravel with angular schist fragments	4
Hard schist bed rock.	
	132

SHAFT NO. 3.

	Feet.
Muck	5
Bowlders, muck, and gravel	6
Coarse sand	6
Fine loose sand	10
Gravel	10
Gravel and sand	6
Gravel	4
Sand	4
Muck	4
Gravel and muck	6
	61

Great variation in the character of the gravels prevails not only in vertical section, but also horizontally. This may most clearly be recognized by the following section made along the grade of the tunnel:

Section along tunnel near Sowik.

	Paces.
End of tunnel toward Iron Creek in coarse gravel.	
Shaft No. 1	41
End of coarse gravel and beginning of sand	14
End of thin sand layer dipping northwest and beginning of gravel	7
End of gravel and beginning of sand, which overlies the gravel	28
Shaft No. 2, in sand; dip in general flat, but strong cross-bedding	83
End of sand and beginning of coarse gravel	56
End of gravel lens and beginning of sand	7
Coarse gravel in roof, sand below, few pebbles in the sand	7
End of sand with strong dip toward the northwest and abrupt beginning of coarse gravel	26
Sand under coarse gravel with strong dip toward Iron Creek. Some of the gravel layers much iron stained and slightly cemented	6
Sand below and gravel above, alternating. All kinds of rocks from the pebbles of the gravel. At this place beginning of rise of sand toward the Kruzgamepa.	31
Shaft No. 3 in fine sand. Looks a good deal like blue muck. Irregular dip but predominantly toward the northwest	13
End of sand and beginning of coarse gravel. The sand goes distinctly below the gravel and dips northwest	11
Strike here seems to be nearly parallel with the tunnel	20
A sand interlaminated with the gravel commences and the gravel decreases in amount toward the northwest	31
Sand decreases and coarse gravel appears in roof, gradually increasing in amount toward the northwest	19
Shaft No. 4	60
End of tunnel on the Kruzgamepa side. All the way in very coarse gravel	43

Throughout these various sections granite and biotite schist fragments, most of which are well rounded, are found. On account of the prevailing slope of the beds toward the Kruzgamepa Valley it is believed that they were deposited by forces working from the east toward the west. If this explanation is accepted, however, it is difficult to account for the depth at which bed rock was encountered in the second shaft, for the bed-rock floor slopes from shaft No. 4, where it lies at an elevation of only a few feet above the Kruzgamepa down toward the east, to a depth of nearly 50 feet below the level of the river in shaft No. 2. Another objection to the theory is the fact that materials from drainage basins other than that of Iron Creek are present in great abundance in the gravels, so that it is not easy to understand whence they could have been derived by streams flowing from the east toward the west. On account of these objections, it has seemed most probable that the old channel here described was formed by a previous stream, antedating the present Iron Creek. The strong cross-bedding, noted in several places in the horizontal section, would seem to indicate the deposition of gravel, possibly as a delta-like formation in a body of standing water of no great depth. Such a lake might have been formed back of a temporary barrier such as an ice sheet, but strong water action is undeniably represented by the well-rounded character of most of the fragments, save in the extreme upper part of the deposit.

The general absence of forms due to glaciation on the surface of the gravel-plain deposits suggests that the formation of these plains took place at the close of the period of maximum glaciation. Here and there, however, as for instance at the mouth of Jasper Creek and the lower end of Salmon Lake, part of the glacial and gravel-plain deposits were contemporaneous. Furthermore, the change in the courses of some of the streams would indicate that some obstruction which has since disappeared, such as ice, must have existed after a portion of the gravel plain had been formed.

As has already been pointed out, there is no granite or biotite schist in the Iron Creek region, although both of these rocks predominate in the Kigluaik and Bendeleben mountains, which form the boundary of the gravel plain to the north. It is therefore believed that the upper limit of the float of these rocks on the south side of the valley indicates the height to which the old deposits, formed in part by the erosion of the land to the north, formerly extended. It was found that the upper limit of granite was at a fairly uniform elevation of 800 feet above the sea. This would correspond very closely with the elevation of Matthews Gap and the upper rim of the American Creek canyon, at both of which places granite wash, well rounded, is of common occurrence. Below this upper limit plains are developed at different elevations down to 450 feet. These levels, however, seem to be constructional rather than destructional in origin.

ECONOMIC GEOLOGY.

The economic resources of the Iron Creek region consist of placers, lodes, and water power and will be treated in the following pages in the order enumerated. Though these are the sources of wealth, the geographic position of Iron Creek determines the cost of supplies;

and many deposits that might be of value in more favorably situated regions can not be developed here. As transportation facilities increase with each succeeding year, the determination of just what ground can be worked to a profit is constantly changing. Even in the old days, when freight on supplies cost from 10 to 25 cents a pound, good returns could be obtained at many places. On the whole, however, the region has not been as thoroughly developed as the showing afforded by the prospects would warrant.

GOLD PLACERS OF THE PRESENT STREAMS.

It has been stated that the unconsolidated deposits of the region are of four distinct types. Each of these types, with the exception of the glacial deposits, has furnished gold in sufficient quantities to pay wages, but the present stream and bench gravels have undoubtedly proved to be the most valuable, and of these two the first have been more largely mined. In describing the different deposits, the placers of the streams tributary to the Kruzgamepa will be taken up from the west toward the east, commencing with Dane Creek and proceeding toward Sherrette Creek and its tributaries. The Niukluk drainage basin, which is represented in the area under discussion by American Creek and Casadepaga River, will be next considered, and then the streams tributary to Eldorado River, commencing with the northernmost and proceeding south.

TRIBUTARIES OF KRUZGAMEPA RIVER.

Dane Creek is the first small tributary to the Kruzgamepa from the south, east of Salmon Lake. It is only a little over 2 miles long and its stream gravels have received but scanty attention. These gravels are thin, but the relation of the stream to the country rock is such as to suggest the probability of finding workable placer deposits. No permanent camps have been established on this creek. In the lower part of its course the stream flows on gravel-plain deposits, consisting of a great variety of different kinds of rocks many of which are foreign to the Dane Creek basin. A low pass separates the eastern fork of Dane Creek from Rock Creek, the next tributary to the Kruzgamepa from the east, and it seems certain that in recent time there has been a discharge of either ice or water across this low sag. This incident has not affected the gravels of the middle portion of Dane Creek, although it probably has had some effect on those farther upstream.

Slate Creek enters Kruzgamepa River about 2 miles east of Dane Creek. Less than a mile above its mouth it divides; the eastern fork retains the name Slate and the western branch is called Rock Creek. Placer mining has been carried on in the past on both of these creeks, and A. H. Brooks states that 25-cent pans have been obtained on bed rock. This creek near its mouth is intrenched in a narrow canyon about 30 feet below an older stream floor. Farther upstream the canyon dies out and the stream flows on a gradient nearly coincident with the former valley, showing that the uplift that caused the intrenching is of recent date, as the stream has not yet been able to perfect its headward slope to fit the new conditions.

During the season of 1908 the only mining operations on Slate Creek were carried on from the junction of Rock Creek for about half a mile upstream. Two outfits were engaged in shoveling creek gravels into sluice boxes. The gold from both of these places was bright, and several small, rather sharp nuggets were seen. The ground lies near the contact of a heavy limestone and a dark-green feldspathic schist. Many heavy bowlders, some of them derived from ledges outside of the basin of Slate Creek, occur in the creek gravels. This stretch of the creek had already been worked over, and the values now obtained are those which were overlooked or lost by the earlier miners. The pay streak is narrow, and the gravels are in few places more than 3 or 4 feet thick. The gold is worth about $18.25 an ounce. The production is small, and but a few thousand dollars have been taken from the creek since its discovery.

The next tributary to the Kruzgamepa from the south, east of Slate Creek, is Willow Creek. During 1908 no productive mining was done on this stream. It was described in 1900 as follows:[a]

Near its mouth this stream flows through a small rock canyon about 50 feet, above which is a bench on either side covered with gravels. This bench represents an old valley floor into which the stream has incised its present valley. The bed rock on which this creek flows includes limestone with interbedded quartz schists, which are of sedimentary origin. With it occur greenstones which are igneous. The strikes are nearly directly across the course of the stream and the dip south—that is, upstream. Gold has been found in limited quantities on this stream. On bed rock we know of pans yielding 25 cents. The dips being upstream and the rock often rather heavily bedded, the lodgment for gold is not so good as in regions where thinly laminated rock with downstream dips forms a natural riffle.

Willow Creek has been mined more or less continuously in a small way ever since its discovery. The small amount of water available for sluicing and the narrow pay streak have prevented any considerable development. The gold is similar in character to that from Slate Creek. In the canyon portion the gold is usually bright and rather well worn. Occasionally some larger pieces are found, which from their shape do not appear to have traveled far. Some foreign material is found in the gravels of the lower part of the stream, but the gold seems to be of local origin and more or less closely connected with the limestone and schist contact.

Three miles east of Willow Creek is Matthews Creek, which heads in the low divide separating Iron Creek from the Kruzgamepa. This

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[a] Brooks, A. H., and others, Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900, a special publication of the U. S. Geol. Survey, 1901, p. 116.

stream nowhere cuts bed rock and is flowing on the gravels of the gravel-plain deposit. No gold has ever been reported from it, but on the other side of Matthews Gap streams flowing on gravel deposits of much the same type have yielded wages where water could be obtained by sluicing. There has, however, been but a slight amount of concentration, and although the bed rock in the neighborhood is of the same character as that which cuts the auriferous part of Willow and Slate creeks, the great depth of the gravel and the lesser amount of concentration will probably preclude the chance of finding economically valuable deposits along its course.

The next stream tributary to the Kruzgamepa is Iron Creek, which is economically the most important stream in the region. Although really continuous, Iron Creek bears three names in different parts of its valley. From its mouth to Left Fork, a distance of about 7 miles, the stream is called Iron Creek; above Left Fork as far as Eldorado Creek, a distance of about a mile, it is called Dome Creek; and from Eldorado Creek to the divide between the Willow and Iron creek basins 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—that is, creeks having different names. In describing the placers of this basin the main stream from its mouth to head, considering Iron, Dome, and Telegram creeks as one stream, will be treated first, and then the tributaries.

In 1908 no mining was done on the main stream below Discovery Creek, but this stretch of the creek has been worked in the past, and there is no reason to believe that the gold content has been exhausted. In fact, a project of considerable magnitude is under way to handle the gravels of that part of Iron Creek above Bertha Creek where the gradient is sufficient. This scheme is based on the fact that near the settlement of Sowik Iron Creek approaches within 1,500 feet of the Kruzgamepa. At this place the difference in elevation of the two streams is 29.65 feet.[a] A tunnel (see pp. 317–319) with a low gradient has been driven to connect the two streams, and it is proposed to place sluice boxes within the tunnel and to sluice the gravels of Iron Creek through the flume and discharge them into Kruzgamepa River. A portion of the flume has been set in position, and by the opening of another summer the actual sluicing of the gravels should be well under way. The experiment will be watched with considerable interest, as it presents many features that have not been tried elsewhere in the region. It is proposed to sort out all the heavy, large bowlders and not to pass them through the flume. The amount of gravel that can be sluiced in this way can be decided only by actual practice, for the amount of reduction of velocity in the upper part of the flume, owing to riffles, can not

[a] Determined by Arthur Gibson, of Nome.

be foretold with accuracy. The problem of disposing of the tailings on the Kruzgamepa end of the flume is a serious one. At the present time this river, near the point of discharge, is divided into two branches. It is proposed to build a wing dam so as to throw these two streams into one channel and thus increase the transporting ability. It may become necessary to install a hydraulic giant near the discharge to help in keeping the material from choking the flume. Water, however, at the low elevation needed for the successful operation of the plan is abundant, and a scarcity need hardly ever, even in so dry a season as that of 1908, be apprehended.

No figures are available as to the tenor of the ground to be handled by the flume, but there are many indications which suggest that it is probably of low grade. Brooks, who visited the region in 1900, reported that colors were plentiful near the surface along the lower part of Iron Creek, but that at that time prospectors, after having gone down 5 or 6 feet, had been unable to reach bed rock on account of water. The fact, however, that this part of the stream long remained without any permanent miners suggests that bonanzas are not to be expected, and that a profit can be made only by handling a large amount of ground at a low cost. The gold that has been found in the creek gravels of the lower part of Iron Creek has been mainly fine flakes of a bright color, which have apparently traveled much farther than the dark angular gold characteristic of the upper part of Iron Creek.

In the past some mining has been done on the creek gravels from Easy Creek to Canyon Creek, but the amount of gold won from this part of the stream was not sufficient to counteract the high cost of labor and supplies, and this ground has lain idle for several years. Placers undoubtedly exist in this area, but the tenor of the gravels is probably so low that the deposit must be worked on a large scale if a profit is to be made, for the ordinary shoveling-in methods do not handle enough ground to pay much more than expenses.

Between Canyon and Discovery creeks on the main stream a small party, consisting of only two or three men, was mining the present stream gravels in 1908 by open-cut methods. At this place the creek floor is about 100 yards wide and the walls of the valley rise abruptly. The gravel is from 2½ to 3 feet thick and rests on a slabby calcareous schist. Several small stretches through this part of the creek have shown good values, but the richest pay streak apparently swings across the creek so irregularly that it is difficult to follow.

In 1905 renewed attention was paid to Iron Creek because of increased activities near the mouth of Discovery Creek. An expensive plant was erected at this point to handle the creek gravels with a hydraulic elevator, and long ditch lines were constructed.

The installation was completed in the fall of 1906 and a small amount of work was done. The venture was not successful, owing to a number of reasons, and a single pit partly cleaned out is all that remains of an investment of many thousand dollars. Near the mouth of Discovery Creek the pay streak is about 150 yards wide and the gravels are 6 to 8 feet thick. Only a little desultory work was done at this place during 1908, but the holders of the ground are expecting to do some work in 1909.

The concentrates from the gravel near the mouth of Discovery Creek show a variety of different minerals. Magnetite forms about a quarter of the entire bulk. Garnet, in rather angular grains, is perhaps the most common heavy mineral. In color it ranges from a light pink to a very dark ruby-red. In addition to the magnetite and garnet, a considerable proportion of ilmenite, the oxide of titanium and iron, is found. This mineral looks like magnetite but is nonmagnetic. It has no economic value as found in the black sands from placer workings. For the most part these three minerals are derived from greenstones and igneous schists, which occur to the south and west of Iron Creek. In addition to these minerals, which form the major part of the concentrates, iron sulphides are found. Much of the sulphide is altered into limonite, and in some of the larger specimens the outer portion is formed of limonite while in the interior still unoxidized sulphides may be recognized. The place from which the sulphide was derived is in doubt, for there are many veins carrying sulphide in the immediate neighborhood.

The gold is usually bright and in fairly coarse flakes, practically no flour gold being present. A few nuggets have been found, but they are relatively uncommon. No attempt was made to determine the exact tenor of the gravels, but they probably run between $1 and $2 a yard. Under the present scale of wages, etc., it is not feasible to work such ground in this district by pick-and-shovel methods.

Above Discovery Creek more gold has been taken out than in any other part of the basin, and here mining work is still in progress. When the region was visited in 1906 it was reported that between Discovery and Left Fork there was a fractional claim which had been worked during the two preceding years on a small scale. In 1906 from one to five men at a time were employed on the claim during the open season. 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 in the bed rock. The small amount of ground held by these operators prevented any large-scale operations. At the junction of Left Fork two men were mining in 1906, but during the last year there was no work done and the ground has probably been mined out. The method used was to carry off the surface water by a bed-rock drain and then to shovel the gravel into sluice boxes. Several nuggets worth $30 to $40 each have been found in this place. The bed rock is a much shattered limestone with thin bands of schist both above and below. The relations of the various rocks through this part of the valley are very complex, owing to faulting. Near the mouth of Left Fork a fault with unknown displacement brings the limestone and schists into contact, the dips and strikes being practically accordant on the two sides of the fault plane. Along the fault plane calcite veins heavily impregnated with iron form a zone about a foot in width and may in part be the cause of the placer which occurs near by.

Iron Creek between Left Fork and Eldorado Creek, as has already been noted, is called Dome Creek. A short distance above Left Fork the largest nugget from the Iron Creek region was found, in 1904. It was a mass of gold with very little quartz attached, on the whole rather well rounded and weighing somewhat over 30 ounces. It was estimated that the gold contained in it was worth about $600. The gravel in which this nugget was found appears to be similar to that which predominates along Dome Creek. It is between 100 and 200 feet wide and from 3 to 5 feet thick. Steep slopes characterize the valley walls.

Work has been done on all the claims on Dome Creek and the returns have been satisfactory. This part of the stream was first worked in 1900 with rockers and every season since has seen some gold won from the gravels. When the region was visited in 1906[a] it was noted that "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 owners, however, are still able to rework the gravels at a profit, and this is practically the only part of Iron Creek where present stream gravels were actively mined during the season of 1908. At this place the stream flows through a rather narrow canyon with only a small strip of flood plain on the south side. The pay streak is from 25 to 30 feet wide and from 18 inches to 2 feet thick. This thickness includes 6 to 12 inches of bed rock which is taken up and cleaned. The overburden is stripped off by horse scrapers and the pay gravels are shoveled into the boxes. Numerous large bowlders of greenish schist and calcareous schist, which have probably fallen from the steep canyon walls, are found in the gravels and are troublesome for the miners to remove. Some of the talus from the walls lies on the creek gravels, and it is proposed to tunnel under it. Farther up Dome Creek the ground has been worked by open cut. The bed rock here is schist, similar to that occurring on the claims below. Large greenstone bowlders, which have probably

[a] Smith, P. S., Geology and mineral resources of Iron Creek: Bull. U. S. Geol. Survey No. 314, 1907, p. 162.

been derived from the high greenstone knobs south of Dome and Telegram creeks, are abundant.

The gold from Dome Creek occurs chiefly in the crevices of the bed rock. This condition is probably explained by the fact that in the earlier working of the creek, owing to the high cost of all essentials, the bed rock was not thoroughly cleaned, so that the values which were not recovered would naturally remain in the places most difficult of access. As a rule the gold is coarse and very dark colored. Some of the particles are so heavily iron stained that save for their weight they might easily escape detection. The dark color is almost invariably due to limonite. When a nugget of the dark gold is broken it is found that the limonite forms not merely a superficial coating but occurs in small particles throughout the nugget, with the gold in filaments. The gold thus forms a spongy mass with the oxide of iron in the interstices. It is believed that the limonite is derived from the decomposition of iron pyrites. If this is the case, the gold may have been deposited in the vein from which the placer was derived between the crystals of pyrite or as a mechanical mixture with the sulphide. Of these two explanations the former is believed to be the more reasonable. The gold from Dome Creek is worth from $18.25 to $18.45 an ounce.

In the concentrates garnet, or "ruby," as it is popularly called by the miners, is the most common mineral. With the garnet is a good deal of magnetite, usually in small grains. Ilmenite is also abundant, but the proportion between it and magnetite is apparently not as great as in the creek gravels near the mouth of Discovery Creek. Cinnabar, the sulphide of mercury, was reported by the owner of the claim to have been recognized in the concentrates from Dome Creek. None of the material was seen by members of the Survey, but there is slight reason to question the identification. Unfortunately, however, it is not known whether this mineral was derived from the Iron Creek basin or from a foreign drainage basin. The claims on which it was found have probably derived some of their gravel from the bench deposit into which the stream has cut, and as the level of the bench is not too high to have marked the 800-foot level already referred to, the possibility of a foreign origin is not precluded. The suggestion of a foreign origin is made because, so far as known, cinnabar is generally connected with intrusions of granite or with hot springs, conditions neither of which is fulfilled in the Iron Creek region, though they exist to the north, in the Kigluaik Mountains. The character of the gravels, however, does not suggest a foreign origin.

Above Eldorado Creek, on the portion of the main stream called Telegram Creek, only a little work was done during 1908, and the entire production probably amounted to only a few hundred dollars.

Several years ago, however, good values were obtained from some of the gravels, and it was currently reported that nuggets worth even as much as $100 each had been found in the upper part of Telegram Creek. The inadequate supply of water in the stream itself and the great expense necessary to bring water to such an elevation will hold back the development of this part of the basin. The gold that has been found is coarse but is not so heavily impregnated with iron as that lower down on Dome Creek. The lack of heavy limonite stain is probably due to the fact that the gold from this part of the creek either did not originate close to the contact of the black quartzitic slate or else has traveled somewhat farther from its source than the Dome Creek gold. Near the mouth of Ready Bullion Creek, however, where the bed rock is similar to that on Dome Creek, the gold has the heavy iron-impregnated spongy character noted on that stream.

The tributaries of Iron Creek, save in the upper part of the basin, have yielded but little gold. Such a condition is believed to be due more to inadequate prospecting than to the absence of profitable placers. Random samples taken on many of the streams show gold in sufficient amounts to warrant further prospecting, and it is believed that in the course of a few years many more camps will be established, and the existing camps will be worked on a much more extensive scale.

In the lower part of the Iron Creek basin the first tributary on which any mining work has been done is Barney Creek, which heads in Matthews Gap. No considerable production is reported from this creek. The common trouble of getting water at a sufficient elevation to handle the gravels is one of the most serious difficulties. The gravel from this creek shows a great number of fragments from foreign drainage basins. Garnets predominate in the concentrates to such an extent that the color of the gravel is distinctly reddish. Magnetite forms a much greater percentage of the iron mineral present than in the Iron Creek gravels, where ilmenite is much more abundant than the magnetic iron. The gold is chiefly in small flakes, not well rounded or smoothed, but as a rule not occurring in nuggets. The bed rock in the upper part of the creek lies at an unknown depth, but in places it is undoubtedly overlain by a thick cover of gravels.

Bobs Creek is the next stream above Barney Creek that enters Iron Creek from the west. The gravels are similar to those occurring on Barney Creek and like them have not been much developed. It is probable that with the completion of the ditch that has been in process of construction for the past two or three years some gold may be gained from this creek. All of the ground is frozen, and it is a very difficult problem to handle the gravels economically. The concentrates from this stream show a large amount of magnetite, with garnet as the most noticeable mineral. The gold is rather fine, although in no sense flour gold, and is invariably of a bright color. No productive work was done on this creek in 1908.

Easy Creek, which enters Iron Creek opposite Bobs Creek, is a small stream heading in the limestone ridge between Iron and Sherrette creeks. A camp was established near the mouth of this stream during the summer of 1908. Unfortunately, the operators were delayed in opening work until the middle of July. Mining at this place showed deposits of many different types, for in the course of development an old channel with a course approximately parallel to the present Iron Creek was discovered. After this old channel had been exploited for some time, work was transferred to a creek claim nearer the mouth of Iron Creek in order that the old channel deposit might be more effectively explored before actual mining work was commenced. Mining ceased before the end of September, so that owing to the late opening and the early closing, together with the time required for preliminary work, the season was not profitable. The owners are particularly fortunate in controlling a large spring, which affords probably 100 inches of water throughout the season. In addition to this supply, a ditch which taps Iron Creek above Sidney Creek gives an additional amount of water. Exploration is to be continued during the winter, and it is expected that with the information gained renewed activity will be shown in mining during the coming season.

Easy Creek has been worked in the past by different small outfits, and the gravels are reported to carry sufficient values to be worked at a slight profit even by pick and shovel methods. If this is true there seems to be no reason why a well-managed company with adequate water supply should not be able to develop a good paying placer. The Easy Creek gravels are not distinctly different from those of the other small streams in the immediate neighborhood. The bed rock consists of a dark, nearly black limestone and interlaminated schists in the lower part of the basin, with more limestone farther upstream, then more schists, and finally the heavy limestone that forms the divide. The dark limestone, which is much shattered, contains numerous veins, some of which are considerably mineralized with sulphides. Sulphides are also common in the concentrates, and it seems probable that a considerable part of the contents of the placer has been derived from very near by sources. Assays of some of the sulphides from Easy Creek show a gold tenor of a few cents to the ton.

Benson Creek is a tributary of Iron Creek entering from the east about half a mile above Easy Creek. The geology of the bed rock of this creek is complex, a series of limestones near the mouth being succeeded upstream by feldspathic schists, which in turn are succeeded by limestones. Gold placers on this stream have been worked more or less continuously since 1900. The various camps, however, have been worked on a small scale, and the production has hardly ever been more than enough to pay wages and leave a small margin of profit. Heavy bowlders, many of them from a foreign drainage basin, are found in the gravels and have to be rolled out of the way by undermining. The gold occurs usually in small grains of a bright color, though small nuggets are by no means uncommon. From the concentrates obtained on this creek it was seen that little of the gold was in thin plates or scales, but that even the smaller particles had subequal dimensions. The gold does not appear to have been worn smooth, but the thin edges of many pieces are bent back so as to form a ball. It seems certain that most of the gold has not traveled far from the place where it was formed. The placer contains a small amount of gold which is somewhat smoothed, and it is believed that this gold has been reconcentrated from the bench gravels through which the stream has cut its course.

Although Benson Creek, or Lulu Creek, as it is sometimes called, undoubtedly has good placer ground, the difficulty of obtaining water under sufficient head is sure to have a deterrent effect on its development. The creek itself has so little water that a supply must be sought from some outside area. None of the branches of Iron Creek from the east carry enough water to warrant ditch building, and the gradient of Iron Creek is so low that it would require a long ditch to tap it far enough upstream to give a good head. Besides this difficulty, the steep canyon walls would require a large amount of rock work and would necessitate so large an investment that it is a question whether the returns would be adequate.

On Hilliard, Sidney, Rocky, and Rabbit creeks, small tributaries entering the main stream below Canyon Creek, the ground has been staked and some work has been done. On the whole, however, none of these streams have yielded valuable placer deposits, although the geologic formation of some, as for instance Hilliard Creek, is similar to that in the vicinity of many of the productive placers. Concentrates from Rabbit Creek show characters very similar to those of the concentrates from Benson Creek, but the gold is finer and as a rule more flaky. Colors of gold, however, are abundant and all that were seen were bright.

Canyon Creek is the longest tributary of Iron Creek. It enters from the southwest near the abrupt bend in the main stream. For most of its distance it flows through a valley formed of feldspathic and chloritic schists, which do not seem to be favorable rocks for the formation of gold placers. Four miles above its mouth, however, the black quartzitic slates and limestones, near which the productive placers are usually found, form the country rock and the indications for placer deposits are good. Unfortunately no workable deposits have been found here, but this is to be explained in part by the lack of assiduous search. A small tributary which enters the main stream near this point has been productive, although no mining was done on it during the past summer. In fact, in the entire Canyon Creek basin no mining was done in 1908 except on El Patron, one of the small tributaries, where a single miner, much hampered by lack of water, has taken out little more than a "grubstake." The placer on El Patron is located near the contact of a limestone with the schists and the conditions seem similar to those prevailing farther up on Canyon Creek, already described. The gold from El Patron is coarse, slightly rounded, and as a rule of a bright color. Magnetite and ilmenite, with a rather smaller amount of garnet than is usual in the gravels of the Iron Creek basin, are present in the concentrates.

No work has been done in recent years on Discovery Creek, the next tributary of Iron Creek above Canyon Creek, save near the mouth. The character of the gravels is similar to that of Iron Creek gravels near this point (see p. 324) and both undoubtedly carry some gold. The bed rock at the mouth of the creek is the black slate that is closely associated with the limestone which occurs between Canyon and Discovery creeks. To judge from the character of the country rock, the probability of finding workable placers on this stream below the headward portion is not good. Near the upper part of the basin the stream cuts a series of limestones and placers might be expected, but in the middle portion of the basin feldspathic schists abound, and it is believed from experience in other districts that this is not a rock from which placer gold is usually derived. Small placer deposits have been reported on some of the eastern tributaries of Discovery Creek, but none of them are being worked and it is not believed that they will prove important.

Left Fork joins Iron Creek about a mile upstream from Discovery Creek. The bed rock consists of rather heavy limestones and schists, three limestones being separated from one another by schist bands. The creek in the lower part flows in a narrow rock-walled canyon, and where the bed rock is limestone the water disappears, to be carried by underground channels. Good placer ground has been found in the lower part of the valley, where the broken and shattered condition of the limestone has afforded natural riffles for the lodgment of the gold. At the present time, however, the ground on Left Fork has been mainly mined out and the only values that remain are those that have been lost by the earlier miners. It is so difficult to clean a hard limestone bed rock thoroughly that probably sufficient values remain to warrant reworking the ground. Such reworking, however, will not be attempted until some of the other more favorable spots have been exhausted. The pay streak was found to be rather irregular and to swing from one side to the other. No accurate estimate of the production from this creek has been made, but probably $20,000 has been taken from it. No mining was in progress in 1908.

Above Left Fork is Hard Luck Creek, which, with its tributary, Hobo Gulch, heads in the limestone ridge between the American and Iron Creek drainage areas. The basin of this stream is bounded by rock scarps and appears to be the remnant of an older drainage channel that has been dammed by talus, behind which alluvium has been deposited. This basin lies at an elevation of about 100 feet above Iron Creek. Angular black slate, with some quartz and greenstone bowlders, forms the placers in which the values occur. A number of the greenstone bowlders are as much as 18 inches in diameter, and some of the fragments are well rounded. Near the head of the basin, however, the greenstone is more angular and shows less water rounding. The angular gravel is about 2 feet thick. In parts of the basin the gold-bearing gravel rests directly upon bed rock, but in other places a thin layer of clay serves as the surface on which the placer was deposited. The floor of the deposits is irregular. Coarse gold is characteristic of this placer. It is usually of a bright color and the grains are well rounded.

On Eldorado Creek, which joins the main stream near the mouth of Hard Luck Creek, no profitable placers have been developed. The valley of this stream lies almost entirely within the area of feldspathic schists and greenstones, which, as already noted, are not the rocks from which placer gold is usually derived in this region. Near the mouth, however, the bed rock consists of the limestones, which seem to be more commonly associated with placer deposits. None of the small tributaries of this stream have yielded any promising placers. A little work has been done on Independence Creek, the branch heading in the low saddle leading to the head of Discovery Creek. The developments at this place, however, are not sufficiently satisfactory to warrant the continuation of the work.

Above Eldorado Creek a number of small tributaries join Telegram Creek. These are Shoal, Penny, Adventuress, and Oversight creeks, entering the main stream from the east, and Ready Bullion and Dividend creeks, coming in from the west. On all these creeks placer ground that is economically profitable has been discovered, and a good deal of work has been done on them in the past. The gravels are shallow and are more or less rapidly worked out. The country rock is similar to that occurring in the productive portion of Dome Creek and is the direct continuation of it. Coarse gold is common and many of the nuggets are of good size. During the past season practically no work was done on any of these deposits, although the ground is staked and the annual assessment work is being kept up.

Sherrette Creek is a tributary of the Kruzgamepa. The upper part of the valley lies in the high limestone ridge to the east of Iron

Creek, and in its lower course the stream flows in a valley but slightly intrenched below the gravel plain that forms the divide in places between the Kruzgamepa and Niukluk basins. Bed rock is exposed everywhere in its upper portion, but in the gravel-plain part of its course the stream has not cut down to bed rock but flows on the gravels. No placer mining has been done on the upper part of the creek, but in the lower mapped portion there has been some prospecting of the stream gravels. In 1908 one camp was established near the point where the trail leading from Sowik to American Creek crosses Sherrette Creek. Work at this place has been carried on mainly with the idea of testing the deep gravels of the gravel-plain deposit, but a little work has also been done in the present stream gravels. The results so far are meager. The creek developments, however, are very interesting, for gold-bearing gravels occur here intimately associated with bowlders of large size and angular outline, which must have come from a foreign drainage basin. The whole floor of the creek is covered with blocks of granite up to several tons in weight which could have been derived only from the Bendeleben or Kigluaik mountains. Indiscriminately mixed with these rocks are fragments that have clearly been brought from the head of the Sherrette basin. Gold is not known to occur in the Kigluaik and Bendeleben rocks, so the placer most probably owes its valuable mineral content to the near-by schists and limestones.

The auriferous material of this placer rests in some places upon thin clay layers in the midst of the re-sorted gravels, but in other places the gold is found throughout the gravel without the presence of any impervious layer on which concentration has been effected. Needless to say, those places where clay layers have served as floors for the concentration of the heavy particles afford the best returns.

All of the gold that was seen was in small particles worth from a tenth to three-quarters of a cent each. No flour gold was noted; all the pieces were easily distinguished by careful inspection with the unaided eye and further study with a lens failed to reveal any pieces that had not been previously recognized. In form the gold is in somewhat flattened flakes, but some of the larger pieces have a spongy appearance. Few of the grains are smooth or well worn. A bright color is common, and no rusty or discolored pieces were noted.

Among the concentrates very little garnet was found, which was rather remarkable, for ordinarily this mineral is abundant. Magnetite and ilmenite are present in about equal proportions. Sulphides of iron and copper were also recognized. The owners of the ground report finding fragments of copper ore in the sluice boxes. These fragments were undoubtedly derived from the upper part of the basin, where copper sulphides are known to occur in place in the limestone-schist series. The copper minerals found in the gravels are usually the carbonates, although some copper sulphide may be found where oxidation and weathering have not proceeded too far. The presence of the copper ores is one of the most definite proofs of the local origin of some of the material of which the placer is composed.

AMERICAN CREEK.

Heading between Iron Creek on the west and the tributaries of the Casadepaga on the south and east, American Creek flows northward, then makes an abrupt bend to the east, and finally joins Niukluk River a short distance upstream from the mouth of the Casadepaga. That this has not always been the course of the stream is shown by the continuation of the northward trend of the valley near the big bend by a channel only 50 to 70 feet above the present stream. This feature would afford material for an interesting physiographic study, but a discussion of it has no place here, for the placers that have been worked are all above this point. All of the headward portion of this stream is in the hilly country where outcrops abound, but the influence of the conditions which helped to produce the gravel plain is to be noted even in this part of the basin. It is well shown by the presence of waterworn gravels and angular fragments derived from foreign drainage basins up to an elevation of 800 feet, or well above the junction of Auburn Ravine and American Creek, or even above the junction of Auburn and Wade creeks and of Nugget and American creeks.

During the past summer the only mining done in this basin was on Auburn Ravine, but the abandoned camps seen on many of the other tributaries show that the ground has been more or less thoroughly prospected, and the numerous claim stakes indicate that even now almost all the available ground is held. Owing to the absence of prospectors practically no data were procured concerning past work. The headward portion of American Creek lies in a region of limestone and schists which in places are much dislocated. None of the black quartzitic slate is found in this part of the valley. Greenstones are rather uncommon. Some work of a prospecting type has been done on Last Chance Creek and also on Nugget Creek and its tributaries.

Auburn Ravine is one of the largest tributaries of American Creek. It enters that stream a short distance above the big bend. It heads in the low saddle that leads to a tributary of Canyon Creek, which in turn flows into the Casadepaga. The bed rock of the east side of the valley and of a large part of the creek is limestone; the western divide is formed for the most part of schists, both chloritic and feldspathic. Owing to the presence of limestone as the bed rock, most of the water escapes by underground channels, and the creek bed is perfectly dry except for a short time immediately after a heavy rain.

When this creek was visited in 1908 there was not even enough water in the bed of the stream to furnish a supply for cooking, and it was necessary to carry water from those places where the small side streams flowing on schist still afforded a little run-off. It is evident that under such conditions the difficulties in the way of economically handling placer gravels are almost too great to be overcome. At one of the claims a short distance below Jack Wade Creek, which was visited about the 1st of September, only enough water could be collected in an hour by damming the side streams to allow from five to ten minutes' sluicing. While the owners were waiting for enough water to collect, the larger bowlders were picked out and everything was done to utilize to the best advantage every second that the water was flowing in the boxes.

Fortunately, however, the gravels of Auburn Ravine all the way from the mouth up to August Gulch, the small headwater stream coming in from the west, carry gold. Two outfits were mining the creek during 1908—one located a short distance above Jack Wade Creek and the other about the same distance below. Work on the upper claim has been carried on for three years. The gold is all coarse, no fine flour gold being found. Whether this condition is due to the absence of fine gold or whether the fine particles are lost in sluicing is not known, but it is certain that the percentage of small nuggets found is very large. A nugget worth $11 was the largest piece found on this ground. It was of a dark color, but most of the gold from this claim is bright and exceptionally pure. Assays made by one of the banks at Nome showed the gold to be worth $19.53 an ounce.

No true bed rock is found in the creek, but instead the auriferous gravels rest upon thin clay layers, which serve as local floors on which concentration has been effected. As a rule, the clay layers have a dip toward the east, and it is believed by the miners that there may be an older, deeper channel to the east of the present stream. The indications, however, are not sufficiently conclusive to warrant such a determination. The gravels of the present creek bed consist of large angular blocks of limestone that have evidently been derived from the steep hills to the east. All these fragments are much corroded and the presence of solution lines shows that a large part of the angularity is due to chemical erosion. In one place there is a bed of clean, well-washed sand that does not look like ordinary river sand, but its origin is in doubt. Where this sand was encountered it was at least 10 feet thick, but as it seems to be missing in several of the near-by holes its areal extent can not be very great.

Samples of the concentrates from this claim proved to be very interesting and in a measure unique. Garnet, as is usual, is one of the most common minerals. With it are magnetite and ilmenite in about equal amounts. Much of the ilmenite occurs in particles up to half an inch in length. These two iron minerals have undoubtedly been derived from the greenstones and feldspathic schists that form the high hill between the heads of American and Auburn creeks. Most interesting, however, was the verification of the report of the miners that cinnabar, the sulphide of mercury, was occasionally found in the gravels. Of this statement there can be no doubt, for careful study of samples in the laboratory has determined the mineral as cinnabar. In view of this determination the statement that cinnabar is also found on Dome Creek, in the Iron Creek basin, seems entirely probable.

On the claim below Jack Wade Creek practically the same conditions are found as those already described. Work at this place, however, has not been carried on for so long a time, and consequently less of the ground has been explored. The bed of sand and gravel already mentioned is here seen to lie definitely below the present stream gravels. The material is almost clear sand, with here and there narrow layers of small pebbles. At the base of the section in the prospect pit angular, partly dissolved fragments of limestone are common. The pit at this point was about 12 feet deep. Attempts to sink it deeper were prevented by the caving of the walls, so that bed rock was not reached. From the character of the lower part of the gravels it seems probable that true bed rock would be encountered within a short distance. The owners, however, are intending to test the gravels with a drill, as they believe the depth to bed rock will be very great.

PORTIONS OF THE CASADEPAGA DRAINAGE BASIN.

The portions of the Casadepaga drainage basin that lie within the area mapped on Plate X are the main stream, from its head to Curtis Creek; Lower Willow Creek, from its head to Cahill Creek; and Canyon Creek, from its head to Connecticut Creek. Although these streams cover so large a territory, there are very few productive placer mines on them, and the places where gold-bearing gravels have been found or are likely to be found are confined within a comparatively small area. In the entire Casadepaga basin north of the main stream, from the head to a point below Curtis Creek, no mining was in progress during the season of 1908. Almost the whole of this area lies in a belt of greenstones and feldspathic schists, and the probability of finding placers of economic importance does not seem good. In the past a few placer miners have worked at different parts of the basin, but the early abandonment of the claims points strongly to the conclusion that the results of the prospecting were not satisfactory.

Lower Willow Creek, or, as it was formerly called, Left Fork, is a stream about 8 miles long, heading in the Iron Creek divide and flowing southward and then eastward to join the Casadepaga. In its headward portion it flows parallel to the dominant structure of the region, but where its trend is easterly it cuts across the structure, so that different kinds of rocks are exposed in different parts of its course. In 1900 Brooks reported that there was no mining on the main stream and only one of the small tributaries had been developed. Soon after that time, however, prospectors found good values in the creek gravels and in the adjacent benches, and mining work was pressed with some energy. Gold was discovered in Lower Willow Creek near the mouth of Green Gulch. Lower Willow Creek was not visited by any of the Survey geologists from 1900 to 1906, so that details as to its development during that period are practically lacking. The visit in 1906 was so near the freeze-up that most of the miners had closed down for the season. It was evident, however, that only a few outfits had been busy and that they consisted of only two or three men each.

In 1907 mining on Lower Willow Creek was more or less inactive. From a point a short distance below Cahill Creek to a point within a mile or so of the head of the stream, the ground has been pretty thoroughly prospected and some gold found. The gold from this part of the creek shows two entirely distinct phases; in one the gold is fine and in small bright flakes; in the other nuggets of coarse gold are common. It is reported that the nuggets are worth from $1.50 to $2.50 each. Both kinds of gold are found in the same pay streak. Although prospectors have proved the presence of auriferous gravels in many places along the creek, there was practically no production during 1907. In 1908 two outfits were at work on the upper part of Lower Willow Creek, one near the big bend and the other a mile or so farther upstream. Mining was not actively conducted, however, and the production of the entire creek did not amount to more than a few hundred dollars. The similarity of the bed rock to that of the productive portion of Dome Creek indicates a similar origin for the gold in the two places.

Of the tributaries of Lower Willow Creek, none were productive during last year, although several have yielded fair returns in the past. In the early days of mining in this basin a good deal of gold was found on Wilson Creek, which flows near the contact of the heavy limestone and the schists. Placers on this stream have, however, been nearly exhausted, and no work has been done for several years. Benches at a low elevation are present along Wilson Creek, and it seems probable that the pay streak is due in a measure to the reconcentration of the higher-level gravel deposits by the present stream. Not only is this true of Wilson Creek, but also of Cahill Creek and several of the other small streams tributary to Willow Creek.

Canyon Creek is the next downstream tributary of the Casadepaga that heads within the Iron Creek region. Mining is being done on the lower portion of this stream, but none within the area mapped. Prospects of gold have been found on many of the side streams and on the main stream, but the returns have not been sufficient to encourage development. On Allgold Creek, the small branch which heads in the low saddle leading to Auburn Ravine, a good many prospect pits have been dug. Colors of gold are almost universally present, but no heavy pieces of gold, such as characterize the Auburn Ravine valley, have been discovered. The valley of this creek is cut mainly on the feldspathic schists, and is therefore a rather unpromising location for productive placers. Some prospecting has also been done on the small stream that heads against the divide of American Creek, but work on this stream has long been abandoned. The small stream that heads in the low pass to Iron Creek cuts a series of heavy limestones, but its grade is so steep that it seldom carries water for more than a few days after a heavy rain, and it has not been prospected. Active water sorting has not allowed much concentration of the gravels, and it is doubtful whether profitable placer ground will be discovered.

ELDORADO RIVER AND TRIBUTARIES.

Only the headward portion of Eldorado River is included within the area mapped as the Iron Creek region. It is not an important producer of placer gold, and although in the past many of the small tributary streams have yielded a little gold, none of them have been profitably exploited except perhaps Venetia Creek, which rises in the divide at the head of Discovery Creek. This valley was prospected in 1900 by the gold seekers who, on finding the country near Nome staked, were forced to seek elsewhere for unoccupied ground. Since that time attempts have been made to develop certain claims, but the results have generally been unsatisfactory. Even in 1903 Collier noted that practically no part of the region was being worked except Venetia Creek. In 1906, when the region was visited by Moffit and Smith, no work was in progress. During 1908 the valley was not studied in detail, but it was learned that there were no camps on the entire upper part of the stream.

As Venetia Creek has not been mined in recent years, it is perhaps appropriate to abstract the main points concerning the geology and mineral resources of this stream from the report of Collier,[a] who saw

[a] Collier, A. J., and others, Gold placers of parts of Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 328, 1908, pp. 221-222.

the creek when mining was most vigorously in progress. He states that gold was discovered on this creek in 1900, but that up to 1903 the production from the entire creek was probably only about $6,000. The lower portion of Venetia Creek is a sharply cut, narrow gorge with steep walls, which rise to elevations of about 100 feet above the stream. Farther upstream the gorge character disappears and the flood plain widens to 100 yards. The bed rock is limestone and calcareous and chloritic schists, which have very variable strikes and dips. Numerous small veins of quartz are universally present. Greenstone is also found in the float and forms intrusive sills and dikes cutting the other rocks.

Placers are not found in the canyon portion of the stream, but exist in those places where there are broad flood plains 3 or 4 miles above the mouth. All the deposits that have been mined are of the present creek gravel type, although terraces which give promise of yielding returns lie along the valley slopes. A large part of the gold is found in the crevices of the bed rock, and in many places it is necessary to clean the bed rock to a depth of 3 or 4 feet. In the lower claims the gravels and overburden have a thickness of 5 or 6 feet, but in the upper portion of the valley they are much thinner. Although the flood plain is locally 100 feet or more in width, the pay streak is usually narrow. In some places the auriferous part is only 10 feet wide, and as a rule it is not over 50 feet.

Mining has been done only by shoveling into sluice boxes. To make the productive ground available, the stream has been turned aside by wing dams and the water carried away by a ditch. Water for sluicing has been derived from Venetia Creek itself. Collier notes that the ditches are particularly well built and are practically sod flumes. Even during a dry season, such as that of 1908, there seems to be sufficient water in this stream to supply the needs of placer miners who use the water only for washing the gravels in sluice boxes. The gold that has been won from Venetia Creek is mostly fine, although nuggets worth several dollars each have been found. In general the gold is bright and, according to Collier, is characterized by flat pieces shaped like pumpkin seeds. Its assay value is said to be very high, $19.40 an ounce being reported. If these figures are correct, the Venetia Creek gold is one of the purest that is found on the entire peninsula. According to current report, the present creek gravels of the stream are exhausted, but the difficulty of thoroughly cleaning bed rock probably prevented complete recovery of the values, so that it would not be surprising if with a reduction of the cost of labor and supplies some of the ground were reworked.

BENCH PLACERS.

The placers occurring in bench deposits include the bench stream placers and the bench gravel-plain placers. As shown in the foregoing account, there are but few claims actively operated on the present creek gravels, where concentration should probably give the most profitable and most easily worked placers, and it follows that few of the bench deposits have been developed. Although benches that may afford placer ground of economic importance are known on almost every stream, the cost of obtaining water at a sufficient elevation above the streams has prevented developments of note. This condition is, of course, inevitable in the early days of a camp, for the high cost of supplies, the necessity of proving the ground to be actually auriferous, and the greater engineering requirements would induce the miners to develop the creek gravels first. Sooner or later, however, if the camp succeeds and the creek gravels approach exhaustion, attention is sure to be turned to the benches. It is believed that when such a stage is reached in the Iron Creek region placer reserves containing large amounts of low-grade ground will be found, and their exploitation will prolong mining activities for a considerable period.

From a general study of the benches that have resulted from the action of former creeks at a higher level, there seems no good reason for doubting that the gravels of the benches are identical in origin with the present creek gravels. If this is the case it necessarily follows that the bench gravels must in many places be auriferous. Although it is possible that some of the bench deposits may be as rich or even richer than the stream placers, it is safe to assume that, as a rule, they are not so well concentrated. Such an assumption is supported by the fact that in many places the gravels of the present streams are reconcentrated gravels derived from bench deposits. At such places the additional sorting of the gravels has generally resulted in the concentration of the heavier minerals.

Outside of the Iron Creek basin itself no bench placers are being operated, and even within this basin there are only one or two that are worthy of note. It must be remembered, however, that there are many bench deposits which only await exploration to become productive. Practically no stream in the entire Iron Creek region, a part of whose valley lies below an elevation of 900 feet, does not show terraces on its valley slopes.. Many of these terraces have been formed by streams, and it seems probable that there is a larger gold reserve in these benches than in any other part of the region.

Some prospecting on the lower part of Iron Creek has shown that it is almost impossible to take a pan of gravel from the benches on either side of the stream without getting colors. This gravel, although undoubtedly modified by stream action, belongs typically to the gravel-plain deposit. The gold that it contains is probably derived from the quartz stringers and veins which are common near the limestone-schist contact, but so much of the material has been transported for long distances that any definite statement as to its origin is impossible. It is, however, probable that this material has not been derived from the rocks which form the Kigluaik or Bendeleben mountains.

In developing some of the creek gravels on Easy Creek (see p. 328) the miners uncovered an ancient channel in the bench deposits, which seemed to have been formed by a stream that was parallel to Iron Creek rather than to Easy Creek. The bottom of this channel has not been reached except on the western rim. Figure 20 shows in a diagrammatic manner the main features at this place. A good section is afforded by a bed-rock drain which has been driven to carry off the seepage water. Sluice boxes were erected and the gravel was shoveled in until a point was reached where the steep

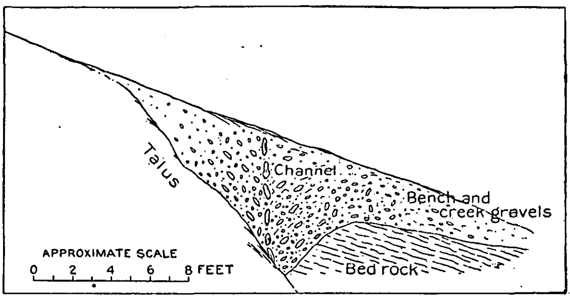

FIGURE 20.—Cross section on Easy Creek, in Iron Creek region.

slope of the bed rock prevented draining the gravel. It was then decided to abandon the pit until after the freeze-up, when the ground could be exploited by sinking a shaft. In this way the tenor of the gravels could be determined and the depth to the lowest part of the channel ascertained, without having to install pumping apparatus. As the channel is approached from the west, the floor of the cut exposes bed rock with a surface slope toward the west at a gentle angle. Overlying the bed rock is a thin layer of waterworn gravels, which are covered by the muck and moss that form the surface. This bench gravel has a slight dip to the west, but is essentially flat. Farther east the bed-rock floor abruptly changes its slope and descends rather steeply toward the east. Gravels of a variety of different kinds of rocks appear and increase rapidly in thickness. The bedding of these gravels seems to dip rather steeply more or less parallel with the slope of the channel rim and to strike approximately north and south. About 10 paces from the beginning of the descent of the bed rock toward the east there is a bed of pebbles which stands practically vertical. It was believed at first that this bed might represent the line occupied by the stream as the old channel was aggraded. Under this interpretation, however, the bowlders that mark the course of the stream should have their longest axes parallel to the direction of stream flow and their shortest axes vertical, whereas, in fact, their longest axes are vertical and their shortest axes horizontal. No suitable explanation of this phenomenon is suggested, for the preservation of bedding in this unconsolidated gravel shows that there can have been no deformation. The structure is evidently one of original stream deposition, but how it was produced has not been solved. Beyond this vertical layer there are indications that the gravel has a strong dip toward the west. This portion of the section, however, is badly masked by the accumulation of talus and slide which has fallen down where the gravels have been undermined. All of the gravel in the old channel is well waterworn, and there is no evidence of glacial action on any of the fragments. Near bed rock there are many slabby angular pieces that seem to have been broken from the surface of the rock but not to have undergone any transportation. As far as the explorations have gone, the gravels of the channel seem to be but slightly auriferous. It should be realized, however, that the greatest amount of concentration would not have occurred in the part of the channel exposed by the present workings, but in the lower part, which is still hidden.

Another interesting bench deposit has been discovered on the southern rim of Dome Creek near Chickamin Gulch, which enters the main stream from the south between Hard Luck Creek and Left Fork. This gulch scarcely forms a notch in the canyon walls of Dome Creek. A cross section near the gulch shows the main stream flowing on a small flood plain about 25 feet wide. Farther south a little talus forms an irregular deposit at the foot of an abrupt canyon wall. The cliff face is about 75 feet high and is formed all the way of rather massive limestone, dipping southwest. At an elevation of about 90 feet the cliff ceases and the surface rises gently southward, the slope steepening at a considerable distance from the stream as the ridge is approached. The gravels are found from the end of the limestone cliff for a distance of 150 paces southward, sloping gently away from Dome Creek. A little exploration has been done near the edge of the cliff, and the excavations afford a few fairly good sections. At this place the gravels are from 3 to 6 feet thick. They consist largely of fine sands with a few pebbles near the base and more angular material near the top. It is believed that the angular fragments are slide or talus that has been derived from the high greenstone hill between Eldorado and Discovery creeks. The surface of the bed rock on which the bench gravels rest is deeply corroded and everywhere shows the dissolving effect of chemical agencies. Into the irregular channels dissolved out of the limestone the sand and gravel have penetrated at many places for considerable distances. No accurate determination of the elevation of this locality has been made, but from aneroid readings it is probably about 800 feet above the sea. It has been stated that the elevation to which rocks from a foreign drainage basin were found along the south side of the Kruzgamepa Valley was about 800 feet. From the similarity of the two elevations it is suggested that the deposit noted on Chickamin Gulch may have been laid down as a result of the obstruction that formed this pronounced level elsewhere in the region. This suggestion is to be regarded only as a working hypothesis, for the data on which it is based are meager. The presence of the peculiar sand, which does not look like that formed by a small stream, is practically the only point, except the perhaps fortuitous similarity of elevation, which requires such an explanation. The occurrence of a similar sand in Auburn Ravine at nearly the same elevation, however, might be considered as throwing some light on this problem. Briefly stated, the suggestion which is made is that small lakes were formed near the heads of many of the northward flowing streams at an elevation of about 800 feet, on account of a barrier, such as ice, in the Kruzgamepa Valley, which formerly obstructed the normal drainage and has subsequently disappeared.

Prospecting on Chickamin Gulch has not been carried on to a sufficient extent to show more than the fact that these sands and gravels are auriferous. The gold is bright, no rusty pieces having so far been found. Only fine gold has been obtained, but as prospecting has not gone very far it is not at all improbable that coarser pieces may occur and will be recovered when active mining work is commenced. The few concentrates saved in the pan tests show the same heavy minerals as those noted in the present creek gravels. It will be a rather difficult problem to handle these bench gravels economically, as the amount of water available is small and the ground is unsuitable for ditch construction. If, however, the water right on Eldorado Creek from which the ditch previously noted takes its water could be obtained at a low price, a satisfactory solution of this problem would be effected.

LODE PROSPECTS.

As yet no lode mines have been discovered within the Iron Creek region. Search for lodes has been carried on in a more or less desultory way, but it has been hampered by the lack of capital and by the fact that many of the prospectors are holding more ground than can be exploited on the capital available.

In a summary of the recent lode developments in Seward Peninsula in 1907,[a] certain copper-bearing localities near Iron Creek were described as follows:

Between Iron Creek and the broad flat drained by tributaries of the Kruzgamepa and of the Niukluk there is a ridge of heavy white limestone underlain by chloritic and feldspathic schists. * * * The limestone would appear to be a continuation of the limestone * * * forming the western margin of the Solomon and Casadepaga quadrangles. In those areas the contact with the underlying schist seems to have been a zone of mineralization. In general, the mineralization is sparsely disseminated, but in places there are stringers of ore which tempt prospecting.

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

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

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

During 1908 no new developments were made on any of the prospects described above. A controversy arose as to the ownership of the ground, and while this gave an impetus to the accomplishment of the annual assessment work it hampered the actual exploration of the deposit. Claims have been staked all the way from the head of Penny Creek, a tributary of Telegram Creek, to a point north of the head of Easy Creek, but on most of them the indications are so trifling they have no economic value. The multitude of corner stakes and location notices gives a false impression of activity.

In the report just cited[b] a galena prospect near the mouth of Iron Creek, on the Kruzgamepa, was described as follows:

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[a] Smith, P. S., Investigation of the mineral deposits of Seward Peninsula: Bull. U. S. Geol. Survey No. 345, 1908, pp. 242-243.

[b] Smith, P. S., op. cit., pp. 246-247.

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

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

Exploration at this place was carried on during the season of 1908 only on the south side of the river, near the mouth of Iron Creek. A short adit was driven through the loose angular talus into the schists that occur east of the limestone. A heavy band of iron sulphide, in places 2 or 3 feet thick, was encountered. The pyrite was practically unmixed with other minerals. A sample assayed by Ledoux & Co. showed a small amount of gold. This ledge, aside from its gold content, contains no minerals of economic importance, but the occurrence seems to be significant as showing that considerable mineralization has taken place in this region. This lens is by far the most promising indication of mineralization in a workable vein which has been seen. As a rule the mineralization is so diffused that it is necessary to treat a large amount of country rock as well as the small ore stringers. Near the contact with the limestone the sulphides have replaced the country rock and a banded appearance has been produced. This is due to the greater permeability of the rock to the mineralizing solutions parallel to the lamination than in any other direction.

Sulphide mineralization, in the shattered limestone on Easy Creek, has already been noted. Here, however, the mineralization is so diffused that there is no probability of finding a vein which could be mined. Assays of some of the thicker sulphide stringers with very little of the country rock attached showed a slight gold value. Mention of this place is made not to suggest that a workable deposit may be found here, but to point out an example of a common type of mineralization near the limestone and schist contact. It is of particular interest as indicating one of the sources from which the gravel deposits received contributions of gold.

When the Iron Creek region was visited in 1900 a quartz vein was noted about 2 miles above the mouth of the creek. Some work had been done at this place, and it was reported that the vein had a tenor of $12 a ton in gold. A little desultory work has been done here at odd times for several years, but only the surface has been uncovered, and the indications are not very promising. The country rock is limestone, very much folded and shattered; a short distance downstream, underlying the limestone, is chloritic schist. The structure is synclinal. On the west side the dip is steep to the southwest, and on the south side the dip is nearly vertical, but slightly to the northeast. Sulphides are abundant, their distribution showing that the mineralization had taken place after the folding and fracturing of the rock. No well-defined leads were seen. This occurrence serves as another illustration of the rather diffused type of mineralization which is so commonly found associated with the contact of the limestone and schist throughout not only the Iron Creek region but also the rest of Seward Peninsula. No work was done on this claim in 1908, and it would appear that operations here have been abandoned.

Throughout the Iron Creek basin there are many sulphide-bearing veins which might warrant further prospecting, but so far as the conditions surrounding them are concerned they are similar to the types already described. In consequence, as they have not been prospected, it does not seem desirable to enumerate their positions on the different creeks. Suffice it to say that while evidence of widespread mineralization can be found almost everywhere east of Iron Creek, the mere fact that it is so widespread suggests that workable veins are few. The contact between the schists and the limestones is, in most places, a horizon of mineralization, but because this mineralization was diffused over so large a surface there has not been the concentration or localization which is essential for the production of a workable vein.

On some of the other tributaries of the Kruzgamepa conditions similar to those prevailing on Iron Creek and its branches have been observed, but to these places the same statement as to the improbability of finding workable lodes would apply. On Slate Creek, however, about a quarter of a mile above Rock Creek, mineralization of a different type was observed. A number of shallow pits have been put down, some inclined and some vertical, but after they have been sunk a few feet the difficulty of handling the surface water has compelled their abandonment. The country rock is a feldspathic schist and greenstone that appear to cut across the limestone, which forms the bed rock lower downstream. In the less sheared phase of the feldspathic schist or greenstone, sulphides in small particles are scattered throughout the rock and seen from their relationship to be original constituents. Some doubt of this conclusion is felt, however, for it is not proved that any unsheared rock exists within the area studied, and it is therefore entirely possible that the sulphides may have been introduced during the period of dynamic metamorphism. Under this hypothesis the sulphides were formed later than the inclosing rock. Whichever interpretation is correct, it is certainly true that throughout the region, where greenstones and the peculiar schists that are believed to be derived from rocks of igneous origin form large areas of the country rock, placers are absent. From this fact it would seem to follow that the absence of placers is due to the absence of mineral-bearing veins or other mineralization which could supply the valuable minerals. This conclusion seems to be supported by the field evidence, for veins are much less abundant in these areas than in those where numerous contacts of limestone and schist have afforded good places for deposition.

In amount the sulphides form but an insignificant portion of the rock. Assays made from selected specimens yield but a small gold value—so low that the rock could not be mined commercially under any conditions. Shearing planes are numerous throughout the exposures and have no pronounced trend, although the mean of a number of observations seems to be northeast and southwest. Owing to the number of planes of movement, the rock is considerably slickensided. This movement, however, does not seem to mark a considerable displacement along any one plane, but rather a series of small movements along a great number. At present it has been impossible to determine the sum of these movements. On many of the joint and shearing planes specular hematite, in bright and shining tabular crystals, has been developed.

In the American Creek drainage basin few veins were seen and no exploration had been undertaken. The difficulty of uncovering or tracing a vein is great, where the mantle of rock waste is as heavy as it is over much of this basin. If veins exist in this part of the region they will be located first on the ridges, and thence traced toward the moss and muck covered lowlands. The American Creek basin lies between two limestone ridges, at the border of which mineralization of the diffused type shown on Iron and Sherrette creeks is common. There are, however, not many distinct veins except the contorted and wrinkled quartz stringers and lenses occurring in the chloritic schists, exposures of which are few.

The part of the Casadepaga region that lies within the area mapped on Plate X has not been prospected for lodes to any great extent. Claims have been staked in many places along the southern continuation of the limestone belt to the east of Iron Creek, already described. Between the limestone and the schist there is a layer of rock, in places a foot or more in thickness, which looks like a silicified limestone. When this rock is studied under the microscope, it is seen to be composed almost entirely of quartz with no limestone or calcite. If, therefore, it has been formed through the replacement of the limestone by silica, the alteration has been so complete that not a vestige of the former condition is preserved. In the siliceous rock copper sulphides and carbonates appear here and there. The copper stains give the rock the appearance of containing a good deal of copper, but in reality the amount of this mineral is small and none of the pits visited showed any encouraging indications of workable lodes.

Near the eastern margin of the area mapped, north of Canyon Creek, numerous holes have been sunk at the lower contact of the limestone and the underlying schists. These holes have failed to uncover any promising leads, but seem instead to show the extreme complexity of the structure in the contact region. The mineral stains at this place also occur in a siliceous band from 1 to 2 feet thick that seems to be a limestone replaced by silica. The metallic minerals form but an insignificant portion of the rock, and there are no indications that profitable leads will be uncovered in the immediate vicinity of any of the prospect holes examined.

Near Whisky Creek, a tributary of the Casadepaga, a short distance above the big bend, a quartz vein, which is said to assay well, is reported. Work was done here two years ago, but evidently the returns were not satisfactory, for no further prospecting has been done. The prospect was not visited, but samples examined indicate that the vein consists of white, somewhat crushed quartz, with very little sulphide mineralization. It occurs in the schists, but is not very far from a limestone contact. This occurrence, however, does not seem to be at all similar to the diffused mineralization so common near this contact, but is in all probability a vein of rather recent date cutting across the schists. From the lithologic character of the vein filling, it does not look as if the vein could be worked under existing conditions. It should be noted, however, in connection with this class of veins, that the valuable mineral is usually in the form of native gold, and therefore even a fairly rich ore might escape detection unless assayed.

In concluding the portion of this report dealing with the lode developments, it may be well to state again that no leads have been discovered within the Iron Creek region which are more than prospects and that few of these prospects seem to hold out much inducement for further exploration. A few, however, are of sufficient promise to warrant the expenditure of a good deal of time and a little money in order to determine whether further outlay is justified. That there is probability of lodes being found can hardly be doubted, for the presence in the placers of large nuggets with quartz attached strongly indicates that they have been derived from quartz veins, and it is entirely inconceivable that all the veins from which these large fragments of gold have been derived have been eroded away. Such veins must have been filled from depth and not from the surface, and therefore their roots at least should still be preserved. It is not meant to suggest that the veins from which the placer gold was derived will show in all places large pieces of gold, for just as in placers hundreds of tons of gravel must be handled to find a large nugget, so in veins even a greater number of tons must be mined to find a large segregation of gold, because in the vein there has been no concentration by the washing away of the lighter particles.

WATER RESOURCES.

The water resources of the Iron Creek region may be divided into two classes—developed and undeveloped. A description of the former will include a statement of the ditches and flumes that have already been built, while under the head of undeveloped water powers a few examples of general application will be considered. All the figures relating to the volume of water in the different streams have been taken from reports of members of the Survey. The records for 1908 have not been incorporated in the following notes, but will be found on pages 382–385, in the paper by F. F. Henshaw.

DEVELOPED WATER RESOURCES.

Of the streams flowing into Kruzgamepa River, only on Willow and Iron creeks have ditches been built. The Willow Creek ditch is a small one, built to carry water from that stream across Matthews Gap to the small streams entering Iron Creek from the southwest below Canyon Creek. Measurements[a] on Willow Creek made about the middle of September, 1907, gave a discharge of 3.3 second-feet at an elevation of 900 feet. From the intake of this ditch for a considerable distance much rock work was encountered. After this difficulty was overcome, frozen ground was struck, which caused a great deal of trouble. Unless the ice is carefully covered with an impervious layer of sod or earth, the running water will quickly melt it and the ditch will be destroyed. In some places the water has cut

[a] Henshaw, F. F., Water-Supply Paper U. S. Geol. Survey No. 218, 1908, p. 59.

holes in the ice 20 feet or more deep. After the ditch was completed from Willow Creek to a point near Bobs Creek, it was found that not enough water was delivered to make mining profitable, and it was therefore proposed to continue the ditch to Slate Creek. According to the report above cited, Slate Creek, at an elevation of 900 feet, had a discharge of 11.3 second-feet on September 19, 1907. The continuation of the ditch to this creek would undoubtedly give a considerable increase in volume, but much of the work is expensive, and should be undertaken only after it has been definitely proved that the ground to which the water is being led has a sufficiently high tenor to repay the cost of installing the ditch as well as the operating expenses.

As yet but little of the Iron Creek water has been utilized. Several small ditches only a few hundred yards in length have been constructed, more for prospecting purposes than for the actual development of power. A small ditch has its intake near the mouth of Sidney Creek, but the head acquired is slight. As has already been pointed out, the walls of this portion of the valley consist mainly of rock and rise abruptly from the gravel-floored flood plain. Under such conditions it is difficult and expensive to construct ditches. To raise the water high enough to reach good ditching ground, expensive flumes are required to lead the water around the jutting ledges of bare rock. Measurements of the volume of Iron Creek below Canyon Creek on August 14 and September 15, 1906, gave a discharge of 17.1 and 26.1 second-feet, respectively. The mean discharge of Iron Creek at the same place for the month of August, 1907, was 48.5 second-feet.[a] There were many fluctuations from this mean, for measurements made on August 22 showed 99 second-feet, while from August 11 to 14 the discharge was only 33 second-feet. It is evident, however, that the supply is more than equal to the demands put on it by the present operators.

On Canyon and Discovery creeks there is the most extensive series of ditches within the region. Some of this construction is, however, only representative of wasted money. These ditches were constructed to bring water to the junction of Discovery and Iron creeks, where it was to be used in operating a hydraulic elevator. The longest ditch has its intake on Canyon Creek at an elevation of about 760 feet, or about 5½ miles from the junction of this stream with Iron Creek. According to measurements on August 13, 1906, the discharge at this place was 1.3 second-feet and on September 15, 1906, it was 1.1 second-feet.[b] This is certainly a small amount of water for which to build a ditch over 5 miles long. The ditch leads the water along the southeast side of the Canyon Creek valley and the south side of Iron Creek to a penstock above Iron Creek near the mouth of Discovery Creek.

[a] Henshaw, F. F., op. cit., pp. 58–59.

[b] Henshaw, F. F., op. cit., p. 58.

Another ditch has its intake on Discovery Creek, at an elevation of about 740 feet. At this place Henshaw measured discharges of 1.25 second-feet and 2.3 second-feet on August 13 and September 15, 1906, respectively. This ditch follows the north and west side of Discovery Creek. It is about 2 miles long and discharges its water into the same penstock as that into which the Canyon Creek ditch empties.

The third ditch of this system has an intake on Eldorado Creek at an elevation of about 750 feet and at a distance of about a mile above the junction of Iron and Eldorado creeks. The volume of Eldorado Creek, as measured near the intake of the ditch, was 4.5 and 5.6 second-feet on August 13 and September 15, 1906. This ditch follows the west side of Eldorado Creek and the south side of the Iron Creek valley as far as Discovery Creek. Thence instead of discharging the water into a penstock from which it could easily be piped to the elevator, the ditch is continued along the south and east side of Discovery Creek to the intake of the other ditch on that creek, and the water is carried by the latter ditch to the penstock between Canyon and Discovery creeks. In this way the water is carried an unnecessary distance of 4 miles along the creek, all the time losing elevation and for half the distance requiring additional ditch construction. Work on this system of ditches was begun late in 1905 and was completed in the fall of 1906. During 1907 the water was not used and the property passed into the hands of a receiver. In 1908 the water rights, ditches, etc., were sold, the price received being far less than the cost of construction.

Water for sluicing on Dome Creek is derived from a short ditch which discharges at an elevation of only a few feet above the stream. Measurements of the volume of this creek have been made by the Survey during both 1906 and 1907. On August 14, 1906, the discharge was 6.0 second-feet.[a] These figures do not include the discharge of Eldorado Creek, for the 5 or 6 second-feet carried by this stream were diverted by the ditch leading to Discovery Creek. In 1907, when none of the water was diverted by ditches, the following measurements were obtained near the same place: August 1, 26 second-feet; August 22, 37 second-feet; September 18, 22 second-feet. The mean daily discharge from August 1 to 18, 1907, was 24.5 second-feet, but good measurements of the low stages were not obtained.

Ditch building in the American Creek basin was confined to Auburn Ravine, and was not extensive. Several small ditches were built to collect water from Jack Wade Creek, but as has been noted in the section dealing with mining, it was often necessary to wait an hour to collect enough water to sluice for five or ten minutes. As the elevation of the ground to be worked is about 700 feet, it will be a serious problem to get water delivered, even at a small head. There

[a] Henshaw, F. F., op. cit., pp. 58–59.

is absolutely no chance of obtaining an adequate supply from this basin, and the distance from any basin furnishing a sufficient supply is so great as practically to preclude the possibility of building ditches or other conduits at a reasonable cost.

In the portion of the Casadepaga drainage area represented on the map (Pl. X) there are a few ditches, none of which are of any great length. On Canyon Creek a ditch takes water from the main stream a short distance below Allgold Creek at an elevation of 510 feet. It follows the north slope of the valley and discharges a short distance east of the margin of the area mapped. It is a small ditch, and during the early part of the season of 1908 was so choked with snow and ice that water did not run in it until July 6. On the upper part of Lower Willow Creek a number of short ditches have been built by small operators, but none of them are more than a mile or two in length, and the volume of water they carry is small. Much of the ground, especially on the east side of this stream, is very bad for building ditches, on account of the broken and fissured limestone ledges which form the bed rock. Limestone is about the worst ground in the peninsula for ditches, as seepage from it is very high. On the main Casadepaga River a short ditch about a mile long has been started from limestone springs on Moonlight Creek. Little more than an intention of utilizing the water has been shown here. Another ditch has its intake near the mouth of upper Willow Creek, whence the water was to be conveyed along the north side of the Casadepaga Valley at such an elevation that it would connect with the ditch from Moonlight Creek. Most of the line of the ditch, however, is marked only by a single furrow turned by a plow. As it has been in this condition for the past two or three years, the projectors probably intend to abandon it.

Two or three years ago there was considerable talk of building a ditch line from Eldorado River near the mouth of Venetia Creek over to Hastings Creek. Hastings Creek enters Bering Sea west of Cape Nome, and the length of the ditch as projected was about 30 miles. Measurements of Eldorado River near the proposed intake gave a discharge of 44 second-feet on August 14, 1906, and of 225 second-feet on September 17, 1907.[a] Work on this project, however, has not been commenced, and from the present indications it will be abandoned. Short ditches have been built on Venetia Creek and one or two of the other small streams tributary to Eldorado Creek, but none of them are in use and they have consequently fallen into ruin.

UNDEVELOPED WATER RESOURCES.

It is a difficult problem to present any adequate discussion of the undeveloped water resources of the Iron Creek region because of the uncertainty as to the place where the water may be used and the head

[a] Henshaw, F. F., op. cit., p. 69.

and volume that may be required. Before any satisfactory statement can be made as to what water powers can be developed for placer mining, it is necessary to determine the value and extent of the auriferous gravels to be worked, for on these factors depend the extreme amount of money that can be expended for water and other essentials. When the value of the land has been determined by careful sampling, the method of applying the water power can be considered. Measurements of the streams should be carried on carefully for several years, in order to ascertain the probable maximum and minimum flow available, and with these data the best methods of developing the natural resources may be determined. Only by carefully analyzing the problems in advance can the expenditure of money for development be safeguarded.

So far as the present indications warrant a suggestion as to where water will be needed in the immediate future in this region, the basin of Iron Creek seems to be the most important locality. This statement is based on the assumption that water is to be carried to the place where the power is needed. If, on the other hand, water power is to be transformed into electric power, the radius of operations is considerably increased. One project of this sort has already been commenced and practically abandoned. It should be said, however, that this project was given up not at all because of impracticability, but because of a contention as to the ownership of the water right. It was proposed to generate power by damming the outlet of Salmon Lake and utilizing the fall thus obtained. This lake, which is the head of Kruzgamepa River, discharges through a narrow gorge only 150 feet wide, where the stream has cut across a morainic deposit formed at one of the later stages in the retreat of a glacier. This gorge affords a remarkably fine situation for a dam. Henshaw, in the report already cited,[a] has discussed the bearings of the problem as follows:

Salmon Lake lies at the foot of the Kigluaik Mountains at an elevation of about 442 feet. It has a water-surface area of 1,800 acres and a drainage area of 81 square miles. Its principal supply comes from Grand Central River, which enters it at its west end. A number of small streams also enter the lake from both the north and the south, but with the exception of Fox Creek and Jasper Creek these are of minor importance. The outlet of the lake is through Kruzgamepa River.

This lake offers an excellent opportunity for a storage reservoir for power purposes and mining along Kruzgamepa River. The use of its water in the vicinity of Nome is practically prohibited, owing to its low elevation and the long tunnel which would be necessary to bring the water through the Nugget divide into the Nome River basin. By raising the water of the lake to an elevation of 500 feet, the shortest tunnel line would be between 5 and 6 miles long; and if any allowance be made for drawing on the storage, water could not be brought through to the Nome Valley at an elevation greater than about 450 feet. The mouth of the tunnel would be near Dorothy Creek, and the loss in grade between that point and Nome would bring the water so low that

[a] Henshaw, F. F., op. cit., pp. 53–54.

> it could not be used to any extent for hydraulicking. Even if the water could be brought to the vicinity of Nome under a sufficient head for hydraulicking, the great cost and difficulty of building so long a tunnel would make the feasibility of the plan very doubtful. * * *
>
> As it [Kruzgamepa River] leaves Salmon Lake the river flows through a narrow outlet having a width of 150 feet at the bottom and 500 feet at the top, offering an excellent dam site and location for a hydro-electric power plant. Plans for the construction of such a plant have been perfected by the Salmon Lake Power Company [1907], which intends to develop 3,000 horsepower to be used on dredges at Nome and Council and on Solomon River.
>
> Salmon Lake at its present level, 442 feet, covers 1,800 acres; if raised to a level of 475 feet, it would cover 3,600 acres; and at 500 feet, 4,600 acres. The reservoir thus formed could be used for the storage of the water of the floods caused by the melting snow in the spring and the occasional heavy rains in the summer. The water thus retained would give a large minimum flow not only in summer but also during the winter months, when the natural run-off becomes small.
>
> Kruzgamepa River seldom freezes over before the first of January, and it is probable that with proper installation, power could be developed throughout the year.

The mean discharge from Salmon Lake from June 15 to October 5, 1907, inclusive, was more than 600 second-feet. This discharge, with a fall of 50 feet, would yield approximately 2,700 horsepower. It is evident, therefore, that to dam the Salmon Lake outlet and use the fall for generating electricity would be a simple way of obtaining power at a relatively low cost and in such a form that it could be transmitted without regard to the slope of the surface of the ground. The radius of transmission would greatly exceed that possible by any other application. It is unfortunate that this scheme has been so hampered by antagonistic claims of ownership that almost no work has been done on the water right since 1907.

During the past summer a number of miners have discussed the possibility of bringing water from the Bendeleben Mountains across the broad lowland to some of the valleys, such as that of American Creek, which head on the south side. Although it must be admitted that a large amount of water could be procured in these mountains, it seems clear that without a very thorough examination of the costs and the technical difficulties of construction such a plan should be avoided. Without going into too much detail, as the data are not sufficient for an elaborate discussion, it may be pointed out that much of the ground which could be developed by this water lies at elevations between 500 and 800 feet above sea level. The broad flat across which it would be necessary to pipe the water in an inverted siphon lies between 200 and 300 feet above the sea in its lowest part. It would therefore be necessary, in parts of the line, to have the pipe under such tremendous pressure that the construction would need to be of extraordinary strength. Such a line would cost a large amount of money, and careful consideration should be given to the question whether the returns would allow for the interest and amortization of the capital within the life of the ground which it was intended to work. It may seem unnecessary to call attention to such obvious conclusions, but the fact that similar or even more evident conditions have been overlooked in the past makes such a warning not amiss, especially to those who, though not conversant with mining, desire to invest rather than to speculate.

For many of the places where gold is known to occur in placer deposits there is slight chance of obtaining water under head at a reasonable cost by means of ditches. In such places it will be necessary to search for water-power sites where the energy may be transformed into electricity or where a large volume of water under low head may be utilized to pump a small volume to a great height. So far in Seward Peninsula these two methods have received but slight attention. The use of the hydraulic ram has, however, been effective in other mining regions, and an inquiry into its availability for certain localities might offer a solution to the problem of obtaining a water supply at a sufficient elevation.

Where water for mining occurs in sufficient quantity within the basin in which it is to be used, ditches afford a ready method of transporting it; but where the water must be carried from one creek to another, there are few, with the exception of Iron Creek, which have a sufficient volume to make the cost of ditch construction feasible. Water from the Kigluaik Mountains can be delivered at an elevation of 600 feet only by means of a long inverted siphon, having a pressure in the center of 200 or 300 feet. Iron Creek water to be effective for use on Sherrette Creek must be delivered by a ditch with an intake near the mouth of Discovery Creek. If the ditch were lower it would not furnish the water at a sufficient elevation to treat the known gold gravels; if it were higher it would encounter much bare limestone, which would make construction extremely expensive. To bring Iron Creek water to American Creek would require a higher intake and a longer ditch, which would be almost all the way in broken fissured limestone without a covering of vegetation. Water could not be taken from Iron Creek to the Casadepaga or its tributaries, or from the Casadepaga Basin to Iron Creek, except at such an elevation that the volume would be insignificant. No water could be obtained from Eldorado River for Casadepaga River or Iron or American creeks. Eldorado River might receive water from some of the streams rising in the Kigluaik Mountains, either by inverted siphons across the Salmon Lake and Kruzgamepa lowlands or by a tunnel a couple of miles long through the Jasper-Eldorado divide. Either of these plans, however, would give water at a low elevation, which could be used only on the main stream, and, as has already been pointed out, the gravels of Eldorado River do not seem to be sufficiently auriferous to warrant any extensive construction work.

MINING IN THE FAIRHAVEN PRECINCT.

By Fred F. Henshaw.

INTRODUCTION.

The Fairhaven precinct was examined by Moffit in 1903,[a] but had not been visited by any other member of the Geological Survey until 1908, when the writer spent about seven weeks in this region. The studies of the placers and mining conditions were incidental to stream-gaging work, so that the following notes are not as complete as could be wished. They will, however, give a general idea of conditions in this extensive area and of the recent mining developments.

The Fairhaven district has been developed mostly by the efforts of the miners themselves, for hardly any outside capital was invested in it until 1906. Since that time a considerable amount of money has been spent, in ditches and mining equipment; it has, on the whole, been wisely spent, and the chances seem good of clearing a considerable net profit from the mining operations in the precinct. A sketch map (fig. 21) has been prepared, showing the location of placers, ditches, and points of stream measurements.

INMACHUK RIVER BASIN.

The basin of Inmachuk River was the scene of the discovery of gold in the Fairhaven precinct, the first finds having been made on Old Glory and Hannum creeks in the fall of 1900.[b] Considerable mining was done during the next summer, but in the fall most of the miners joined the stampede to Candle Creek. In 1903 a number of them had returned, and since that time mining and development work have steadily progressed. Prior to 1903 most of the work had been done on the smaller streams, but since that time a large part of the production has come from the Inmachuk itself between the mouth of Pinnell River and the point where it leaves the hills and flows across the coastal plain.

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

[b] Moffit, F. H., op. cit., p. 49.

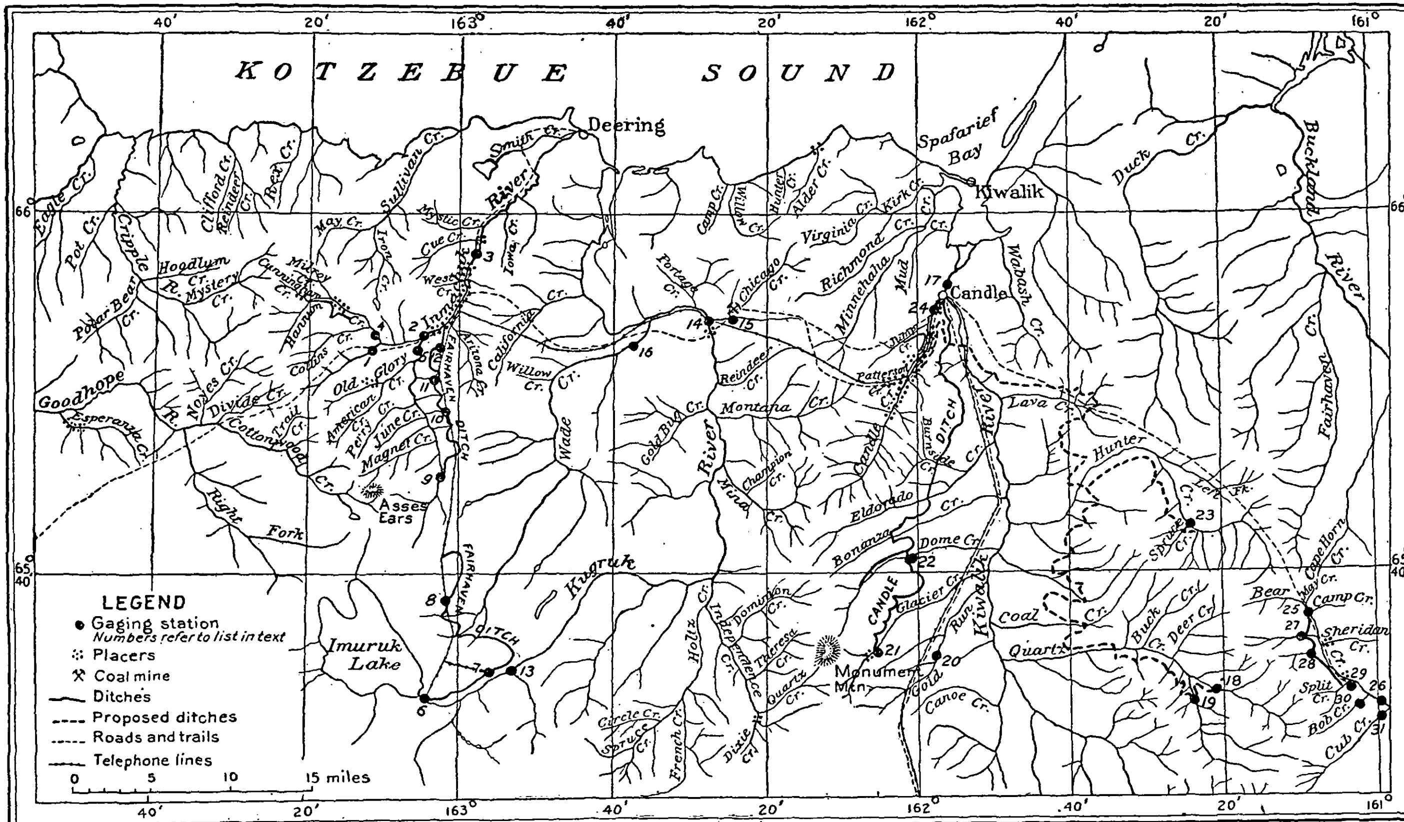

FIGURE 21.—Sketch map of part of Fairhaven precinct.

PINNELL RIVER.

Practically no work was in progress on the Pinnell in 1908, as all the old workings on Old Glory and the adjoining creeks had been abandoned.

HANNUM CREEK.

A ditch built on Hannum Creek in 1907 to furnish water for hydraulicking has its intake at the mouth of Cunningham Creek and extends for 5 miles along the right bank of the creek to a point a short distance above the mouth of Collins Creek, where a pressure of 200 feet is obtained. The ditch was built 4 feet wide on the bottom and has a grade of 4.2 feet to the mile. The character of the ground is very unfavorable for ditch construction, as there is much ground ice, containing little sediment and covered with only a few inches of moss and muck. There are also many places where the ground is fairly solid, and these conditions cause an unequal settlement in the bottom and banks of the ditch. In 1908 only about 2 miles of the upper end of the ditch were in use, from the intake to Milroy Creek. The water was being used to strip the muck from the ground lying on the right bank of Hannum Creek. Some work has been done in the stream bed at this point in previous years, mostly by shoveling into boxes.

INMACHUK RIVER ABOVE PINNELL RIVER.

Little mining has been done in the part of the river above the mouth of the Pinnell, and in 1908 the only development work was a little prospecting just above Hannum Creek. The depth of the gravel in the stream bed is here about 6 to 8 feet and the width not over 200 feet. Prospects were found, but nothing rich enough to pay to shovel. It was reported in the fall that practically all the ground from the mouth of Pinnell River to the springs on the upper Inmachuk had come under one control and that a ditch would be built to bring water from the springs for hydraulicking. It may be possible to reduce mining costs in this way, so that much of the ground can be profitably worked. The springs furnish a constant supply of water of about 8 second-feet,[a] and a pressure of about 150 to 200 feet can be obtained on most of the ground.

INMACHUK RIVER BELOW PINNELL RIVER.

The 7 miles of Inmachuk River below the mouth of the Pinnell have contributed a large share of the production in this basin, the total amount to date, as nearly as can be learned, being from $400,000 to $500,000, nearly all of which has been taken out by winter drifting. The gravel flat in this part of the river is from 800 to 1,200 feet wide

[a] The second-foot is equal to 40 miner's inches as used in the Fairhaven district. It is defined on page 372.

and the depth to bed rock varies from 15 to 30 feet outside of the river channel. The greatest depth, 25 to 30 feet, is in the upper portion, on claim "No. 1 below Pinnell;" below the mouth of Washington Creek the ground is shallowest, being 12 to 15 feet deep. The channel thaws to bed rock in summer, and as the gravel is mostly fine and loose, being called by the miners "chicken feed," there is a large underflow of water which has hindered open-cut work of any kind. In the winter the river is filled with the ice formed by the overflow of the water from the springs, and under these conditions the ground has been drifted, the ice being used as a roof. In some places enough light came through this cover to make candles unnecessary.

The bed rock is schist with interbedded limestone. The limestone seems to have served as a natural riffle and carries most of the gold. It lies in large, irregular slabs cemented together with clay, and is very hard to handle in drifting or open-cut work. Gold is sometimes found in the gravel, but only in the lower 2 or 3 feet.

Operations were being carried on at three places in the summer of 1908. The first, which has been a large producer, is claim "No. 1 below Pinnell." Here the values are on the left bank of the river. The surface of the bed rock is wavy, its depth below the surface varying from 20 to 30 feet, but the pay streaks seem to occur only at points where this depth is 24 to 26 feet. Some very rich spots have been found; one, 75 feet square, is said to have produced $33,000, or about $6 a square foot. In 1908 the river was turned to the left near the upper end of claim "No. 9 below Hannum" and a cut and drain were excavated in the thawed ground of the river channel in the hope of finding an extension of this pay streak that could be worked in the summer. The drain discharged on claim "No. 1 below Pinnell" and extended upstream for over 2,000 feet. Bed rock was reached in several hundred feet of the upper portion, but it was schist and carried no values.

On the Utica group of claims, about 2 miles below the mouth of Pinnell River, some ground was worked by drifting in the winter of 1906–7, but the operations of the past season were confined to hydraulicking with elevators, water being obtained from the Fairhaven ditch. This ditch takes its water from Imuruk Lake, which lies at an elevation of about 950 feet above sea level. A dam 500 feet long and 5 feet high has been built to form a storage reservoir, and this will hold the total inflow at the lake for two years if necessary. The ditch is in three sections; the upper section, 17 miles long, lies on top of the lava and extends from the lake around the head of Wade Creek to the divide between Wade Creek and Pinnell River. Here the water is dropped into a channel emptying into a sink hole in the lava, which seems to be connected by an underground passage with Wade Creek. The water is diverted from this channel into Pinnell River by the middle section of the ditch, which is 850 yards long. The water runs about 6½ miles between the upper and lower ditches and the drop is estimated at 140 feet. The lower section of the ditch extends from the intake on Pinnell River along the left side of the valley to a point a few hundred feet below Logan Gulch, a small tributary of the Inmachuk above Arizona Creek, and has a length of about 19 miles, making a total of 36½ miles of ditch.

The ditch has a grade of 4.2 feet to the mile and was built 11 feet wide on the bottom, 1 foot in cut at the lower side, and with a 4-foot lower bank. The removal of 1 or 2 feet of the upper moss and soil put the bottom of the ditch into ground ice and muck, much of the ice being fairly pure. This material thawed when the water was turned in and a large part of the bottom of the ditch has settled at least 2 feet and has widened in many places to 15 to 20 feet or more. As the upper bank thawed the material was thrown against the lower bank to protect it and keep the water from getting under it. Practically the whole of the upper ditch and at least three-fourths of the lower ditch, including all the upper 6 or 8 miles, is built in frozen ground of this character. Where the lower ditch is built around the steep gulches that carry the eastern tributaries of the Pinnell the northerly slopes of the gulches are covered with muck, but the southerly slopes are made up of a more solid clay and decomposed mica schist. Along the upper ditch lava bowlders are present in the muck from the surface to bed rock. At some places the material encountered was composed of angular fragments of lava with little soil between them. Above and below Snow Gulch, the lowest tributary of Pinnell River which the ditch crosses, there are short pieces of rock work. The rock is much shattered and could have been loosened with picks if it had not been frozen. Much difficulty was experienced in making the rock work water-tight on account of the lack of good sod, as the surface covering is commonly decayed moss or peat containing much fibrous matter, with little earthy material to give solidity, and will generally float even though saturated with water.

The ditch was built under contract and construction was begun early in 1906. The upper section and more than half of the lower section had been built by October 12, when work had to be suspended for the year; it was completed in July, 1907. Water was run through the ditch for a short time in September, 1907, and from July 1 to September 21, 1908, except for a few hours when it was turned out on account of breaks. About 12 second-feet were used in July and 25 to 35 second-feet in August and September. The ultimate capacity of the ditch when some low parts of the bank are raised will be about 100 second-feet. The pressure pipe leading from the penstock below Logan Gulch to the mine has a total length of 10,600 feet.

The elevation of the ditch above bed rock on the Utica claim is 530 feet, a greater head than that of any other ditch in Seward Peninsula, but the water is dropped into a second penstock 200 feet below the ditch, so that the pressure on the nozzles is that due to a fall of about 300 feet when allowance is made for frictional loss.

A diversion dam and waste ditch were built in 1907 to carry the surplus water past the mine. The dam was laid on top of the river bed, so that there is a large underflow, which seeps into the elevator pits. The first pit was sunk in July, 1908, at a point in the river bed where the gravel was about 15 feet deep. Two water lifts were required to handle the seepage, which amounted to about 4 second-feet, and it was found impossible to set the elevator more than 2 feet into bed rock. The gravel is moved to the door of the elevator very easily, as it is loose and well rounded. The bed rock encountered in 1908 was a very heavy limestone. All of it had to be taken up by hand, as the large slabs would not pass through the door of the elevator and could not be sledged to pieces and driven in with a giant because of the flat grade in the pit. The equipment consisted at first of a light hydraulic elevator with a 9-inch throat and a 14-inch upcast pipe, using a 3½-inch nozzle and lifting 32 feet vertically. A second elevator was set with a lift of 35 feet and the first one reset to raise 38 feet. One giant with a 2½ to 3 inch nozzle was used in each pit. The pits worked were about 250 to 300 feet square, a small size in ground of such depth. It will probably be found more satisfactory to use larger and heavier elevators and a larger stream on the giant, and to set the elevator deeper into the bed rock. Much larger pits can thus be worked and the bed rock can be run through the elevator.

Below the Utica lie the Dashley group of five claims, the Polar Bear group of four claims, and the Homestake group of eight claims, all of which have yielded considerable gold. They have been mined by winter drifting, outside coal landed at Deering and costing $60 a ton at the mine being used. Values as high as 5 to 8 cents to the pan—$7.50 to $12 a yard—for a pay streak 3 to 4 feet thick are said not to be uncommon for small areas; but as the gold is irregularly distributed and lies mostly in a creviced limestone, similar to that found on the Utica claim, mining is difficult and costly. The profits from these operations have not been large, and the plan of most of the owners seems to be to wait until the whole river bed can be worked on a large scale with water from the Fairhaven ditch.

The only plant operated in 1908 on this section of the river was below Washington Creek and included a steam scraper and derrick. At this point the gravel in the river bed is about 6 feet deep; but only the lower 2 or 3 feet is gold bearing. This material rests on a blue clay that is easily cleaned. The overburden was removed with a bottomless steam scraper handling half a cubic yard and operated by a double-drum hoist. The pay streak was then shoveled into buckets 3½ by 2½ feet by 20 inches, holding half a cubic yard, which were trammed to the derrick on short pieces of track and hoisted to a dump box about 18 feet above bed rock. Sluice water was pumped by a 12-horsepower gasoline engine lifting about 100 inches. The river water was carried by a channel scraped out on one side of the stream bed, and although this channel had a sufficient capacity for the low water of 1908, with a heavy rain storm it would have been quickly flooded. The seepage water that collected in the pit, amounting to about 20 inches, was handled by a large China pump run by an engine. Ten men were shoveling into buckets in the pits at the time the claim was visited in August, and it was stated that about 150 cubic yards of gravel was handled daily.

KUGRUK RIVER BASIN.

GOLD.

Though there has been considerable prospecting for gold in the Kugruk basin, it has not been very fruitful of results, and in 1908 the only camps in this region were those along the Fairhaven ditch and at the Chicago Creek coal mine.

The only mine that has produced any considerable amount of gold is on Discovery claim, on the Kugruk, a short distance above the mouth of Chicago Creek. At this point the river valley has a width of about a mile and the channel, which lies on the east side of the valley, is about 200 feet wide. The depth to bed rock on Discovery claim is only 12 to 14 feet, including the overburden. The pay streak is crescent shaped in outline and nearly a claim length from end to end. At the points of the crescent the gold is fine; in the middle it is coarse. The production from this claim during the winters of 1903–4 and 1904–5 is said to have amounted to $150,000. Its success led to much prospecting in the vicinity and over 100 holes were sunk to bed rock without finding any values. One hole, three-fourths of a mile from the river and a short distance above Discovery claim, is of interest in showing the great depth of ice and muck sometimes found in this part of Seward Peninsula. The following section was furnished by the prospector:

Section three-fourths mile from Kugruk River, near Discovery claim.

	Feet.
Clear ice	26
Muck	60
Reddish gravel	8
Muck	3
Bluish gravel	10
Schist bed rock.	

COAL.

Moffit has described the coal-bearing rocks of Kugruk River as follows:[a]

Sandy and shaly sediment interbedded with thin limestones were noticed at several localities in the valley of Kugruk River, especially in the vicinity of Chicago Creek, where they are associated with deposits of lignitic coal. These beds are folded and much jointed, but have not been altered to the same degree as have the neighboring schists. They have the same north-south strike and high dips common in the highly metamorphic rocks, and, when weathered, their altered surfaces present an appearance very similar to that which would have resulted had they been burned. Such outcrops were noticed on Kugruk River near the mouth of Chicago Creek and for several miles to the south, also on Chicago Creek one-half mile above the Kugruk. A rather imperfect cleavage was observed at one locality, where the difference in strike of cleavage and bedding amounted to more than 30°.

Lignitic coal was discovered on Chicago Creek in 1902 by men who were prospecting in the creek for gold. Some development work was done in that year and in the following winter, but it was not until the discovery of gold values in the second and third tier of the benches on the left side of Candle Creek, which had to be worked by winter drifting, that any considerable market was found for the coal. Since then the mine has been operated each winter and the Chicago Creek coal has proved an important factor in the development of the Candle Creek placers.

The Chicago Creek coal mine is operated only during the winter months, and the writer was fortunate in being able to examine it on the only day for several summers when the workings have been ventilated and made accessible.

The coal seam strikes about N. 8° W. and has a westerly dip of 53°. The strata in which the coal is included are soft and crumble easily. As nearly as could be determined from the exposures in the mine, the coal bed is 88 feet thick, with no partings except a few thin layers of bone and sandy shale. Drillings made during August, 1908, revealed the presence of the coal bed one-half mile N. 12° W., at a depth of 69 feet below the surface. An inclined shaft that follows the coal bed exposed on the left bank of Chicago Creek is 330 feet long and slopes downward at an angle of 18° to 36°. The shaft reaches a depth of 144 feet below its mouth and the bottom is more than 200 feet below the surface of the ground perpendicularly above it. The coal is solidly frozen to this depth. The incline lies 20 to 30 feet from the hanging wall down to a point near the lowest level, where the irregularity of the dip of the coal bed brings them nearly together.

The mine has been worked on four levels at approximately 33, 80, 100, and 144 feet below the shaft house. On the upper level a cross-

[a] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 247, 1905, p. 25.

cut 55 feet long was run in 1903, but did not reach the foot wall. On the lowest level a crosscut 104 feet long exposes the whole width of coal. The bed is here at least 85 feet thick, but appears to be somewhat thinner than at other points. On the upper three levels the coal has been taken from the portion of the seam lying within 20 feet of the hanging wall, which yields the solidest and most desirable fuel. Most of the coal mined in the last two years has been stoped from the area between the shaft and crosscut and discharged by chutes into cars in the crosscut. The coal at the lowest level appears to be more uniformly good than it is higher up, where only the part of the bed nearest to the hanging wall was worked.

The coal is of a lignitic character; it burns easily with a bright flame and leaves a small amount of white ash. Several samples of the coal from different parts of the mine were analyzed with the following results for the mean:

Analyses of Chicago Creek coal.

[Sample as received.]

Proximate analysis:	
Loss on air drying	33.59
Total moisture	37.73
Volatile combustible	24.14
Fixed carbon	29.27
Ash [a]	8.86
Ultimate analysis:	
Sulphur	.80
Hydrogen	6.77
Carbon	37.61
Nitrogen	.63
Oxygen	45.33
Calorific value:	
Calories	3,441
British thermal units	6,194

All the coal is frozen as it comes from the mine and must be allowed to thaw and dry to give the best results. A large percentage of it is seamed, and checks and crumbles when exposed to the air. This quality is objectionable when it is used under boilers, much of the coal being lost through the grates. Nearly half of the coal hoisted has been left in waste piles at the mine. As it requires about 2 tons of Chicago Creek coal to produce as much steam as 1 ton of Wellington coal, the native product can be sold low enough to compete with that from the outside only at mines on Candle Creek and Inmachuk River, where it can be delivered cheaply. For a greater length of haul the less bulky fuel is less expensive.

[a] There was considerable variation in the amount of ash from different parts of the vein; the mean for the 60 feet nearest the hanging wall was 4.13; for the next 12 feet, 7.08; and for the last 32 feet, 17.36.

An investigation was made during the past summer of the possibility of using the coal for generating power at the mine, to be transmitted electrically to some of the placer districts of Seward Peninsula. The development of dredging and other mechanical means of hoisting gravel will probably go forward rapidly in the next few years and will cause a large demand for power. One of the most important points to be considered in the discussion of this plan is the possibility that water powers which would compete with such a steam power plant may be developed.

KIWALIK RIVER BASIN.

CANDLE CREEK.

Candle Creek, although it has never been a bonanza like Anvil Creek and Snow Gulch in the Nome district, shows a wide distribution of values. Gold has been taken from practically every creek claim for over 10 miles and is found in the benches on one side or the other for fully one-half of this distance, in some places extending into the third tier. The total value of the production to date has been estimated from the best information available at $2,245,400, distributed by years as follows:

Estimated value of gold production of Candle Creek, 1901–8.

1901	$70,400
1902	250,700
1903–4	181,500
1904–5	321,200
1905–6	542,400
1906–7	609,200
1907–8	270,000
	2,245,400

Placer gold was discovered in July, 1901, on Jump Creek, a tributary of Candle Creek, about 2 miles above its mouth. The creek bed was mined by rocking and shoveling during that and the following summer, but by 1903 the easily worked gravels had been nearly exhausted and the miners began to turn their attention to the benches. Gold was found in the benches on the left bank in the following winter, and since the season of 1904–5 they have yielded approximately $1,200,000, over half of the total production of the creeks.

The term "bench" is commonly applied to any claim outside of the stream channel. The claims lying adjacent to the creek claims are designated "first tier," those next above "second tier." Bench placers have been defined by Purington[a] as "placers in ancient stream deposits from 50 to 300 feet above the present stream."

[a] Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905, p. 27.

So far as is known the bed rock on the left side of Candle Creek shows no rim or escarpment but slopes uniformly to the present stream. The gravel deposits seem therefore to belong more strictly to the hillside placers, which lie intermediate between the creeks and benches and show no indication of the benching of their bed rock.

On bench claims No. 18 and 19, just below the mouth of Patterson Creek, the pay streak lies in the first tier, only a few feet above the level of the creek, and is possibly an extension of the old Patterson Creek channel, mentioned on page 366. On bench claim No. 17 it lies in the second tier and from No. 16 to No. 12 values have been found in both the second and third tiers. The bed rock at the lower end of the pay streak is probably higher than at the upper end. The gravel is thin, varying from 6 inches to 2 or 3 feet; in some places it is lacking altogether and the gold lies entirely in the bed rock. In one such place a narrow bed of gravel, evidently from a side stream, runs across the pay streak. Near Patterson Creek and above Jump Creek the bed rock is a decomposed mica schist. Between claims Nos. 12 and 17 it is a granitic dike, which can be traced by outcrops for a much greater distance. These facts are noted as showing some of the unusual features of these placers, but point to nothing conclusive concerning their origin. The writer spent only one day late in the season in studying the mining operations on Candle Creek, so that the developments in 1908 can only be outlined.

Four creek claims between Jump and Patterson creeks were being operated. An open cut on the side of the creek at claim No. 5 and a small steam hoisting plant on claim No. 14 were not visited. On claim No. 16 a cut was ground sluiced across a bend of the stream, and the gravel was thawed by steam and shoveled into boxes. On No. 17 a large hoisting plant had been installed, with buckets holding three-fifths of a cubic yard. The pay streak cuts across a bend in the creek. A shaft 35 feet deep was sunk to reach it, and as nearly as could be determined the bottom of the shaft was about at the level of the bed rock in the present channel. There are 8 to 18 feet of gravel, and gold was said to be found in the portion lying within 6 inches to 3 feet of the decomposed schist bed rock.

Mining on the benches has been confined mostly to winter drifting, and a little prospecting is about the only summer work on most of the claims. Bench claim No. 19, first tier, has been worked by open cutting, the water of Patterson Creek being brought through a short ditch for stripping the overburden and the gravel being then shoveled into boxes. This is the largest open cut on the stream. Four smaller pits were worked during the summer as much as the meager water supply permitted.

The only benches on the right bank of Candle Creek where values have been found are in the second tier, near the mouth of the creek, on what is known as John Bull Hill, where a considerable area of auriferous gravels was blocked out in 1907 with a keystone drill. Here the bed rock has an elevation of 10 to 90 feet and slopes toward the Kiwalik with a sufficient grade to carry the tailings into the river. In three holes the bed rock is limestone; in the remaining fifty, which are on or near the pay streak, it is a decomposed schist. The gold is mostly well worn and rather coarse. The depth of gravel and overburden is greater than on the benches on the left of Candle Creek.

The sections found in the drill holes are summarized below:

Mean sections of drill holes on benches of Candle Creek.

Material.	Thickness (feet).		
	Greatest.	Least.	Average.
Ice and muck	60	15	35.0
Barren gravel	18	0	4.2
Gravel carrying values	25	0	6.7
Total gravel	29	1	10.9
Bed rock carrying values	13	0	3.1

The only tributary of Candle Creek on which any considerable mining has been done is Patterson Creek, which enters from the left about 7 miles above the settlement of Candle. Gold was first found on this stream in the winter of 1907–8. In September, 1908, claims Nos. 6, 7, and 8 were being operated, and later reports indicate that the pay streak extends from No. 4 to No. 11, inclusive. As developed, it lies about 50 feet to the left of the present creek on claims Nos. 7 and 8 and crosses to the right near the upper end of No. 6. The bed rock is 5 or 6 feet below the present stream. At a depth of 12 to 15 feet below the surface there are 6 inches to 2 feet of flat gravel, not well worn, covered with ice and muck.

Several small ditches have been built to supply water for sluicing purposes on Candle Creek. The longest is the Jump Creek ditch, which extends up Candle Creek on the left bank as far as claim No. 7. It is 3½ miles long and 3 feet wide at the bottom. A ditch 2 miles long and 4 feet wide on Patterson Creek supplies water for stripping and sluicing on a bench on Candle Creek, just below the mouth of Patterson Creek. A slightly longer ditch takes water from Candle Creek near Blank Creek. There are also two or three short ditches from small tributaries. All these ditches depend for their water supply on the rains and the melting snow in the spring. In a dry summer like that of 1908 they can be used for only a few days.

The Candle ditch was built by the Candle-Alaska Hydraulic Gold Mining Company in 1907. It has its intake on Glacier Creek and extends for 33½ miles along the left bank of Kiwalik River to John Bull Hill, opposite the mouth of Candle Creek. Of this length nearly

3 miles is made up of three siphons—2,250 feet of 28-inch pipe across Dome Creek, 912 feet of 30-inch pipe across Bonanza Creek, and the big 12,580-foot siphon across Eldorado and Burnside creeks, composed of equal lengths of 35½, 37½, and 39½ inch pipe. The lateral to Dome Creek consists of 3½ miles of 4-foot ditch, making a total of 37 miles. The ditch is 6 feet wide at the intake, increasing to 9 feet at the lower end. It has a grade of 3.7 feet to the mile, a capacity of 20 to 30 second-feet, and an elevation at the penstock of 249 feet above Kiwalik River. A cut of 9 inches was made on the lower side. This gave a rather low ditch bank in places where the ground was solid, but in the frozen muck the ditch bottom has settled from 1 to 2 feet. The material encountered varied greatly. Near the upper end there were 2 miles of decomposed mica schist; below Burnside Creek there was some rocky ground with too little sediment to make the ditch tight without a great deal of work. Repair work in such places was difficult on account of the general lack of good sod. The portions of the ditch built over the muck gave the least trouble. A berm 1 foot wide was left on the lower bank between the cut and fill, and formed a protection for the inside of the bank when the bottom settled. An extension of the ditch at Gold Run, requiring 8 miles of ditch and a siphon, will probably be built eventually, as the measurements of 1908 show that the flow of that stream was about two-thirds that of Glacier Creek. The mining operations in 1908 were confined to stripping the overburden from the bench on John Bull Hill.

During the summer of 1908 operations on Candle Creek were handicapped and for weeks sluicing was stopped altogether by lack of water. The creek was dry at its mouth from the middle until the end of July and there was a scarcity of water all through the season, except for a very few days late in the fall. A drought has occurred every summer for the last three or four years, though operators have usually been able to sluice for at least a month at the end of the season. The fact that nearly $2,500,000 in gold has been extracted under such difficulties indicates the value of the ground and its possibilities if a good supply of water can be obtained.

Conditions are such as to make the hydraulic method the most feasible one for handling the gravels. Most of the producing claims lie along the benches, high enough to dispose of tailings without elevating. The overburden is ice, with little sediment, and can be removed by exposure to the air, assisted by a little water. The gravel on some of the claims carries gold in several feet of its depth. The builders of the Candle ditch were confident that its construction would revolutionize mining conditions in this region, and make it possible to hydraulic all the ground where drifting had been the only method available. The season of 1908 showed that the water supply that can be counted on throughout the season is only a small part of what had been expected. A summer as dry as that of 1908 may not occur again for years, but it is hard to see how Gold Run, Glacier Creek, and Dome Creek, having an aggregate drainage area at the ditch intakes of only 28 square miles, can furnish 30 second-feet even in a year with considerable rain. Two other ditches have been proposed. One, intended to bring the water of Quartz and Hunter creeks into the Candle Creek valley, would require about 65 miles of ditch and 14,000 feet of pipe, besides a distributing ditch on Candle Creek. The great cost of such an enterprise and the uncertainty of the water supply make its feasibility very doubtful. The other proposed ditch was to bring water from Imuruk Lake to the head of Candle Creek. It was shown by a preliminary survey that this ditch would require 65 miles of open ditch and over 20,000 feet of siphon, besides a long tunnel.

The most practicable method to obtain an adequate water supply would seem to be to pump it from Kiwalik River by electric power. It would require about 2,400 horsepower to pump 50 second-feet to a height of 300 feet, where it would cover all the ground of proved value on Candle Creek. There are two principal sources of power within a reasonable transmission distance of Candle Creek. The first is at the Chicago Creek coal mine, 15 miles distant, where the possibilities of power development have already been noted. The second is on Kugruk River, below Imuruk Lake. The Fairhaven ditch will probably never use more than one-half the inflow into the lake. About 90 second-feet of surplus water should be available for one hundred days, and can be carried in a ditch to a point about 4½ miles below the dam and then dropped into the canyon 500 feet below, developing nearly 4,000 horsepower. The power plant would be 40 miles in a direct line from the mouth of Candle Creek. The relative cost and advantages of these two plants can be determined only after an examination by an experienced engineer, but they present possibilities that may well be considered before any more long ditch lines are attempted.

GLACIER CREEK.

Glacier Creek, the only tributary of Kiwalik River besides Candle Creek on which gold has been found, lies about 25 miles north of Candle in an area of interbedded schist and limestones. The limestone springs in its basin give the creek a fairly well sustained low-water flow, so that there is always enough water for sluicing. These springs remain open during the greater part of the year; in the winter the water flows for about a mile and then freezes, forming a large "glacier" or ice bed. The ice prevents the growth of vegetation and leaves the gravel under it free from muck or other overburden. The depth to bed rock is only 2 to 4 feet, and the gravels thaw as soon as the ice is gone. The intake of the Candle ditch is just below the lower end of the "glacier." Colors of gold had been found in this part of the creek, but no prospecting was done until August, 1908, when two men who had been working on the Candle ditch ran an open cut and uncovered an area of high bed rock at the mouth of a small tributary from the left. They located a pay streak about 20 feet wide and it was reported that they took out nearly $200 by shoveling seven hours each; moreover, a much greater width is said to be rich enough to be worked at a profit by shoveling. This discovery caused a stampede to the creek and will probably lead to much prospecting in the hope of finding gold in benches and in creek claims farther downstream. It should also lead to more careful examination of the other western tributaries of the Kiwalik—Dome, Bonanza, Eldorado, and Burnside creeks—which have hardly been prospected.

BUCKLAND RIVER BASIN.

Bear Creek, the most easterly of the gold-producing streams of the Fairhaven district, is a tributary of West Fork of Buckland River. Gold has been found on lower Bear, Sheridan, and Cub creeks, and some mining has been done each year since 1901, but no extensive developments were undertaken until 1907, when the Bear Creek ditch was built to furnish water for hydraulicking. The ditch has its intake below May Creek and extends along the right bank to Split Creek, picking up the waters of Eagle and Polar creeks, which are its principal feeders. The ditch is 5.8 miles long and 4 to 6 feet wide on the bottom. It has a grade of 4.2 feet to the mile and the pressure obtained is nearly 200 feet. On account of lack of water no actual mining was done in 1908, operations being confined to prospecting on Bear Creek at the mouth of Split Creek. Here the gravel is loose with little fine sediment; the gold is bright and flaky, and lies in a bed rock of seamed and fractured eruptive rock, which will have to be moved to a depth of several inches in some places to recover all the values. There is also a small ditch for ground sluicing, which takes its water from Split Creek.

GOODHOPE RIVER BASIN.

Goodhope River is the westernmost of the larger rivers that drain into Kotzebue Sound. Little prospecting was done in its basin until the winter of 1907–8, when a party of Laplanders discovered gold near the mouth of Esperanza Creek, a small tributary from the south. The values were reported to be good and the news of the discovery caused a stampede from all parts of the Fairhaven district in the late summer of 1908. There will probably be much prospecting during the winter. Esperanza Creek lies about 25 miles in a direct line from the mouth of Rex Creek, which is the most convenient landing place for supplies.

WATER-SUPPLY INVESTIGATIONS IN SEWARD PENINSULA, 1908.

By FRED F. HENSHAW.

INTRODUCTION.

SCOPE OF WORK.

The operation of the gold placers in Seward Peninsula had by 1906 reached such a stage of development that their future success was largely dependent on the possibility of mining large bodies of relatively low grade gravel. The most common method of working such ground has been by hydraulicking. For this method a large and steady supply of water under a high head is a necessity. To obtain such a supply a large number of ditches have heen built, many of them long and constructed at great expense. There has been a great tendency to push forward their construction without first making sure of the primary requisite of their successful operation, an adequate water supply. The results of such a policy were forcibly shown during the last three summers, particularly in 1908, when in some parts of the peninsula the severe droughts caused much loss and inconvenience to mine operators.

In the whole of Seward Peninsula, as in most of the interior of Alaska, the climate is comparatively arid, except in small mountain areas. The total yearly precipitation ranges from 10 to 25 or 30 inches, and as much of this comes in the form of snow, which melts and runs off in a few days in the spring, the discharge of the streams becomes very small in an ordinarily dry summer. Too much stress, therefore, can not be laid on the importance of procuring stream-flow data, covering not one but from three to five years. The low-water period generally lasts only a part of the season, and the water supply is usually sufficient at other times, but in view of the other unfavorable conditions—the shortness of the season, the frozen state of the ground, the distance from base of supplies and consequent high cost of transportation—a reduction of even two or three weeks in the working season may mean the difference between profit and loss. The cost of the useless machinery and ditches which can be seen in some parts of Alaska amounts to hundreds of thousands of dollars, and most of this loss could have been saved by a preliminary investigation of conditions by a competent engineer.

Hydraulic developments have been carried farthest in southern Seward Peninsula, which has been an important producer of placer gold since 1899. Investigations of stream flow were begun in this area in 1906 by John C. Hoyt and the writer. In 1907 they were continued and extended into the Kougarok region in central Seward Peninsula. The results of these two seasons' work have been published,[a] and the present report is supplementary, bringing the statistics up to date. During the past season the more important stations in the Nome, Grand Central, Kruzgamepa, and Kougarok basins were maintained and the field of work was still farther widened to include the Solomon and Casadepaga drainage basins and the Fairhaven precinct. The writer was assisted in the work by A. T. Barrows, who spent his time in the southern and central portions of the peninsula.

The work in the Fairhaven precinct was in the nature of a reconnaissance, as the field season was so short that the writer was able to spend only about seven weeks in this area, from July 23 to September 9, and to make only two round trips over it. The report on this area should, therefore, be regarded as only preliminary, and can not be taken as indicating the normal conditions, for the drought of 1908 was without precedent since the beginning of mining operations in Seward Peninsula.

COOPERATION.

It was possible to cover this large area properly and to obtain daily records of flow only through the hearty and intelligent cooperation of mining operators, ditch companies, and others. Acknowledgment is due for gage readings to the employees of the Miocene Ditch Company, Wild Goose Mining and Trading Company, Pioneer Mining Company, Canyon Creek Gold Mining Company, Kougarok Mining and Ditch Company, Candle-Alaska Hydraulic Gold Mining Company, and to Messrs. Frank H. Waskey, W. L. Leland, F. F. Miller, C. F. Merritt, J. B. Gilvrey, A. Martell, and C. O. Mason.

METHODS OF WORK.

The methods of carrying on the work and collecting the data were substantially the same as those previously used for similar investigations, but were adapted to the special conditions found in Seward Peninsula. These have been outlined in the previous report.[b]

[a] Henshaw, F. F., and Covert, C. C., Water-supply investigations in Alaska, 1906-7: Water-Supply Paper U. S. Geol. Survey No. 218, 1907.

[b] Henshaw, F. F., and Covert, C. C., op. cit., pp. 9-12.

In the consideration of the water supply for any mining or other industrial project, it is necessary to know the mean discharge, its fluctuation throughout the season, and the causes which govern these variations. Several terms are used, such as "second-feet," "miner's inch," "gallons per minute," etc., to describe the quantity of water flowing in a stream, the one selected depending on the use to be made of the data.

"Second-feet" is in most general use for all classes of work, and from it the quantity expressed in other terms may be obtained. It is an abbreviation of cubic feet per second, and may be defined as the rate of discharge of water flowing in a stream 1 foot wide and 1 foot deep at the rate of 1 foot per second. It should be noted that to obtain the actual quantity of water it is necessary to multiply the second-feet by the time.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly, as regards both time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is expressed in depth in inches.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage problems.

The "miner's inch," the unit used in connection with placer mining, also expresses a rate of flow and is applied to water flowing through an orifice of a given size, with a given head. The head and size of the orifice used in different localities vary, thus making it a most indefinite and unsatisfactory unit. Owing to the confusion arising from its use, it has been defined by law in several States. The California miner's inch is in most common use in the United States and was defined by an act approved March 23, 1901, as follows: "The standard miner's inch of water shall be equivalent or equal to 1½ cubic feet of water per minute, measured through any aperture or orifice." This miner's inch corresponds to the so-called "6-inch pressure" and is one-fortieth of a second-foot. The inch in most common use in Seward Peninsula is the "old California inch," which was the standard in that State prior to the passage of the above-mentioned act, and is equivalent to 1.2 cubic feet per minute, or one-fiftieth of a second-foot.

HYDRAULIC DEVELOPMENTS.

The developments of the past season showed a marked decrease of activity in ditch construction from the three or four previous seasons. This was due largely to the financial depression in the States, but two other influences contributed—first, the appropriation of practically all the available water that can be conducted by gravity to proved mining ground, and, second, the growing caution of capital in taking up ditch projects in Seward Peninsula. The fact that unfavorable conditions outside of Alaska could practically stop construction work on nearly every big project after the large gold output of the two previous seasons shows how dependent the country is on outside capital. In a survey of the whole peninsula it is difficult to see where more than two or three new ditches could be built that would have a chance of success. The failure of many of the waterways already built, from the lack either of an adequate water supply or of values in the ground, has at last begun to make investors realize that investigation should be made before rather than after a large amount of money is spent. Another unsatisfactory feature is the looseness of the laws concerning water rights, which has led to many disputes and lawsuits and has hindered the development of many feasible projects.

The more progressive mining men of the region have begun to turn their attention to the possibilities of pumping water by hydroelectric power. There are seven or eight power sites in Seward Peninsula, reasonably near to important mining fields, where power could probably be generated economically. The best of these sites are on Kruzgamepa River at Salmon Lake, Kuzitrin River above Lanes Landing, and Kugruk River below Imuruk Lake. At all the points the low-water flow could be reinforced by storage, and the aggregate power on a continuous basis for a mining season of one hundred and twenty days could be at least 25,000 horsepower.

Little ditch work was carried on in Seward Peninsula in 1908 beyond the maintenance of the ditches already built. Two short ditches were built in the vicinity of Nome. One on Osborn Creek takes its water about 3 miles below the mouth of New Eldorado Creek, has a length of 4.2 miles, and a bottom width of 6 feet, and gives a pressure of about 130 feet. The old ditch from Last Chance Creek to Pioneer Gulch was extended to Bangor Creek, near the mouth of Jorosa Creek, where a pressure of nearly 200 feet is obtained. Water is taken from North Fork in a branch ditch and piped across Last Chance Creek to the main ditch; two small ditches from Bangor Creek are also included in the system. A few men were employed on the pipe line from Grand Central River and a small force of men and horses on the Grand Central branch of the Miocene ditch. In the Kougarok region no new work was undertaken. In the Fairhaven district the water was used from the Fairhaven and Candle ditches. (See pp. 392–396.)

The tunnel for sluicing the Iron Creek gravels into Kruzgamepa River, which has been described by Mr. Smith (pp. 322–323), will be watched with much interest. The plan of moving gravels through a flume on a low grade, using a large volume of water, is new to this district and, should it prove successful, may point the way to handling some of the extensive gravel deposits that carry low values.

SOUTHERN SEWARD PENINSULA.

DESCRIPTION OF AREA.

Southern Seward Peninsula is here taken as embracing the area from the coast to and including the Kigluaik Mountains. The region shows three types of topography—a coastal plain, an upland, and a mountain mass.

Bordering the coast line is an area of low relief, absent at Point Rodney, Cape Nome, and Topkok Head, but more than 10 miles wide back of the lagoon at Port Safety. This lowland is made up of wet moss-covered ground, rising with a gentle slope to an elevation of 200 or 300 feet at the southern margin of the upland.

The upland is made up of limestone and schist hills, ranging in elevation from a few hundred to over 2,000 feet. The general trend of the ridges is north and south, especially in the area back of Nome, and the streams flowing into Bering Sea are roughly parallel. This upland extends back about 30 miles from the coast and presents a steep escarpment toward a wide, gravel-filled valley that separates it from the mountain mass.

North of the depression the Kigluaik Mountains, locally known as the Sawtooth Range, rise abruptly, constituting a rugged east-west mass, sharply dissected, with serrated crest line. These mountains have been the center of local glaciation in recent times, and their valleys are characterized by cirques.

Nome River is the only stream which crosses the depression and brings water from the mountains to the vicinity of the rich placer ground near Nome. Hence its waters have been the most sought after for mining purposes, and the three largest ditches in this region have been built to divert them. West of Nome River the Sinuk follows this depression and collects the drainage from the south slope of the mountains, and the valley to the east is occupied by Salmon Lake and Kruzgamepa River, which flows in a broad sweep around the east end of the mountains to Imuruk Basin. The divides between the Nome and the Grand Central and Sinuk valleys are low—785 and 1,012 feet, respectively—a fact which makes it possible to divert water from the headwaters of these rivers to Nome River, where it can be carried in the existing ditches to the mines.

The mountains have a heavy precipitation, reaching as high as 50 to 60 inches a year for small areas, as indicated by run-off records, and are therefore an excellent source of water for mining purposes. The area south of the mountains has a rainfall of 15 to 25 inches, or fully twice that of the country north of the steep mountain wall.

In this region the flow of the streams comes in the early summer from the melting snow, and later from the rains. When the snowfall is heavy, as in 1907, it remains until some time in July, and if the rains come early the streams maintain a good flow all summer. In 1908 the snowfall was light and disappeared early, the ground became dry, and the rains were late, so that the run-off for July was small. In the mountains the snow is protected in the steep gorges and cirques, and remains well into the summer. The ground is generally frozen within a foot or two of the surface, a condition which prevents any water from being taken up as ground storage and causes the rains to run off immediately, producing rapid fluctuations of stage. The greatest regulating effect is produced by the limestone springs that occur on some streams, notably Hobson Creek, Moonlight Creek, Canyon Creek, Solomon and Grand Central rivers.

GAGING STATIONS.

The points in southern Seward Peninsula at which gages were established or measurements made in 1908 are given in the following list:

Gaging stations in southern Seward Peninsula, 1908.

Nome River drainage basin:
- Nome River above Miocene intake.
- Nome River below Pioneer intake.
- Hobson Creek at Miocene intake.
- Hobson Creek below Manila Creek.
- Miocene ditch at Black Point.
- Miocene ditch above Hobson Creek.
- Miocene ditch below Hobson Creek.
- Miocene ditch at flume.
- Campion ditch at Black Point.
- Seward ditch at intake.
- Pioneer ditch at intake.

Grand Central River drainage basin:
- Grand Central River below the forks.
- West Fork of Grand Central River at the forks.
- Crater Lake outlet.
- Thompson Creek.

Kruzgamepa River drainage basin:
- Kruzgamepa River at outlet of Salmon Lake.
- Kruzgamepa River above Iron Creek.
- Fox Creek at mouth of canyon.

Kruzgamepa River drainage basin—Con.
- Crater Creek.
- Big Creek.
- Iron Creek.
- Pass Creek.
- Smith Creek.

Solomon River drainage basin:
- Solomon River below Johns Creek.
- Solomon River below East Fork.
- East Fork ditch.
- Midnight Sun ditch.

Casadepaga River drainage basin:
- Casadepaga River below Moonlight Creek.
- Moonlight Creek at ditch intake.
- Lower Willow Creek above Ridgeway Creek.
- Canyon Creek below Boulder Creek.

American Creek drainage basin:
- American Creek below Auburn Ravine.
- American Creek below Game Creek.

NOME RIVER DRAINAGE BASIN.

Nome River is formed by the junction of Buffalo and Deep Canyon creeks, which have their sources in the Kigluaik Range. The principal tributaries are David, Sulphur, Darling, Buster, and Osborn creeks from the east, and Divide, Dorothy, Clara, and Hobson creeks from the west. Hobson Creek, the most important of these tributaries, is a short stream, but receives a large flow from limestone springs.

Four ditches have been built to divert water for mining purposes, and any additional water supply that may be obtained in other high-level streams can best be brought to the mines by way of the valley of Nome River.

The Miocene ditch has its intake on Nome River just below the mouth of Buffalo Creek and extends along the right bank of Nome River to the Ex. Here it forks, one branch delivering water to Glacier and Anvil creeks, the other to Dexter Creek and its tributaries. The ditch crosses and diverts the flow of Hobson Creek and several other small creeks. The David Creek lateral delivers water to Nome River above the intake, the Grouse Creek branch comes in at the flume, and the Glacier Creek branch enters at the Ex.

The Campion ditch has its intake on Buffalo Creek, about one-half mile above the mouth, and extends 4 miles to Dorothy Creek, into which its water is dropped. The Seward ditch has its intake just below the mouth of Dorothy Creek and receives much of its water supply from the Campion ditch. The Pioneer Nome River ditch takes its water about 3 miles below the Seward. Both of the latter ditches have laterals to Hobson Creek, and measurements of these laterals are given with those of that stream.

The total amount of water that can be made available for these ditches includes not only the discharge of Nome River itself, but also that of Grand Central River and some of its tributaries, which can be directed over the Nugget divide. (See p. 374.) These discharges have been summarized by weekly periods in the accompanying table. The amount available for use at elevation 400 to 450 feet includes all above the level of the Miocene ditch; that for use at elevation 220 to 280 feet includes all additional water down to the level of the Pioneer ditch. Sinuk River and its tributaries, Windy and North Star creeks, could also be made to furnish some water, but only by a rather long ditch line and at considerable expense. Their discharge at elevation 800 feet may be estimated at one-half that of upper Grand Central River, Thompson Creek, and Gold Run.

Mean weekly water supply, in second-feet, available for Nome River ditches, 1908.

Date.	For use at elevation 220 to 280 feet.	For use at elevation 400 to 450 feet.			Total.
	Nome River, low-level flow.	Nome River, high-level flow.	Upper Grand Central River, Thompson Creek, and Gold Run.	Nugget, Copper, and Jett creeks.	
June 17-23	98.7	124	....	24.8	248
June 24-30	64.4	83.2	....	16.6	164
July 1-7	25.0	32.3	132	5.8	195
July 8-14	18.5	24.9	89.2	4.0	137
July 15-21	14.6	18.5	64.4	3.0	100
July 22-28	16.0	14.0	45.1	2.2	77.3
July 29-August 4	49.1	83.9	148	15.1	296
August 5-11	107	62.7	159	11.3	340
August 12-18	91.5	61.8	182	11.1	346
August 19-25	70.2	77.8	218	14.0	380
August 26-September 1	62.4	69.2	154	12.4	298
September 1-8	44.0	58.5	99.3	10.5	212
September 9-15	38.3	40.3	56.0	7.3	142
September 16-22	29.5	33.7	49.4	6.1	119
Mean	52.1	56.1	116	10.3	218
Maximum	107	124	218	24.8	380
Minimum	14.6	14.0	45.1	2.2	77.3

Daily discharge, in second-feet, of Nome River and Hobson Creek, 1908.

Day.	Nome River at Miocene intake.[a] Elevation, 572 feet; drainage area, 15 square miles.				Nome River at Pioneer intake.[b] Elevation, 320 feet; drainage area, 38 square miles.			Hobson Creek at Miocene intake.[c] Elevation, 500 feet; drainage area, 2.6 square miles.			
	June.	July.	Aug.	Sept.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	......	23	35	38	53	94	117	......	14.3	6.7	12.8
2	......	17.3	26	42	44	50	104	......	11.1	6.6	12.5
3	......	18.3	34	39	41	53	90	......	10.6	6.4	12.5
4	......	17.2	142	35	38	202	82	......	8.5	6.7	12.5
5	......	17.3	96	33	37	476	75	......	8.2	8.8	12.7
6	......	18.7	57	33	35	192	73	......	8.1	9.1	12.7
7	......	16.8	32	31	35	102	69	......	7.8	10.2	13.0
8	......	13.3	25	29	33	75	68	......	8.7	8.5	12.1
9	......	11.6	19.4	27	32	63	65	......	7.6	7.9	11.8
10	......	9.8	17.6	24	27	62	62	......	7.9	8.0	11.0
11	......	12.7	33	20	29	85	58	......	7.5	8.7	11.1
12	......	24.3	65	20	36	190	58	......	6.2	9.6	10.6
13	......	16.3	40	20	32	185	61	......	6.9	10.3	10.2
14	......	10.8	46	18.4	26	166	53	......	7.3	11.7	9.8
15	......	8.5	31	23	22	120	61	......	7.2	11.4	9.9
16	......	8.4	28	22	22	84	63	......	7.1	12.3	9.5
17	......	9.9	27	22	20	81	54	......	7.6	11.9	8.1
18	......	9.7	25	22	20	76	48	......	7.6	12.2	7.4
19	......	8.6	48	21	19.4	128	48	13.8	7.7	12.5	7.1
20	......	8.7	66	18.3	21	93	46	12.0	6.6	12.8	7.3
21	82	9.0	43	17.5	21	47	44	10.0	6.9	12.0	6.2
22	76	7.1	36	16.0	20	83	46	10.0	6.6	12.4	6.8
23	85	6.1	42	......	18.8	144	......	10.0	6.4	13.1	6.5
24	67	6.8	47	......	19.1	213	......	10.0	6.6	13.1	......
25	54	6.3	54	......	19.2	164	......	12.0	6.6	14.1	......

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

[b] These values were found by subtracting the flow of the Nugget Creek and Jett Creek ditches from the actual flow of Nome River below Pioneer intake and adding the discharge of the Pioneer and Seward ditches and of the Miocene ditch at Clara Creek as estimated from the records at Black Point and above Hobson.

[c] These values were found by subtracting the discharge of the Miocene ditch above the dam from that below the dam; practically no water was spilled from the wasteway.

Daily discharge, in second-feet, of Nome River and Hobson Creek, 1908—Continued.

Day.	Nome River at Miocene intake. Elevation, 572 feet; drainage area, 15 square miles.				Nome River at Pioneer intake. Elevation, 320 feet; drainage area, 38 square miles.			Hobson Creek at Miocene intake. Elevation, 500 feet; drainage area, 2.6 square miles.			
	June.	July.	Aug.	Sept.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
26	75	6.5	45	......	19.1	142	......	12.3	6.2	14.1	......
27	49	6.5	42	......	19.1	104	......	12.6	6.0	14.1	......
28	47	6.3	36	......	18.9	85	......	13.3	5.7	14.1	......
29	29	6.1	34	......	18.9	84	......	14.1	5.7	13.8	......
30	31	66	32	......	121	79	......	15.7	6.2	14.4	......
31	......	93	61	......	316	140	......	......	6.3	13.1	......
Mean	59.5	16.2	44.0	26.0	39.8	125	65.7	12.2	7.5	11.0	10.2
Mean per square mile	3.97	1.08	2.97	1.73	1.05	3.29	1.73	4.69	2.88	4.23	3.92
Run-off, depth in inches	1.48	1.24	3.42	1.41	1.21	3.79	1.41	2.09	3.32	4.88	3.35

Discharge measurements of Hobson Creek below Manila Creek and diversions, 1908.

[Drainage area, 5.1 square miles.]

Point of measurement.	June 19.	July 10.	Aug. 12.	Sept. 1.
	Sec. ft.	*Sec. ft.*	*Sec. ft.*	*Sec. ft.*
Miocene intake	[a] 13.8	7.9	9.6	12.8
Seward lateral	7.1	3.1	6.1	5.3
Pioneer lateral	6.1	2.6	5.0	4.8
Desephan ditch	1.8	0	3.4	2.0
Hobson ditch below Manila Creek	8.4	5.0	3.3	5.2
	27.1	18.6	27.4	30.1

[a] Only 3.7 second-feet was diverted in the Miocene ditch.

Daily discharge, in second-feet, of Miocene ditch, 1908.

Day.	Miocene ditch at Black Point.				Miocene ditch above Hobson Creek.				Miocene ditch below Hobson Creek.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
1	......	30.1	38.8	42.2	......	19.3	28.3	32.7	......	33.6	35.0	45.5
2	......	20.8	28.6	42.2	......	15.7	23.8	33.0	......	26.8	28.0	45.5
3	......	16.4	26.4	42.2	......	11.4	22.4	33.0	......	22.0	26.5	45.5
4	......	14.5	31.3	42.2	......	9.3	25.3	33.0	......	17.8	28.0	45.5
5	......	14.2	36.4	38.8	......	8.4	30.4	31.1	......	16.6	39.2	43.8
6	......	13.1	42.2	34.5	......	7.9	31.1	28.6	......	16.0	40.2	41.3
7	......	12.5	41.2	32.6	......	6.6	30.4	28.6	......	14.4	40.6	41.6
8	......	9.7	33.5	33.5	......	4.7	28.3	29.2	......	13.4	36.8	41.3
9	......	8.8	29.8	30.4	......	5.3	25.0	27.4	......	12.9	32.9	39.2
10	......	7.4	27.0	29.5	......	4.1	25.0	26.8	......	12.0	29.8	37.8
11	......	7.8	40.5	26.4	......	4.1	29.8	23.2	......	11.6	38.5	34.3
12	......	13.6	42.2	23.2	......	8.8	31.7	21.6	......	15.0	41.3	30.8
13	......	9.9	42.2	26.7	......	6.8	31.7	23.8	......	13.7	42.0	34.0
14	......	8.5	42.2	22.9	......	4.1	31.7	19.6	......	11.4	43.4	29.4
15	......	7.4	42.2	29.2	......	3.4	32.4	24.4	......	10.6	43.8	34.3
16	......	6.9	37.4	28.8	......	2.7	30.4	28.3	......	9.8	42.7	37.8
17	......	6.7	35.8	24.9	......	1.4	30.1	26.2	......	9.0	42.0	34.3
18	......	6.6	36.4	22.3	......	1.4	29.8	22.4	......	9.0	42.0	29.8
19	......	5.5	42.2	22.9	......	.5	33.0	21.6	5.7	8.2	45.5	28.7
20	......	5.8	42.2	20.4	......	.8	32.4	20.4	8.3	7.4	45.2	27.7
21	......	5.0	0	20.4	......	.8	0	18.2	10.0	7.7	12.0	24.4
22	......	4.2	42.2	20.1	......	.2	32.4	18.2	10.0	6.8	44.8	25.0
23	......	4.1	42.2	......	......	.1	32.4	15.4	10.0	6.5	45.5	13.4
24	12.9	4.3	42.2	......	......	.1	32.4	......	10.0	6.7	45.5	......
25	22.3	4.3	42.2	......	15.4	.1	31.4	......	12.0	6.7	45.5	......

Daily discharge, in second-feet, of Miocene ditch, 1908—Continued.

Day.	Miocene ditch at Black Point.				Miocene ditch above Hobson Creek.				Miocene ditch below Hobson Creek.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.
26	24.0	4.3	42.2	......	15.7	0	31.4	......	28.0	6.2	45.5	......
27	24.0	4.3	42.2	......	15.4	0	31.4	......	28.0	6.0	45.5	......
28	28.8	3.8	42.2	......	18.2	0	31.4	......	31.5	5.7	45.5	......
29	27.6	3.8	42.2	......	21.6	0	31.4	......	35.7	5.7	42.0	......
30	31.0	31.3	38.8	......	22.1	10.4	30.4	......	37.8	14.4	44.8	......
31	......	37.1	42.2	......	......	28.0	32.7	......	......	34.3	45.8	......
Mean	24.4	10.7	37.3	29.8	18.1	5.4	29.0	25.5	18.9	12.8	39.5	35.3

Daily discharge, in second-feet, of Campion, Seward, and Pioneer ditches, 1908.

Day.	Campion ditch at Black Point.				Seward ditch at intake.				Pioneer ditch at intake.		
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	July.	Aug.	Sept.
1	......	9.6	7.1	5.0	......	22.6	27.8	34.0	17.0	20.5	33.3
2	......	9.6	6.7	11.2	......	18.9	18.9	34.0	16.0	14.3	34.1
3	......	9.8	11.0	9.6	......	18.9	19.6	34.0	15.0	14.0	30.5
4	......	8.8	0	8.4	......	17.6	22.6	30.6	14.0	23.7	26.9
5	......	8.2	0	10.2	......	16.3	30.6	27.8	13.4	33.3	24.9
6	......	7.3	0	12.3	......	15.0	34.0	29.0	12.5	31.7	24.1
7	......	6.3	13.9	9.6	......	15.0	34.0	26.2	12.5	30.5	22.5
8	......	5.4	11.6	9.2	......	14.7	29.0	25.8	12.5	23.7	20.9
9	......	4.9	9.6	9.0	......	14.7	23.8	24.6	11.6	18.8	20.5
10	......	4.7	11.6	8.2	......	10.7	23.4	21.8	11.3	17.7	19.8
11	......	7.7	13.4	7.3	......	13.7	34.0	21.1	11.0	26.9	18.8
12	......	13.9	0	7.3	......	16.3	34.0	21.8	11.0	38.1	18.8
13	......	9.2	7.0	7.0	......	15.0	34.0	21.8	9.5	34.5	19.1
14	......	6.5	17.8	6.7	......	12.4	34.0	18.2	8.3	32.5	18.8
15	......	5.2	13.2	7.3	......	10.4	34.0	23.8	7.8	32.5	17.7
16	......	4.9	12.1	8.2	......	9.6	31.9	22.6	8.0	28.9	17.7
17	......	4.9	11.2	8.2	......	9.0	29.0	17.9	8.0	28.5	16.7
18	4.0	4.9	10.8	7.3	......	9.0	28.2	15.6	7.6	24.1	15.5
19	6.0	4.2	0	7.0	......	9.0	34.0	16.3	8.0	34.5	15.2
20	7.3	4.1	14.4	6.7	31.1	9.6	34.0	15.6	8.6	32.5	14.0
21	11.2	4.2	13.9	5.7	29.4	9.3	34.0	16.9	8.3	27.7	12.5
22	11.2	3.1	13.4	......	29.8	9.0	34.0	16.6	7.6	25.3	......
23	13.6	2.8	10.8	......	29.8	8.8	34.0	15.0	7.0	33.3	......
24	12.1	3.3	10.8	......	29.8	9.0	34.0	......	7.0	33.3	......
25	11.2	3.3	12.1	......	29.8	9.0	34.0	......	7.0	32.5	......
26	13.0	3.3	13.6	......	29.0	9.0	34.0	......	7.0	32.5	......
27	10.4	3.3	13.0	......	29.8	9.0	34.0	......	7.0	33.3	......
28	10.2	2.9	11.9	......	29.8	9.0	34.0	......	7.0	28.9	......
29	10.8	2.7	11.2	......	27.4	8.8	34.0	......	7.0	26.9	......
30	11.2	0	10.8	......	28.2	31.5	31.9	......	27.7	25.3	......
31	......	7.0	0	......	......	32.3	34.0	......	29.3	34.9	......
Mean	10.2	5.7	9.4	8.2	29.4	13.6	31.1	23.1	11.1	28.2	21.1

GRAND CENTRAL RIVER DRAINAGE BASIN.

Grand Central River rises in the heart of the Kigluaik Mountains, where the peaks reach an elevation of 3,000 to 4,500 feet. The river and its tributaries head in glacial cirques and flow through U-shaped valleys over broad gravel beds. North Fork rises on the east side of Mount Osborn, the highest peak of the range; West Fork rises to the south of the same mountain, and the two forks join at elevation 690 feet. West Fork receives the waters of Crater Lake, a glacial lake having an area of 43 acres, through a short tributary from the south. About 3 miles below the junction of the forks the river is joined by the two principal tributaries, Thompson Creek from the west and Gold Run from the east. From this point the river flows southeastward into Salmon Lake.

In order to make the waters of Grand Central River available for use near Nome, they must be carried over the Nugget divide, which has an elevation of 785 feet. The diversion must be made about a mile above the forks and 8 or 9 miles of ditch will be required. There are two waterways being built to divert this water—a 42-inch wood pipe line, starting at Crater Lake, with laterals taking water from North Fork at about elevation 1,030 feet and from West Fork at elevation 1,010 feet, and a ditch 8 feet wide on the bottom with a 5-foot bank, having its intake on the forks at an elevation of about 850 feet.

Daily discharge, in second-feet, of Grand Central River and tributaries, 1908.

Day.	Grand Central River below the forks. Elevation, 680 feet; drainage area, 14.6 square miles.			West Fork of Grand Central River at the forks. Elevation, 690 feet; drainage area, 7.7 square miles.			Crater Lake outlet. Elevation, 925 feet; drainage area, 1.8 square miles.			Thompson Creek, Elevation, 720 feet; drainage area, 2.5 square miles.		
	July.	Aug.	Sept.	July.	Aug.	Sept.	July.	Aug.	Sept.	July.	Aug.	Sept.
1	115	72	146	70	67	60	20	21	11.5	32	18	17
2	105	80	125	62	48	58	18	9.0	10.5	29	13	11.0
3	95	80	108	55	60	48	16	18	9.0	26	13	11.0
4	85	99	90	48	77	43	14	21	7.8	24	18	9.0
5	80	225	71	40	170	36	12	63	5.0	21	35	7.0
6	70	150	62	35	101	34	11	30	4.5	18	25	6.0
7	60	123	55	32	60	32	10	14	4.0	16	13	5.2
8	57	91	50	28	60	31	8.4	11.5	3.5	14	11.0	5.2
9	43	80	48	25	43	30	7.5	11.5	3.0	9.4	9.0	5.2
10	43	80	46	25	36	29	6.9	9.0	3.0	9.4	9.0	5.0
11	65	80	44	35	36	29	9.0	9.0	3.0	16	9.0	5.0
12	106	210	44	77	170	29	21	40	3.0	25	35	4.8
13	58	180	44	36	112	29	14	26	2.9	13	22	4.6
14	52	123	44	26	87	29	11.5	21	2.9	10.2	18	4.4
15	50	99	44	25	60	29	9.0	14	2.9	9.0	13	4.2
16	46	123	43	25	60	28	7.8	14	2.8	9.8	16	3.9
17	46	99	42	25	48	27	8.4	9.0	2.7	9.8	9.0	3.7
18	46	90	41	26	48	26	9.0	9.0	2.6	11.0	9.0	3.5
19	43	150	40	22	94	26	8.7	21	2.5	11.0	35	3.3
20	41	150	40	22	77	26	7.5	14	2.5	9.0	18	3.1
21	41	123	39	22	60	25	7.5	14	2.4	7.5	13	2.9
22	36	99	38	21	60	24	7.5	9.0	2.3	6.9	9.0	2.8
23	33	180	37	18	94	23	6.0	21	2.2	6.0	42	2.7
24	33	195	36	20	60	22	6.9	21	2.1	6.0	50	2.6
25	33	169	35	18	87	22	5.6	20	2.1	6.0	35	2.5
26	31	132	33	18	77	22	5.2	14	1.9	5.6	18	2.3
27	29	132	33	18	60	22	5.0	14	1.9	6.0	13	2.3
28	29	88	33	20	29	22	5.0	9.0	1.9	6.0	9.0	2.3
29	29	71	33	20	22	22	5.6	7.5	1.9	6.0	9.0	2.3
30	180	71	33	130	22	22	30	6.0	1.9	50	8.7	2.3
31	165	160	......	170	80	......	63	14	......	42	25	......
Mean	62.7	123	52.6	39.2	69.8	30.2	12.2	17.2	3.7	15.2	18.7	4.9
Mean per square mile	4.29	8.42	3.60	5.09	9.06	3.92	6.78	9.56	2.06	6.08	7.48	1.96
Run-off, depth in inches	4.95	9.71	4.02	5.87	10.4	4.37	7.82	11.0	2.30	7.01	8.62	2.19

NOTE.—Discharges from September 6 to 30 are based on gage readings taken about five days apart; from July 1 to 7 they are estimated by comparison with Salmon Lake; at other times the gages were read daily.

KRUZGAMEPA RIVER DRAINAGE BASIN.

Kruzgamepa or Pilgrim River heads in Salmon Lake and, after traversing a valley filled with glacial débris, flows around the east end of the Kigluaik Mountains and through broad flats to Imuruk Basin. Its principal tributaries are Iron and Sherrette creeks from the south; Crater, Big, and Homestake creeks from the southern slope of the Kigluaik Mountains; and Goldengate, Pass, Smith, Grand Union, and several unnamed creeks from the northern slope of the mountains. The Kruzgamepa offers excellent opportunities for power development at Salmon Lake and at other points lower down.

Daily discharge, in second-feet, of Kruzgamepa River, 1908.

Day.	At outlet of Salmon Lake. Elevation 442 feet; drainage area, 81 square miles.							Above Iron Creek. Elevation, 250 feet; drainage area, 150 square miles.			
	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	June.	July.	Aug.	Sept.
1	......	375	295	210	99	70	67	......	536	681	456
2	......	355	275	210	87	70	67	......	476	576	425
3	......	335	242	210	92	68	67	......	445	566	425
4	......	295	242	210	96	68	67	......	395	735	410
5	......	275	418	210	103	68	67	......	370	808	385
6	......	242	465	196	92	67	67	......	338	533	365
7	......	226	395	182	89	67	67	......	324	456	345
8	......	210	355	182	86	67	67	......	320	450	345
9	......	196	295	182	86	67	67	......	304	425	336
10	......	182	258	169	84	67	67	......	284	375	309
11	......	182	258	156	82	67	67	......	288	400	296
12	......	196	315	156	79	67	67	......	278	472	264
13	......	182	335	156	78	68	67	......	262	560	264
14	......	182	335	156	73	68	67	......	242	506	264
15	......	169	335	156	76	68	67	......	230	472	284
16	......	156	315	156	76	70	(a)	......	226	445	300
17	......	156	295	156	74	70	......	......	223	425	304
18	......	156	258	156	73	70	......	......	220	405	260
19	......	144	258	156	73	68	......	......	216	400	260
20	......	132	258	144	73	68	......	......	220	415	236
21	550	144	242	144	73	68	......	......	216	395	252
22	465	132	242	144	73	68	......	602	206	385	244
23	465	132	242	132	73	68	......	586	202	420	228
24	465	132	258	110	72	68	......	597	195	533	228
25	440	121	275	101	73	68	......	663	186	500	214
26	465	121	275	92	73	68	......	636	177	478	224
27	440	110	258	101	73	68	......	674	171	456	207
28	465	92	242	99	74	68	......	652	171	425	190
29	418	92	242	97	76	68	......	614	165	415	178
30	395	110	226	97	74	68	......	570	342	385	169
31	......	226	210	......	73	......	......	......	808	400	......
Mean	457	186	288	154	80.0	68.1	67.0	622	291	481	289
Mean per square mile	5.64	2.30	3.56	1.90	.99	.84	.83	4.15	1.94	3.21	1.93
Run-off, depth in inches	2.10	2.65	4.10	2.12	1.14	.94	.46	1.39	2.24	3.70	2.15

[a] The river was frozen over after about December 15, but the discharge probably remained nearly constant.

Daily discharge, in second-feet, of Iron and Pass creeks, 1908.

Day.	Iron Creek near mouth. Elevation, 280 feet; drainage area, 50 square miles.				Pass Creek. Elevation, 1,100 feet.		Day.	Iron Creek near mouth. Elevation, 280 feet; drainage area, 50 square miles.				Pass Creek. Elevation, 1,100 feet.	
	June.	July.	Aug.	Sept.	July.	Aug.		June.	July.	Aug.	Sept.	July.	Aug.
1	......	73	59	55	......	52	21	......	21	46	44	22	......
2	......	39	40	51	......	36	22	112	21	45	35	20	......
3	......	42	38	50	......	24	23	97	20	73	32	20	......
4	......	37	38	46	......	32	24	122	19	68	38	14	......
5	......	37	213	44	......	82	25	108	19	59	30	17	......
6	......	37	70	43	......	46	26	87	19	53	35	15	......
7	......	34	52	45	......	36	27	101	20	49	38	15	......
8	......	34	44	45	......	32	28	99	19	47	40	15	......
9	......	32	43	43	......	30	29	67	19	46	31	15	......
10	......	28	38	40	24	30	30	80	146	44	25	82	......
11	......	29	46	40	32	30	31	......	202	59	......	82	......
12	......	29	55	36	53	64							
13	......	26	64	34	29	41	Mean	97.0	37.6	57.4	40.0	28.9	38.3
14	......	26	64	33	28	28							
15	......	24	55	33	28	36							
16	......	23	68	42	26	32	Mean per square mile	1.94	.75	1.15	.80	......	......
17	......	24	49	42	26	28							
18	......	23	46	50	24	30							
19	......	23	58	40	24	......	Run-off, depth in inches	.65	.86	1.33	.89	......	......
20	......	21	49	41	24	......							

Miscellaneous measurements in Kruzgamepa River drainage basin, 1908.

Date.	Stream and locality.	Elevation.	Discharge.
		Feet.	*Sec.-ft.*
June 21	Crater Creek 2 miles above mouth	550	76
July 17	Big Creek at edge of mountains	....	14
July 18	Iron Creek below Canyon Creek	425	23
July 20	Smith Creek	950	47
August 18	.....do	950	40
September 5	Fox Creek at mouth of canyon	550	26

SOLOMON RIVER DRAINAGE BASIN.

Solomon River empties into Bering Sea at Solomon, 40 miles east of Nome. This stream has been a good producer of gold, and several ditches have been built to utilize its water and that of its tributaries, including the East Fork ditch, the Midnight Sun ditch from Big Hurrah Creek, the Brogan ditch from the mouth of Johns Creek to East Fork, and a ditch about 7 miles long on Coal Creek. A ditch has been started by the Three Friends Mining Company to furnish power for its dredge at Oro Fino. It will take water from the river just below East Fork and extend to a point below the mouth of Shovel Creek, where a head of 75 feet will be available.

Daily discharge of Solomon River below East Fork, 1908.

[Elevation, 140 feet; drainage area, 66 square miles.]

Day.	July.	Aug.	Sept.	Day.	July.	Aug.	Sept.
1	130	164	105	20	44	100	....
2	100	115	100	21	43	90	....
3	75	95	95	22	44	90	....
4	72	223	90	23	43	130	....
5	70	626	85	24	44	120	....
6	69	280	82	25	43	115	....
7	69	150	82	26	41	107	....
8	62	112	80	27	40	93	....
9	76	110	78	28	43	90	....
10	72	110	75	29	43	85	....
11	70	120	75	30	360	85	....
12	76	140	72	31	638	110	....
13	63	170	70				
14	65	140	70	Mean	89.3	140	83.8
15	61	120	70	Mean of East Fork			
16	58	110	85	ditch	6.7	10	12.2
17	58	110	100	Mean total	96.0	150	96.0
18	50	110	93	Mean per square mile	1.45	2.27	1.45
19	47	105	....	Run-off, depth in inches	1.67	2.62	.97

NOTE.—The above values are approximate, on account of lack of sufficient measurements and gage readings, and the shifting character of the stream bed.

Miscellaneous measurements in Solomon River drainage basin, 1908.

Date.	Stream and locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 4	Solomon River below Johns Creek	245	60	40	1.50
July 12	do	245	37	40	.92
August 6	do	245	190	40	4.75
August 27	do	245	61	40	1.52
September 18	do	245	57	40	1.42
July 4	East Fork ditch near mouth of East Fork	290	11.9	....	....
July 12	do	290	0	....	....
August 6	do	290	7.5	....	....
August 27	do	290	12.6	....	....
September 18	do	290	12.7	....	....
September 18	Midnight Sun ditch near mouth of Big Hurrah Creek	160	18.6	....	....

CASADEPAGA RIVER DRAINAGE BASIN.

Casadepaga River, the largest western tributary of the Niukluk, rises south of Iron Creek and joins the main stream about 15 miles above Council. Its principal tributaries are Willow, Curtis, Ruby, Penelope, and Big Four creeks from the southeast, and Moonlight, Lower Willow, Canyon, and Goose creeks from the northwest. Placer gold has been found widely distributed in its basin and considerable mining has been done from Ruby Creek to the mouth of the river, but the total output has probably not been large. Several ditches have been built to obtain water for hydraulicking. There are two on Canyon Creek and one on Moonlight, Ruby, Penelope, and Goose creeks. There are many limestone springs in this basin, notably on Moonlight and Canyon creeks.

Daily discharge of Casadepaga River below Moonlight Creek, 1908.

[Elevation, 400 feet; drainage area, 47 square miles.]

Day.	July.	Aug.	Sept.	Day.	July.	Aug.	Sept.
1	110	76	60	19	30	56	....
2	70	56	55	20	36	56	....
3	66	56	52	21	36	42	....
4	100	100	50	22	30	42	....
5	100	246	50	23	25	75	....
6	66	300	50	24	25	70	....
7	56	76	50	25	20	70	....
8	56	56	50	26	20	66	....
9	56	56	49	27	20	60	....
10	49	56	48	28	20	55	....
11	49	76	45	29	20	52	....
12	49	76	42	30	1,080	50	....
13	49	127	40	31	420	70	....
14	42	76	38				
15	42	76	42	Mean	92.1	78.7	51.9
16	36	56	50	Mean per square mile	1.96	1.67	1.10
17	42	56	88	Run-off, depth in inches	2.26	1.93	.74
18	36	56	76				

NOTE.—At times there was a little water diverted past the station in the Moonlight Creek ditch.

Miscellaneous measurements in Casadepaga River drainage basin, 1908.

Date.	Stream and locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 3	Moonlight Creek at ditch intake	485	8.0	0.8	(a)
July 12	.....do	485	7.6	.8	(a)
August 5	.....do	485	17.0	.8	(a)
August 26	.....do	485	10.2	.8	(a)
September 17	.....do	485	6.5	.8	(a)
August 4	Lower Willow Creek above Ridgeway Creek	400	[b] 6.0	15.4	0.39
August 26	.....do	400	10.4	15.4	.68
September 17	.....do	400	17.0	15.4	1.10
July 11	Canyon Creek below Boulder Creek	355	15.4	22	.70
August 3	.....do	355	11.0	22	.50
August 25	.....do	355	21.9	22	1.00
September 17	.....do	355	27.0	22	1.23

[a] The discharge of Moonlight Creek comes from large limestone springs, having their source outside of the drainage basin of the creek.
[b] Estimated.

AMERICAN CREEK.

American Creek rises in the hills lying to the west of the area mapped as the Casadepaga quadrangle. About 8 miles from its head it flows through a canyon 2 miles long and nearly 400 feet deep in places. Below this canyon it enters the lowland area east of Kruzgamepa River and skirts along the edge of the hills to its junction with the Niukluk. In its upper portion it has a fairly wide, gravelly bed and a considerable amount of fall. Its principal tributaries are Auburn Ravine and Game Creek, both from the south. Some prospecting has been done on American Creek and its tributaries, but very little mining.

Discharge measurements of American Creek, 1908.

Date.	Point of measurement.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 9	Below Auburn Ravine	600	2.0	13	0.15
July 18	do	600	1.2	13	.092
August 3	do	600	2.0	13	.15
September 17	do	600	7.2	13	.55
July 9	Below Game Creek	480	5.7	24	.24
July 18	do	480	2.6	24	.11
August 25	do	480	5.9	24	.25

CENTRAL SEWARD PENINSULA.

DESCRIPTION OF AREA.

The central portion of Seward Peninsula, lying north of the Kigluaik and Bendeleben mountains, shows two types of topography—(1) a lowland area 10 to 15 miles wide, lying at the foot of the mountains, and (2) an upland, with flat-topped ridges rising to an elevation of 1,000 to 1,600 feet, representing a former level of erosion. Several mountain masses rise above the level of the plateau, notably Kougarok, Midnight, and Baldy mountains. The streams have cut their channels deep into this plateau, and one or more levels of benches can usually be traced above the present streams. The principal streams are Kuzitrin River and its tributaries Kougarok and Noxapaga rivers.

This region is an area of low precipitation, especially in the early summer, and as there is no unfrozen ground the discharge is very small at low water.

GAGING STATIONS.

The points in central Seward Peninsula at which gages were established or measurements made in 1908 are given in the following list:

Gaging stations in central Seward Peninsula, 1908.

Kuzitrin River drainage basin:
- Kuzitrin River at Lanes Landing.
- Birch Creek at elevation about 400 feet.

Kougarok River drainage basin:
- Kougarok River at Homestake intake.
- Kougarok River above Coarse Gold Creek.
- Macklin Creek at mouth.
- Henry Creek at mouth.
- Coarse Gold Creek at mouth.

Kougarok River drainage basin—Cont'd.
- North Fork above Eureka Creek.
- Windy Creek above Anderson Gulch.
- Homestake ditch at intake.
- Homestake ditch at penstock.
- Windy Creek ditch above Anderson Gulch.

Noxapaga River drainage basin:
- Noxapaga River above Goose Creek.
- Turner Creek at intake.
- Boulder Creek at claim No. 5.

KUZITRIN RIVER DRAINAGE BASIN.

Kuzitrin River is formed by the junction of North and South forks, which rise in the lava beds in the central portion of Seward Peninsula. Below their junction the river crosses the Kuzitrin Flats, a lowland area 20 miles long and averaging over 10 miles in width, lying north of the Bendeleben Mountains. The valley narrows to less than half a mile just above Lanes Landing, but widens as the river enters the lowland lying around Imuruk Basin. In the lower 10 miles of its course the Kuzitrin mingles its waters with those of the Kruzgamepa in an intricate network of channels and sloughs. The principal tributaries are Minnie, Ella, Bonanza, Birch, and Belt creeks from the Bendeleben Mountains on the south and Noxapaga River, Garfield Creek, and Kougarok River from the plateau region to the north.

A measurement made of Birch Creek at elevation about 400 feet, July 30, gave a discharge of 122 second-feet.

Daily discharge, in second-feet, of Kuzitrin River at Lanes Landing, 1908.

[Elevation, 40 feet; drainage area, 1,720 square miles.]

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	5,900	870	955	385	19	2,860	345	310	480
2	5,900	790	752	408	20	2,640	328	365	455
3	5,900	680	680	385	21	1,640	310	345	430
4	6,560	645	408	408	22	1,520	328	345	385
5	6,180	715	680	430	23	1,300	310	345	385
6	6,940	530	1,040	385	24	1,460	328	385	328
7	6,360	505	1,140	408	25	1,520	295	408	295
8	4,840	430	1,000	408	26	1,580	295	408	250
9	4,330	430	752	365	27	1,460	280	385	250
10	3,850	430	715	365	28	1,300	280	365	250
11	3,690	408	505	345	29	1,090	265	345	250
12	3,770	408	480	328	30	912	280	345	250
13	3,770	430	480	310	31	....	680	345	......
14	3,690	408	480	328					
15	3,690	385	430	310	Mean	3,490	433	528	357
16	3,770	345	408	310	Mean per square mile	2.03	0.25	0.30	0.21
17	3,160	345	385	365	Run-off, depth in				
18	3,080	345	385	455	inches	2.26	.29	.35	.23

NOTE.—Discharges for June are very uncertain, as no high-water measurements were obtained.

KOUGAROK RIVER DRAINAGE BASIN.

Kougarok River drains a large area lying in the central portion of Seward Peninsula and empties into the Kuzitrin about 8 miles above Lanes Landing. It rises southeast of Kougarok Mountain and flows northward, then eastward, and after making a sharp bend to the right, a little east of south to its mouth. The largest tributaries are Taylor Creek and North Fork from the east and Henry, Coarse Gold, and Windy creeks from the west. Of less importance are Washington, Columbia, Macklin, Homestake, Goose, California, Arctic, Arizona, Louisa, Galvin, and Dan creeks and Left Fork. Quartz Creek, which empties into the river below those named above, and its tributaries, Coffee, Dahl, Checkers, Carrie, and Independence creeks, have been the most important gold producers of the region, but have a very small run-off except at times of heavy rain.

Several ditches have been built to divert water of the river and its tributaries for hydraulicking. The largest are the Homestake ditch, on the upper Kougarok, the North Star and Cascade ditches, on Taylor Creek; and the Henry Creek and Coarse Gold Creek ditches. There are smaller ditches on Arizona Creek, North Fork, and Windy Creek.

The amount of water available for the principal ditches in the Kougarok River drainage basin, built and proposed, is summarized by weekly periods in the following table:

Mean weekly water supply, in second-feet, of Kougarok River drainage basin, 1908.

Date.	For Dahl Creek at elevation 300 feet.			For upper Kougarok, at elevation 550 to 650 feet.				
	Kougarok River.	North Fork.	Total.	Kougarok River.	Taylor Creek.[a]	Henry Creek.	Coarse Gold Creek.[b]	Total.
July 1-7	57.7	33.9	91.6	11.6	9.8	18.1	8.1	47.6
July 8-14	29.0	11.8	40.8	5.2	5.3	8.6	3.6	22.7
July 15-21	24.1	9.1	33.2	4.1	5.1	5.5	2.9	17.6
July 22-28	17.7	8.1	25.8	3.1	4.0	3.3	2.2	12.6
July 29-Aug. 4	27.7	8.1	35.8	5.0	6.3	4.6	3.5	19.4
August 5-11	40.0	10.2	50.2	5.8	8.8	9.2	4.1	27.9
August 12-18	27.0	8.6	35.6	4.5	6.5	4.0	3.2	18.2
August 19-25	30.4	8.2	38.6	5.8	6.6	5.7	4.1	22.2
August 25-September 1	33.7	8.2	41.9	6.3	7.8	5.2	4.4	23.7
September 2-8	47.4	8.5	55.9	11.7	9.8	7.8	8.2	37.5
Mean	33.5	11.5	45.0	6.3	7.0	7.2	4.4	24.9
Maximum	57.7	33.9	91.6	11.7	9.8	18.1	8.2	47.6
Minimum	17.7	8.1	25.8	3.1	4.0	3.3	2.2	12.6

[a] These values are estimated from the discharges at other points; about 75 per cent of the discharge is available for the North Star ditch, the remainder for the Cascade ditch.
[b] Estimated.

Daily discharge, in second-feet, of Kougarok River below Homestake intake and of Homestake ditch at intake, 1908.

[Elevation, 635 feet; drainage area, 44 square miles.]

Day.	June.		July.		August.		September.	
	River.	Ditch.	River.	Ditch.	River.	Ditch.	River.	Ditch.
1			15.6	3.1	5.6	8.3	1.2	11.5
2			11.2	5.6	.3	3.6	1.2	7.2
3			3.7	5.8	.4	3.3	6.8	10.6
4			3.2	5.6	.3	3.9	6.2	13.7
5			2.7	4.3	.3	8.6	1.8	9.3
6			7.2	2.9	.3	8.3	1.5	6.2
7			6.7	3.9	.3	7.8	3.1	7.2
8			1.8	4.3	4.1	.0	3.4	3.9
9			1.2	3.9	3.4	.0	2.8	2.9
10			1.2	3.9	.3	3.7	1.2	.0
11			1.1	4.5	.3	3.3		
12			1.1	3.9	.0	2.3		
13			1.2	3.9	.0	2.0		
14			1.1	3.6	.0	2.0		
15			1.1	3.6	.0	10.6		
16			1.1	3.6	.0	7.6		
17			1.1	3.9	.0	4.3		
18			.8	2.9	.0	2.9		
19			.6	2.9	.0	2.6		
20			.6	2.6	.4	10.9		

Daily discharge, in second-feet, of Kougarok River below Homestake intake and of Homestake ditch at intake, 1908—Continued.

Day.	June.		July.		August.		September.	
	River.	Ditch.	River.	Ditch.	River.	Ditch.	River.	Ditch.
21	......	......	.9	2.9	.1	6.0	......	......
22	......	......	.8	2.6	.1	3.6	......	......
23	......	......	.8	2.6	.1	3.9	......	......
24	......	......	.6	2.3	.1	6.5	......	......
25	......	......	.5	2.3	.1	6.5	......	......
26	......	......	.4	2.3	.4	12.1	......	......
27	0.41	9.1	.5	2.6	.0	6.5	......	......
28	.36	5.3	.4	2.8	.5	3.4	......	......
29	.22	14.0	.4	2.6	.5	2.8	......	......
30	.32	.0	.4	2.6	.4	2.0	......	......
31	......	......	.5	2.6	.5	2.6	......	......
Mean	32.8	7.1	2.3	3.4	.61	4.9	2.9	7.3
Mean total	39.9		5.7		5.5		10.2	
Mean per square mile	.91		.13		.125		.23	
Run-off, depth in inches	.14		.15		.14		.09	

Daily discharge, in second-feet, of Kougarok River and tributaries, 1908.

Day.	Kougarok River above Coarse Gold Creek. Elevation, 356 feet; drainage area, 250 square miles.				Henry Creek at mouth. Elevation, 410 feet; drainage area, 50 square miles.				North Fork above Eureka Creek. Elevation, 370 feet; drainage area, 66 square miles.			
	June.	July.	Aug.	Sept.	June.	July.	Aug.	Sept.	June.	July.[a]	Aug.	Sept.
1	......	96	36	51	......	42	13.4	9.3	......	8.4	8.1	8.8
2	......	76	32	51	......	35	6.6	13.4	......	50.0	7.8	8.8
3	......	49	28	57	......	26	5.5	12.9	......	43.0	7.8	8.6
4	......	49	32	65	......	26	7.8	12.4	......	37.0	8.4	8.4
5	......	49	36	57	......	19.7	14.4	11.4	......	37.0	8.8	8.4
6	......	44	54	44	......	17.0	19.0	10.3	......	37.0	11.6	8.4
7	......	41	57	32	......	15.7	18.4	9.2	......	25.1	11.4	8.4
8	......	36	39	26	......	13.4	18.4	8.2	......	15.0	10.3	8.4
9	......	32	36	28	......	12.9	9.8	6.8	......	12.5	9.7	8.1
10	......	26	30	21	......	11.8	6.6	5.4	......	12.5	9.9	......
11	......	30	28	15	......	13.4	5.5	4.1	......	11.6	9.7	......
12	......	32	26	13	......	12.6	5.5	......	......	10.3	9.9	......
13	......	26	30	......	......	11.8	5.5	......	......	10.3	9.2	......
14	......	21	23	......	......	10.5	6.0	......	......	10.3	8.4	......
15	......	23	26	......	......	9.3	6.6	......	......	10.3	8.1	......
16	......	17	30	......	......	8.5	5.9	......	......	9.4	8.1	......
17	......	32	28	......	......	8.5	5.4	......	......	9.2	8.1	......
18	......	28	26	......	......	7.6	4.9	......	......	9.5	8.1	......
19	......	23	26	......	......	6.6	4.4	......	......	8.4	8.1	......
20	......	23	23	......	......	6.6	9.3	......	......	8.1	8.1	......
21	......	23	28	......	......	7.4	8.8	......	......	8.4	7.9	......
22	......	19	44	......	......	5.9	8.3	......	......	8.4	8.1	......
23	......	26	39	......	......	5.5	7.8	......	......	8.4	8.4	......
24	......	21	30	......	......	4.7	9.3	......	......	8.4	8.4	......
25	......	15	23	......	......	4.5	9.0	......	......	7.9	8.1	......
26	285	17	30	......	......	4.3	8.8	......	......	7.8	8.2	......
27	150	13	36	......	154	4.1	8.5	......	......	7.8	8.1	......
28	166	13	32	......	64	3.9	7.4	......	......	7.8	7.9	......
29	112	17	23	......	57	3.7	5.9	......	37.0	7.6	7.9	......
30	96	21	28	......	50	3.5	4.9	......	9.9	8.1	7.8	......
31	......	28	36	......	......	5.9	7.6	......	......	8.6	9.0	......
Mean	162	31.2	32.1	38.3	81.2	11.9	8.6	9.4	23.4	15.0	8.7	8.5
Mean per square mile	.65	.12	.13	.15	1.62	.24	.17	.19	.35	.23	.13	.13
Run-off, depth in inches	.12	.14	.15	.07	.24	.28	.20	.08	.03	.27	.15	.04

[a] Most of the discharge from July 2 to 7 came from the melting of the ice bed just above the station.

Miscellaneous measurements in Kougarok River drainage basin, 1908.

Date.	Stream and locality.	Discharge.
		Sec.-ft.
June 27	Macklin Creek at mouth	3.8
June 26	Coarse Gold Creek at mouth	30
June 28	do	35
July 26	do	1.4
June 25	Windy Creek above Anderson Gulch, including ditch	15.2
June 29	do	8.5
July 24	do	2.1
September 11	do	2.0
June 27	Homestake ditch above penstock	5.8
June 28	do	8.3
September 10	do	.8
June 25	Windy Creek ditch above Anderson Gulch	2.1
July 24	do	1.3

NOXAPAGA RIVER DRAINAGE BASIN.

Noxapaga River is the largest tributary of the Kuzitrin and enters that stream from the north about 15 miles above the mouth of the Kougarok. The northwestern portion of its basin resembles that of Kougarok River, which it adjoins. An extensive lava flow covers the eastern portion, and the southern or lower end lies in the lowland area known as the Kuzitrin Flats.

Above the mouth of Goose Creek the river has been crossed by a recent lava flow that forms rapids in which there is a descent of 96 feet in 2.3 miles. Above the rapids the river has hardly any fall for several miles.

During 1907 a ditch was built by the McKay Hydraulic Mining Company from Turner Creek, a tributary to the Noxapaga from the northwest, to benches on the river above Goose Creek. It has a total length of 16 miles and diverts water from Turner, Boulder, Miller, Winona, and several smaller creeks.

Miscellaneous measurements in Noxapaga River drainage basin, 1908.

Date.	Stream and locality.	Discharge.	Drainage area.	Discharge per square mile.
		Sec.-ft.	*Sq. miles.*	*Sec.-ft.*
June 30	Noxapaga River above Goose Creek	126	340	0.37
July 21	do	67	340	.20
September 8	do	71	340	.21
June 29	Turner Creek at intake	4.1	13	.32
July 20	do	.6	13	.046
September 8	do	1.6	13	.12
July 1	Boulder Creek at claim No. 5	3.4	6.5	.52
July 21	do	.9	6.5	.14

FAIRHAVEN PRECINCT.

DESCRIPTION OF AREA.

The Fairhaven precinct (see fig. 21) comprises all of Seward Peninsula that drains northward into Kotzebue Sound, except the flat area near Devil Mountain, west of Goodhope Bay. It is an area of relatively low relief, none of the mountains having an elevation of more than half a mile. There is no dominant mountain range like the Kigluaik and Bendeleben mountains to the south. The principal rivers, in order from west to east, are the Goodhope, Inmachuk, Kugruk, Kiwalik, and Buckland. The southwestern portion of the precinct, together with parts of the adjacent Kougarok and Koyuk precincts, is covered with a recent lava flow, which has caused a considerable readjustment of drainage. The most notable effect of this flow is the formation of Imuruk Lake, the largest body of fresh water in Seward Peninsula. An area of older eruptive rocks east of Kiwalik River forms a rugged, dissected mass which reaches an altitude of 2,000 to 2,500 feet. In general, the country is underlain by frozen muck and ground ice, in some places to a depth of 30 or 40 feet or more.

The climatic and other conditions affecting the run-off from the Fairhaven precinct are very similar to those prevailing in the Kougarok region. The run-off during the summer comes mostly from the rain, aided somewhat by melting snow and ice, ground water, and springs. The rainfall is relatively small, even in a rainy season, and runs off quickly. Most of the streams have a large drainage area, however, and in an ordinary season should yield a good volume of water.

There are springs in limestone on Glacier Creek, in the Kiwalik River basin, and on the upper Inmachuk, and in the lava on Kugruk, Pinnell, and Goodhope rivers. These springs give the streams a steady flow during the summer, and the melting of the ice banks formed by their overflows during the winter yields a large amount of water during the early part of the open season.

GAGING STATIONS.

The points in the Fairhaven precinct at which gages were established or measurements made in 1908 are given in the following list. The numbers refer to figure 21, page 356.

Gaging stations in Fairhaven precinct, 1908.

1. Inmachuk River above Hannum Creek.
2. Inmachuk River below Pinnell River.
3. Inmachuk River above Cue Creek.
4. Hannum Creek at mouth.
5. Pinnell River at mouth.
6. Fairhaven ditch at intake of upper section.
7. Fairhaven ditch at Camp 2, upper section.
8. Fairhaven ditch at Camp 4, upper section.
9. Fairhaven ditch at intake of lower section.
10. Fairhaven ditch at Camp 2, lower section.
11. Fairhaven ditch above Snow Gulch.
12. Fairhaven ditch above penstock.
13. Kugruk River at mouth of canyon.
14. Kugruk River above Chicago Creek.
15. Chicago Creek at coal mine.
16. Wade Creek (Burnt River) near mouth.
17. Kiwalik River below Candle Creek.
18. North Fork of Quartz Creek near proposed intake.
19. South Fork of Quartz Creek near proposed intake.
20. Gold Run near proposed intake.
21. Glacier Creek at Candle ditch intake.
22. Dome Creek at siphon crossing.
23. Hunter Creek near proposed intake.
24. Candle Creek at mouth.
25. Bear Creek at intake.
26. Bear Creek above Cub Creek.
27. Eagle Creek at intake.
28. Polar Creek at intake.
29. Split Creek near mouth.
30. Bob Creek near mouth.
31. Cub Creek near mouth.

INMACHUK RIVER DRAINAGE BASIN.

Inmachuk River rises against the head of Trail Creek, a tributary of the Goodhope, flows northeastward and empties into Kotzebue Sound at Deering. Its principal tributaries are Hannum Creek, from the northwest, and Pinnell River, from the south, each of which has a larger drainage area than the main stream above the junction. Arizona, Fink, Washington, West, Cue, and Mystic creeks are small tributaries below the mouth of Pinnell River. About 3 miles from its source and the same distance above Hannum Creek the Inmachuk receives the flow of a large limestone spring.

Hannum Creek occupies a deep and rather narrow valley. Its principal tributaries are Cunningham, Milroy, and Collins creeks. Pinnell River rises in a broad, flat swamp, or "goose pasture," formed by the lava flow. About 6 or 8 miles from its source the river has cut down through the lava, forming a deep, narrow canyon in which it drops 250 to 300 feet in about half a mile. Its principal tributaries are Magnet, June, Perry, and Old Glory creeks and Snow Gulch.

A striking feature of the Inmachuk Valley is the lava rim which extends down the Pinnell from the canyon, following the left side of the valley for several miles, then crossing to the right side and extending down the Inmachuk to the coastal plain and up Hannum Creek nearly to its head. Its elevation is generally 300 to 400 feet above the stream.

Only a few measurements were made in the Inmachuk River basin, but the river was low and the discharge steady after July 15, so that the following results give a good idea of the conditions during the latter part of the summer of 1908.

Discharge measurements in Inmachuk River drainage basin, 1908.

Date.	Stream and locality.	Elevation.[a]	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 26	Inmachuk River above Hannum Creek	230	8.5	10	0.85
August 15	do	230	7.5	10	.75
July 27	Inmachuk River below Pinnell River	160	19.0	142	.13
August 15	do	160	16.4	142	.12
August 22	do	160	14.3	142	.10
August 21	Inmachuk River above Cue Creek	60	38.0	177	([b])
July 26	Hannum Creek at mouth	230	2.3	34	.068
August 15	do	230	2.9	34	.085
July 26	Pinnell River at mouth	160	5.2	90	.058
August 15	do	160	4.1	90	.046

[a] Approximate. [b] This includes about 25 second-feet from the Fairhaven ditch.

FAIRHAVEN DITCH.

The Fairhaven ditch takes water from Imuruk Lake and delivers it to claims on Inmachuk River. It is described in the paper on the mining operations. (See pp. 358–359.)

The object of the measurements made along the ditch was principally to determine the amount of water lost by seepage. The Fairhaven is a good example of a waterway built mostly in "glacier." The bottom has settled in some places 2 feet or more. The fine material is taken up in suspension by the water and redeposited along the sides and bottom, forming a tight lining. The measurements show that nearly all the water turned into the intake is delivered to the mine, over 40 miles below. As there was almost no inflow from the upper side of the ditch during either series of gagings the seepage from the ditch must be very small.

Seepage measurements of Fairhaven ditch, 1908.

Date.	Point of measurement.	Distance between stations.	Discharge.
		Miles.	*Sec.-feet.*
July 23	Intake of upper section		12.2
July 24	Camp 2, upper section	4.5	12.5
July 24	Camp 4, upper section	7.5	12.2
July 24	Intake of lower section	11.5	12.4
July 25	Camp 2, lower section	5.8	12.2
July 25	Above Snow Gulch	5.7	12.0
July 25	Above penstock	7.1	[a]10.6
August 18	Intake of upper section		27.2
August 18	Camp 4, upper section	12.0	[b]25.6
August 19	Intake of lower section	11.5	[b]25.5
August 19	Camp 2, lower section	5.8	[b]24.4
August 20	Above Snow Gulch	5.7	[b]22.7
August 20	Above penstock	7.1	[b]22.6
August 22	Above penstock		26.7

[a] About 0.6 second-foot was spilled from waste gate below Snow Gulch.
[b] Discharge less than normal; water was turned out for repairs to the ditch about 5 miles below intake for a few hours August 18. Water had again reached normal stage above penstock on August 22.

IMURUK LAKE DRAINAGE BASIN.

Imuruk Lake has an area of 30 square miles and a drainage basin of 99 square miles and therefore affords an abundant supply of water for the Fairhaven ditch. The amount of inflow can be determined for two periods of twelve months each—August 16, 1906, to August, 1907, and October 1, 1907, to September 25, 1908. During the first period there was no outflow and the water surface rose 2.17 feet; during the second period the rise was 1.53 feet and the outflow was estimated as follows: June, ten days, 75 second-feet; July 1 to 20, 12.5 second-feet; July 21 to September 25, 30 second-feet. From these data the total run-off has been computed.

Water supply and run-off from Imuruk Lake drainage basin, 1906–1908.

[Elevation, 950 feet; area, 99 square miles.]

	August, 1906, to August, 1907.	Oct. 1, 1907, to Sept. 25, 1908.
Rise of lake surface ... feet	2.17	1.53
Equivalent water supply ... acre-feet	41,600	29,400
Outflow ... do	0	6,400
Total water supply ... do	41,600	35,800
Mean annual discharge ... second-feet	58	49
Discharge for 100-day season ... do	210	180
Run-off from drainage area ... inches	7.9	6.8

KUGRUK RIVER DRAINAGE BASIN.

Kugruk River rises in Imuruk Lake and empties into Kotzebue Sound near Deering. It has a total length of over 60 miles. About 4 miles below its source, at the edge of the plateau on which Imuruk Lake lies, the river has cut into the lava, forming a canyon about 300 feet deep and 1,000 feet wide at its deepest point. At the mouth of the canyon the river is nearly 550 feet below the level of the lake and is probably at about the elevation it had before the invasion of the lava flow. This canyon affords a favorable location for a plant to develop electric power. Water from the lake can be diverted through a ditch for about 4½ miles and then through a pipe line to the bottom of the canyon, developing a pressure of about 500 feet. Below the canyon the grade of the river is relatively flat. Its principal tributaries are Holtz, Mina, Montana, Reindeer, and Chicago creeks from the east and Ruby and Gold Bug creeks and Wade Creek, locally known as Burnt River, from the west. During the summer of 1908, when the dam was closed at the lake, most of the discharge of the river came from springs in the lava above the canyon. The yield of the area draining into the river below the canyon was very small.

Chicago Creek is of interest on account of the coal mine which lies near its mouth. A weir station was installed on the creek at the mine to determine the supply of water available for condensers at the proposed power plant. The miscellaneous measurements give a fair idea of conditions of flow in this basin during the low water of 1908.

Daily discharge, in second-feet, of Chicago Creek at coal mine, 1908.

[Drainage area, 37 square miles.]

August 24	0.14	September 6	1.97
August 25	.14	September 7	2.19
August 26	.12	September 8	1.56
August 27	.16	September 9	.92
August 28	.12	September 10	.79
August 29	.11	September 11	.70
August 30	.11	September 12	.61
August 31	.09	September 13	.55
September 1	.35	September 14	.55
September 2	.30		
September 3	.64	Mean	.69
September 4	1.56	Mean, August	.12
September 5	1.56	Mean, September	1.02

Miscellaneous measurements in Kugruk River drainage basin, 1908.

Date.	Stream and locality.	Elevation.[a]	Discharge.	Drainage area.[b]	Discharge per sq. mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
August 17	Kugruk River at mouth of canyon	440	31	53	0.58
July 28	Kugruk River above Chicago Creek	120	33	470	.070
August 14	do	120	31	470	.066
July 28	Wade Creek (Burnt River) near mouth	120	1.6	170	.009
August 14	do	120	.9	170	.005

[a] Approximate. [b] Exclusive of Imuruk Lake drainage.

KIWALIK RIVER DRAINAGE BASIN.

Kiwalik River, the longest river on the north side of Seward Peninsula, rises in a low ridge which separates the drainage from that of the Koyuk and flows northward for nearly 70 miles to Kotzebue Sound, at Kiwalik. The river traverses a flat lowland area, several miles wide in places, which narrows a few miles above Candle to less than half a mile. Near its mouth the river widens into a lagoon.

The tributaries from the west drain rather narrow basins, roughly parallel and separated by long, low ridges. The principal streams from this side are Canoe Creek, Gold Run, and Glacier, Dome, Bonanza, Eldorado, Candle, and Minnehaha creeks. The largest tributaries from the east are Quartz and Hunter creeks, which rise in the mountainous mass separating the Kiwalik basin from that of Buckland River.

The Candle ditch was built in 1907 to divert water from Glacier and Dome creeks to Candle Creek. It is proposed to extend it eventually to Gold Run. It is described in the paper on mining developments (pp. 366–367). A line has been surveyed for a second ditch to Candle Creek which will take its water from Quartz and Hunter creeks. It will have its intakes on the forks of Quartz Creek, about 2 miles above the junction, and extend along the left bank of the river for about 7 miles, then cross the creek as a siphon 4,230 feet long and follow the east side of Kiwalik River valley to a point about 3 miles above Candle. The water will be carried across Hunter Creek in a siphon 4,850 feet long and across Kiwalik River in 5,880 feet of pipe. The flow of Hunter Creek will be diverted by a ditch about 9 miles long on its left bank. The proposed system will require a total of about 65 miles of ditch and 14,000 feet of pipe. The ditch will give a pressure of 303 feet above the mouth of Candle Creek.

The 1908 measurements on Quartz Creek were made after a rain, when the discharge was larger than it had been earlier in the season. At low water the flow of Glacier Creek comes mostly from springs; early in the summer it comes from the melting of the ice bed formed by the freezing of the spring water in the winter. The measurements of Dome Creek were made about 3 miles below the ditch intake. Candle Creek was dry part of the summer and supplied sufficient water for sluicing for only a few days early in the season and late in September.

Daily discharge, in second-feet, of Glacier and Hunter creeks, 1908.

Day.	Glacier Creek at Candle ditch intake. Elevation, 409 feet; drainage area, 10 square miles.			Hunter Creek, near proposed intake.[b] Elevation, 510 feet; drainage area, 37 square miles.		Day.	Glacier Creek at Candle ditch intake. Elevation, 409 feet; drainage area, 10 square miles.			Hunter Creek, near proposed intake.[b] Elevation, 510 feet; drainage area, 37 square miles.	
	July.[a]	Aug.	Sept.	Aug.	Sept.		July.[a]	Aug.	Sept.	Aug.	Sept.
1	14.0	2.9	2.1	8.0	9.0	20	2.9	2.1	5.8	6.1	13.0
2	12.0	2.2	2.1	8.0	9.4	21	2.5	1.9	......	6.1	......
3	10.0	2.2	2.2	7.0	13.0	22	2.5	1.9	......	6.1	......
4	8.5	2.5	2.1	7.0	15.8	23	2.5	2.5	......	6.5	......
5	6.9	3.5	2.1	13.0	14.1	24	2.5	2.2	......	7.0	......
6	5.5	4.0	2.4	17.4	13.6	25	2.5	2.1	......	7.0	......
7	6.2	2.5	2.1	15.8	9.8	26	2.0	1.9	......	8.5	......
8	6.4	2.2	2.1	9.8	9.0	27	2.0	1.9	......	7.0	......
9	4.5	1.9	1.9	11.0	7.8	28	2.0	1.9	......	6.5	......
10	4.4	1.9	2.5	9.0	6.8	29	2.0	1.9	......	6.5	......
11	5.8	1.8	2.5	8.0	6.8	30	2.0	1.9	......	6.5	......
12	5.1	2.1	2.2	8.0	6.8	31	5.8	2.1	......	6.8	......
13	4.8	1.9	2.2	7.0	6.5						
14	4.4	1.9	2.2	7.0	6.8	Mean	4.7	2.1	3.4	8.1	11.9
15	3.6	1.8	3.0	8.5	6.8						
16	2.9	1.7	5.6	7.0	15.8	Mean per square mile	.47	.21	.34	.22	.32
17	2.9	1.8	7.3	6.1	21.8						
18	2.9	1.7	8.2	6.5	26.6	Run-off, depth in inches	.54	.24	.25	.25	.24
19	2.9	1.7	6.4	6.1	19.1						

[a] Discharges for July are based on estimates and float measurements by D. H. Davidson and H. M. Long.
[b] The discharge for the latter part of July was probably less than that for the period covered by the records.

Miscellaneous measurements in Kiwalik River drainage basin, 1908.

Date.	Stream and locality.	Elevation.	Discharge.	Drainage area.	Discharge per square mile.
		Feet.	*Sec.-ft.*	*Sq. miles.*	*Sec.-ft.*
July 29	Kiwalik River below Candle Creek	0	33	800	0.041
August 1	.....do	0	43	800	.054
August 13	.....do	0	137	800	.171
August 25	.....do	0	70	800	.088
September 9	.....do	0	126	800	.158
August 27	North Fork of Quartz Creek at proposed intake.	590	13.4	21	.64
August 30	.....do	590	8.7	21	.41
August 27	South Fork of Quartz Creek at proposed intake.	580	13.1	26	.50
August 30	.....do	580	8.6	26	.30
August 10	Gold Run at proposed intake	....	1.4	9	.16
September 4	.....do	....	1.9	9	.21
August 10	Boulder Creek at proposed intake	....	.2	4	.05
September 4	.....do	....	.3	4	.08
July 31	Dome Creek at siphon crossing	230	.7	16	.044
August 9	.....do	230	.5	16	.031
August 11	.....do	230	.4	16	.025
September 5	.....do	230	1.7	16	.11
September 6	.....do	230	1.9	16	.12
July 29	Candle Creek at mouth	0	0	60	.00
August 13	.....do	0	.5	60	.008
August 25	.....do	0	2.6	60	.043
September 9	.....do	0	1.7	60	.028

BEAR CREEK DRAINAGE BASIN.

Bear Creek rises opposite the headwaters of Quartz and Hunter creeks and flows southeastward for about 20 miles into West Fork of Buckland River. Its principal tributaries are Eagle, Polar, Split, Bob, and Cub creeks from the west, and May, Camp, and Sheridan creeks from the east. The Bear Creek ditch has its intake just below the mouth of May Creek and extends along the right bank nearly to Split Creek, diverting water from Eagle and Polar creeks. Measurements were made in 1908 of Bear, Eagle, and Polar creeks at the ditch intake and of the other principal streams near their mouths.

Miscellaneous measurements in Bear Creek drainage basin, 1908.

Date.	Stream and locality.	Discharge.
		Sec.-ft.
August 6	Bear Creek at intake	1.6
August 28	....do	.4
August 31	....do	.5
August 29	Bear Creek above Cub Creek	19.2
August 5	Eagle Creek at intake	1.2
August 28	....do	1.4
August 31	....do	1.2
August 5	Polar Creek at intake	2.9
August 28	....do	2.1
August 31	....do	2.3
August 5	Split Creek at mouth	16.0
August 28	....do	4.0
August 31	....do	3.3
August 29	Bob Creek at mouth	5.9
Do	Cub Creek at mouth	12.3

RAINFALL RECORDS.

Records of precipitation were obtained at eight stations in Seward Peninsula for a part or the whole of the season of 1908. It has been the object, as far as possible, to obtain the records near the drainage basin on which records of discharge were kept. The stations have, therefore, been placed in the interior, at mining and ditch camps, where it is hard to obtain records for an entire season. The location, elevation, etc., of these stations is given in the following table:

Rainfall stations in Seward Peninsula, 1908.

Station.	Latitude.	Longitude.	Elevation.		Observer.	Date established.
			Above sea level.	Above ground.		
	° ′	° ′	*Feet.*	*Feet.*		
Nome	64 30	165 24	40	20	Arthur Gibson	June 14, 1906
Black Point	64 51	165 16	575	2	F. F. Miller	June 23, 1907
Grand Central	64 58	165 14	690	2	Fred Walford	July 10, 1907
Sowik	64 58	164 38	350	2	Clyde Hager	June 22, 1908
Shelton	65 13	164 48	60	2	Lars Gunderson	July 12, 1907
Taylor	65 42	164 48	500	2	A. Schrader	July 18, 1907
Budd Creek	65 37	165 33	200	2	J. P. Samuelson	July 1, 1908
Candle	65 55	161 56	25	15	Ward Estey	Aug. 11, 1908

The records obtained show, as in previous years, that the precipitation is high in the Kigluaik Mountains, moderate in the area south of them, and very low in the northern half of the peninsula. The daily rainfall for 1908 and the monthly total for the seasons of 1906 to 1908 are given below.

Monthly rainfall, in inches, in Seward Peninsula, 1906–1908.

Station.	June.	July.	August.	September.	Total, June to August.	Total, June to September.	Total, July to September.
1906.							
Nome	Trace.	2.38	2.50	1.02	4.88	5.90	5.90
Salmon Lake	Trace.	4.92	3.33	3.26	8.25	11.51	11.51
Ophir	Trace.	3.57	1.91	(a)	5.48		
1907.							
Nome	1.31	2.08	2.68	1.41	6.07	7.48	6.17
Black Point	2.62	1.94	2.85	3.26	7.41	10.67	8.05
Salmon Lake	2.31	1.79	3.65	2.26	7.75	10.01	7.70
Grand Central	(a)	3.61	7.19	5.06			15.86
Shelton	(a)	.71	1.33	.47			2.51
Taylor	(a)	.66	.96	1.17			2.79
1908.							
Nome	.90	2.10	2.92	.52	5.92	6.44	5.54
Black Point	.57	2.30	3.42	.63	6.29	6.92	6.35
Grand Central	(a)	4.02	6.21	.72			10.95
Sowik	(a)	1.67	1.27	.30			3.24
Shelton	.44	1.32					
Taylor	(a)	.68	1.11	.23			2.02
Budd Creek	(a)	.69	1.87				
Candle	(a)	(a)	b.50				

a No record. b August 11–31.

Daily rainfall a and snowfall, in inches, at Nome, 1907–8.

Day.	December.		January.		February.		March.		April.	
	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.
1							0.16	2.0		
2							.23	(b)		
3							.23	(b)		
4	0.06	2.0			0.09	1.5				
5					.15	2.5	.09	1.0		
6							.08	1.0		
7										
8					.04	.8				
9					.03	.5				
10									0.02	0.3
11										
12					.02	Trace.	.06	1.0		
13										
14										
15	.02	.5	0.03	0.5						
16	.11	2.0	.03	.8						
17					.08	1.0				
18	.05	1.0								
19	.01	Trace.								
20	.03	.75			.11	1.75				
21	.02	.5			.14	2.4				
22							.06	1.0		
23			.13	2.8			.19	(b)		
24			.03	.8						
25			.16	3.0	.10	1.5	.06	(b)		
26			.05	1.0						
27										
28							.03	.4		
29										
30										
31										
	.30	6.75	.43	8.9	.76	11.95	1.19	(c)	.02	.3

a Water equivalent of snow. b Snow and rain. c Total, estimated, 13.1 inches.

Daily rainfall and snowfall,[a] in inches, at stations in Seward Peninsula, 1908.

Day.	May.		June.			July.						
	Nome.	Black Point.	Nome.	Black Point.	Shelton.	Nome.	Black Point.	Grand Central.	Sowik.	Shelton.	Taylor.	Budd Creek.
1												
2	0.06					0.08		[b]0.10			Trace.	
3					0.18	.13	0.15	[b].30	0.06	0.18	0.01	
4			0.30		.02						Trace.	
5			.09	0.12	.12							
6			.14	.14	.02							
7			.30	.25	.10							
8			.07	.06								
9												
10	.04											
11						.37	.19	.25	.09	.44	.11	0.10
12							.04	.52		.03		.08
13												
14												
15	.09	0.11										
16							Trace.			.02		
17												
18						Trace.						
19						.04	.05					
20						.21	.12		.11			
21								.15		.01		
22										.14	Trace.	
23						.01			.06		.11	
24						Trace.	.05					
25						.02						
26							.04					
27		.29									Trace.	
28												.30
29						.07	.06					
30						.80	.82	1.20	.79	.10		.21
31						.37	.78	1.50	.56	.40	.45	
	.19	.40	.90	.57	.44	2.10	2.30	4.02	1.67	1.32	.68	.69

[a] Figures give rainfall, except where snow also is given; there the figures for rain give the water equivalent of the snowfall.

Estimated, gage installed July 8.

Daily rainfall and snowfall, in inches, at stations in Seward Peninsula, 1908—Cont'd.

Day.	August.							September.		
	Nome.	Black Point.	Grand Central.	Sowik.	Taylor.	Budd Creek.	Candle.[a]	Nome.	Black Point.	
									Rain.	Snow.
1			0.13							
2		0.01						0.16		
3	0.02	.04				0.18				
4	.72	.93	.52	0.42	0.25					
5	.13	.23	1.70	.13	.35					
6	.43	.05	.20			.44				
7										
8										
9								Trace.		
10	.04	.01								
11	.20	.34		.24	.09		0.10			
12	.23	.25	.70	.06			Trace.			
13	.22	.10	.20		Trace.	.30		.07	0.12	3.5
14		.03			.15	.10	.03	Trace.		
15	.03	.04		.11				.12	.27	
16		.01	.39					Trace.	.10	
17						.18				
18		.05			Trace.		.02			
19		.33	.67						.01	
20		.02						Trace.		
21					Trace.			.08	.05	
22	.07	.16					.04	.09	.08	.4
23	.41	.37	.30	.29	.15	.12	.10			
24	.05	.09	.80	.02						
25		.02			Trace.	.18	Trace.			
26							.06			
27										
28										
29										
30										
31	.37	.34	.60		.12	.37	.15			
	2.92	3.42	6.21	1.27	1.11	1.87	[b].50	.52	.63	3.9

[a] Gage installed August 10. [b] August 11-31.

Daily rainfall and snowfall, in inches, at stations in Seward Peninsula, 1908—Cont'd.

Day.	September—Continued.						October.		November.	
	Grand Central.		Sowik.		Taylor.	Candle.	Nome.		Nome.	
	Rain.	Snow.	Rain.	Snow.			Rain.	Snow.	Rain.	Snow.
1			Trace.							
2	0.16	2.0			0.14	Trace.				
3						0.16	0.05			
4							.05			
5										
6					.09	.04				
7										
8										
9										
10										
11										
12										
13	.24	3.0								
14										
15			0.14	1.4			.25	3.0	0.04	1.0
16										
17										
18							.02			
19			.16	2.0			.11	2.0		
20	.32	4.0							.07	1.0
21										
22	Trace.	Trace.							Trace.	
23										
24										
25							.45	3.0	.10	1.0
26							.04	.5		
27							.16	2.0		
28			Trace.	Trace.						
29										
30									.05	.5
31										
	.72	9.0	.30	3.4	[a].23	[b].20	1.13	10.5	.26	3.5

[a] September 1-10. [b] September 1-9.

INDEX.

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GENERAL.

Reports.

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper No. 45, 1906, 327 pp. $1.00.

*Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin No. 259, 1905, pp. 18–31.

The mining industry in 1905, by A. H. Brooks. In Bulletin No. 284, 1906, pp. 4–9.

The mining industry in 1906, by A. H. Brooks. In Bulletin No. 314, 1907, pp. 19–39.

*The mining industry in 1907, by A. H. Brooks. In Bulletin No. 345, pp. 30–53.

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*Administrative report, by A. H. Brooks. In Bulletin No. 345, pp. 5–17.

*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.

Markets for Alaska coal, by G. C. Martin. In Bulletin No. 284, 1906, pp. 18–29.

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*Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin No. 263, 1905, 362 pp. 35 cents. (*Abstract in Bulletin No. 259, 1905, pp. 32–46.)

Geographic dictionary of Alaska, by Marcus Barker, second edition, by James McCormick. Bulletin No. 299, 1906, 690 pp.

*The distribution of mineral resources in Alaska, by A. H. Brooks. In Bulletin No. 345, pp. 18–29.

*Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin No. 345, 1908, pp. 54–77.

*Water-supply investigations in Alaska in 1906–7, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, 156 pp. 25 cents.

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*Topographic map of Alaska; scale, 1:2500000. Preliminary edition by R. U. Goode. Contained in Professional Paper No. 45. Not published separately.
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Map of Alaska, showing areas covered by exploratory, reconnaissance, and detailed surveys; scale, 1:5000000. (Map A.) 10 cents.

SOUTHEASTERN ALASKA.

Reports.

Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by Alfred H. Brooks. Professional Paper No. 1, 1902, 120 pp.
*The Porcupine placer district, Alaska, by C. W. Wright. Bulletin No. 236, 1904, 35 pp. 15 cents.
*The Treadwell ore deposits, by A. C. Spencer. In Bulletin No. 259, 1905, pp. 69–87.
*Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin No. 259, 1905, pp. 47–68.
The Juneau gold belt, Alaska, by A. C. Spencer, pp. 1–137, and A reconnaissance of Admiralty Island, Alaska, by C. W. Wright, pp. 138–154. Bulletin No. 287, 1906, 161 pp.
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The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright. Bulletin No. 347, 1908, 210 pp.
Yakutat Bay region, Alaska: Physiography and glacial geology, by R. S. Tarr; Areal geology, by R. S. Tarr and B. S. Butler. Professional Paper No. 64, 1909, 185 pp.

Topographic maps.

Topographic map of the Juneau gold belt, Alaska. Contained in Bulletin 287, Plate XXXVI, 1906. Not issued separately.
Juneau special map; scale, 1:62500. (Map 581A.) 5 cents.
Berners Bay special map; scale, 1:62500. (Map 581B.) 5 cents.

In preparation.

Geology and ore deposits of Kasaan Peninsula and the Copper Mountain region, Prince of Wales Island, by C. W. Wright.
The Yakutat Bay earthquake of September, 1899, by R. S. Tarr and Lawrence Martin.
Geology of Glacier Bay and Lituya Bay region, by F. E. Wright and C. W. Wright.
Kasaan Peninsula special map; scale, 1:62500, by D. C. Witherspoon, R. H. Sargent, and J. W. Bagley.
Copper Mountain special map; scale, 1:62500; by R. S. Sargent.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

Reports.

*The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall and F. C. Schrader. Professional Paper No. 15, 1903, 71 pp. 30 cents.
*Bering River coal field, by G. C. Martin. In Bulletin No. 259, 1905, pp. 140–150.
*Cape Yaktag placers, by G. C. Martin. In Bulletin No. 259, 1905, pp. 88–89.
*Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139. Abstract from Bulletin No. 250.
The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.
Geology of the central Copper River region, Alaska, by W. C. Mendenhall. Professional Paper No. 41, 1905, 133 pp.
Copper and other mineral resources of Prince William Sound, by U. S. Grant. In Bulletin No. 284, 1906, pp. 78–87.
Distribution and character of the Bering River coal, by G. C. Martin. In Bulletin No. 284, 1906, pp. 65–76.
Petroleum at Controller Bay, by G. C. Martin. In Bulletin No. 314, 1907, pp. 89–103.
Geology and mineral resources of Controller Bay region, by G. C. Martin. Bulletin No. 335, 1908, 141 pp.
Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin No. 345, 1908, pp. 176–178.
Mineral resources of the Kotsina and Chitina valleys, Copper River region, by F. H. Moffit and A. G. Maddren. In Bulletin No. 345, 1908, pp. 127–175.
The Kotsina-Chitina copper region, by F. H. Moffit and A. G. Maddren. Bulletin No. 374.

Topographic maps.

*Map of Mount Wrangell district; scale, 12 miles=1 inch. Contained in Professional Paper No. 15. Not issued separately.
Copper and upper Chistochina rivers; scale, 1:250000; by T. G. Gerdine. Contained in Professional Paper No. 41. Not issued separately.
Copper, Nabesna, and Chisana rivers, headwaters of; scale, 1:250000; by D. C. Witherspoon. Contained in Professional Paper No. 41. Not issued separately.
General map of Alaska coast region from Yakutat Bay to Prince William Sound; scale, 1:120000; compiled by G. C. Martin. Contained in Bulletin No. 335. Not issued separately.
Map of Controller Bay region; scale, 1:62500. (Map 601A.) 35 cents.

In preparation.

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Nome special map; scale, 1:62500. (Map 464B.) 5 cents.

Map of Casadepaga quadrangle; scale, 1:62500. (Map 646C.) 5 cents.

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