MINERAL RESOURCES OF THE NULATO-COUNCIL REGION.

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INTRODUCTION.

West of Koyukuk and Yukon rivers a large area long remained geologically unexplored. During the season of 1909 a party from the Geological Survey worked in a portion of this area, and it is the results of the studies there carried on and extended as far as Council, on Seward Peninsula, that the following paper aims to set forth:

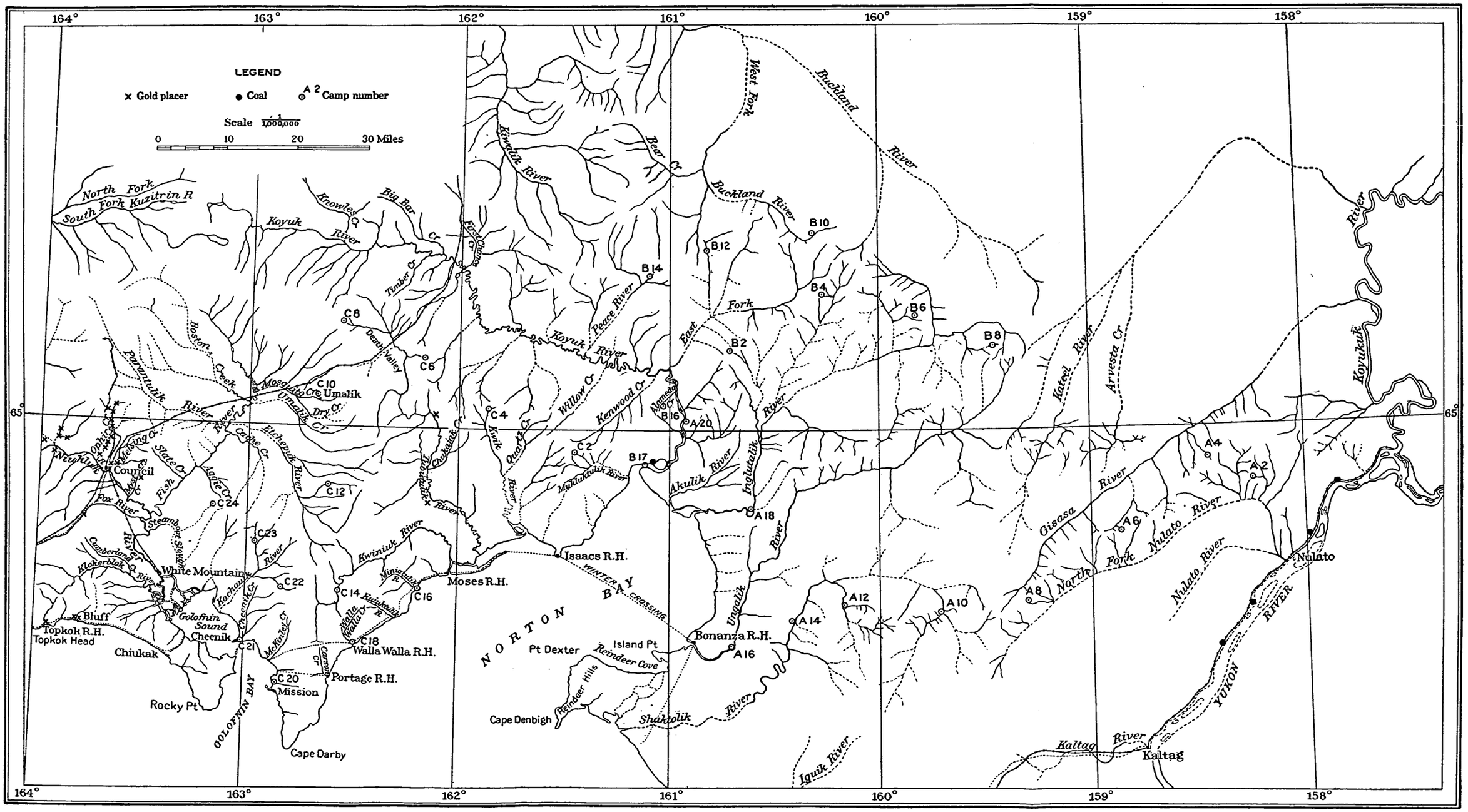
GEOGRAPHY.

LOCATION OF AREA.

From the itinerary of the expedition of 1909, as indicated by the different camps, the area in which new geographic and geologic information has been obtained may be inferred. It has seemed feasible, however, to extend the discussions of this paper beyond the area actually visited so as to include contiguous regions which throw light on parts of the region visited in 1909 or in which problems have been raised by other parties and are explained wholly or partly by the 1909 results. The area treated in this report, therefore, is in the main rectangular and may be roughly described as bounded by parallels 64° and 65° 30′ north and meridians 156° and 164° west. The southern margin is near the settlement of Unalaklik and the northern is a short distance north of the big bends of Koyukuk and Kateel rivers. On the east the region is bounded by a north-south line midway between the mouths of Melozi and Koyukuk rivers. On the west the best-known point to which to refer the margin is the town of Council, on Niukluk River. (See Pl. VIII.)

GENERAL TOPOGRAPHY.

Throughout the Nulato-Council region the relief is relatively low. There are few hills over 3,000 feet high, and the larger part of the upland area is only about 2,000 feet above sea level. Although there are no high ranges, steep slopes lead from the flat river bot-



MAP OF NULATO-COUNCIL REGION.

toms to the highlands. In the Nulato-Norton Bay region there are numerous parallel northeast-southwest ridges, the highest of which forms the divide between Inglutalik-Ungalik and Kateel-Gisasa rivers. The hills to the north of the East Fork of Koyuk River are low and rolling, without pronounced direction. To the west, in Seward Peninsula, three ranges form prominent landmarks. These are the hills between Buckland and Kiwalik rivers and the Darby and Bendeleben mountains. The higher points of the first range rise to elevations of about 2,500 feet. In the Bendeleben Mountains the highest point is a little over 3,700 feet and in the Darby Range the highest peak is 3,000 feet. In the two latter ranges precipitous slopes rising to 2,000 feet or more give wildness to the topography.

Outside of these three higher areas the uplands are usually rolling, with elevations of 1,000 to 2,000 feet above sea level, unforested, well drained, and covered with angular fragments of frost-riven waste. Pinnacles of the underlying rocks form fantastic knobs here and there.

The drainage of the region studied flows either into the Yukon, into Norton Bay, or into Kotzebue Sound. The streams belonging to the Yukon drainage area and the eastern part of the Norton Bay show pronounced parallelism with the geologic structure, the result being long, narrow valleys, as for instance that of the Gisasa. The gradients of the main valleys are low, but the small side streams rise rapidly headward. In some places the streams flow through narrow rock-walled canyons of slight depth, but in others there are flat flood plains and gravel deposits. In the headward portions of the basins the relations of the streams on opposite sides of the divide are complex, and it is by no means possible to foretell the direction of the drainage at long range. In Seward Peninsula, where the geologic structure is more complex, its effect on the streams is not well marked and irregular courses are the rule. In this part of the area the longer streams, such as the Koyuk, the Kiwalik, and the Tubutulik, flow more or less parallel with the mountains, but Fish River and its larger tributaries flow at right angles to the Bendeleben Range.

Almost all the valleys show signs of having been eroded entirely by stream action. In the headwaters of the rivers rising in the Bendeleben and Darby ranges, however, there are glacial cirques and valleys produced by ice erosion. Here the present streams form irregular threads on the broadly open floors of valleys that have very steep sides. Many of the streams flowing into Norton Bay, instead of showing erosion features at their mouths, have filled the former valleys, which have been depressed, with sand and gravel. Examples of topography of this kind are found at the mouths of Kwik, Tubutulik, and Kwiniuk rivers, where numerous lakes and sloughs form an untraversable network during the summer.

The coast line presents numerous examples of different types of shore topography. From the Reindeer Hills to the Koyuk a coastal plain, recently emerged, affords a relatively straight shore with such slight depths of water off the coast that approach for large vessels is impossible. Of course, under such conditions, harbors do not exist. On the west side of Norton Bay the sinking of the land and the attack of the waves have resulted in harbors and a rugged cliff-lined coast. This part of the coast is formed by the Darby Range, which rises in abrupt slopes from the sea and forms a long southward-pointing peninsula. West of this range the deep reentrant of Golofnin Sound and Bay, which probably represents the submerged portion of an old valley similar to that of Fish River, affords a good harbor. Still farther west rocky headlands with intervening beaches produce a diversity of forms. In the depressed portions of the coast there are sand spits, such as the long point extending eastward from a point near the mouth of the Kwiniuk.

GENERAL GEOLOGY.

GENERAL STATEMENT.

In this paper no attempt will be made to discuss in detail the geology of the Nulato-Council region. There are, however, certain general features which it is important to set forth in order to understand the geology of the area and it will be the purpose of this section to describe these features.

The rocks of the region fall into four main divisions—the metamorphic rocks, the older igneous rocks, the nonmetamorphic sediments, and the late effusive rocks.

METAMORPHIC ROCKS.

West of the Koyuk the rocks belong predominantly to the metamorphic complex known in other parts of the peninsula as the Nome group, of Paleozoic age or older. They consist of a variety of lithologic types, many of which persist over large areas, whereas others are distinctly local. This group consists essentially of schists and limestones, all highly metamorphosed and in places showing structures due to more than one period of deformation.

Schists form the greater part of the metamorphic complex and may be described according to the mineral or minerals characteristic of them. The schists most commonly found are quartzose, graphitic or carbonaceous, biotitic, feldspathic, and calcareous. Gradations between different types are numerous and the differentiation is by no means certain. It appears, however, that the present lithologic differences are in considerable measure due to original characters, so

that in a broad way identity of lithology may be taken as indicating deposits formed at essentially the same time. This is true of most of the feldspathic and graphitic schists and of some of the calcareous schists, but is in general not true of the biotitic schists.

Quartz is the most common mineral found in the schists and is of small diagnostic value, except where its proportion to other minerals is high. Quartzose schists are widely distributed through the entire area and are apparently not restricted to any single geologic relation with respect to the other rocks. Associated with the quartz is usually more or less chlorite or other mica-like minerals. As the amount of quartz decreases calcite or feldspar and chlorite increase and the schist may gradually merge into one of the other types. This usually takes place near the contact of the quartz schist with beds of limestone or with the sheared intrusive rocks.

The black quartzites and schists in the western part of Seward Peninsula, known as the Kuzitrin group, are also represented in this field. No accurate determination of the coloring matter has been made, but a part of it is certainly graphite, although some may be another form of carbon. The carbonaceous schists are more or less closely related geologically to some of the limestones which occur along the flanks of the Darby Mountains, but they are also found in many other parts of the region. Where not too thoroughly metamorphosed they are usually high in quartz and low in alumina and lime minerals. It is believed that this type is similar to the Hurrah slate of the Solomon region and to the quartzites and slates of the region around Lanes Landing. Where much sheared this type shows an increased amount of chlorite and merges into the quartz schists until separation of the two is impossible.

Biotite schists are found only in the Bendeleben and Darby mountains. The presence of biotite seems to be due in large measure to the effect of the igneous intrusions that have taken place in these ranges, and the biotite is therefore believed to be of no significance in determining the stratigraphy. This conclusion is not in accord with the work of the Survey in the Kigluaik Mountains to the west, but seems justified where the presence of biotite in the limestones as well as in the schists and igneous rocks is so pronounced as in the Darby Range. So far as observations go they point to the conclusion that the biotite is one of the later minerals and may either have been introduced subsequent to the other minerals or have been formed by the recrystallization, under dynamic processes, of some earlier minerals, such as chlorite.

Feldspathic schists such as are common in the eastern part of the Nome and Solomon areas are not abundantly developed in the area of metamorphic rocks studied in 1909. Small areas of schist of this kind were noted at several places. No new facts bearing on the

origin were ascertained, but nothing was seen to controvert the previously expressed idea that in the main the feldspathic schists are the sheared equivalents of intrusive rocks of diabasic character in the older schists. This of necessity is true only in a general way, for it is realized that marginal phases merge with the other types of schist, and sharply defined boundaries do not exist. The feldspathic schists are as a rule less quartzose and higher in alumina and soda than the other rocks. Although they are assumed to be of igneous origin it has not been feasible to indicate the position of these rocks on the geologic map (Pl. VIII), and they have been included with the metamorphic rocks.

Calcareous schists are probably the second most widespread type of schist. Some of these rocks undoubtedly represent original calcareous sediments subsequently metamorphosed, but a large part has been derived from the metamorphism of the massive limestones through mountain building. Owing to the question as to their origin, therefore, the lithology of the schists is not of definite stratigraphic value and probably this type includes rocks of diverse ages. The distribution of these rocks in places affords a clue as to their relations, and the chemical character is also of considerable importance. The largest areas of calcareous schists are in the divide east of the canyon of Fish River and in the hills around the head of the Mukluktulik. In the former the calcareous schists seem to have been derived from the more massive limestones through shearing, but in the latter their origin is not clear.

In addition to the schists, bands of limestone, in places many hundred feet thick, are found, in some places continuous and elsewhere in isolated masses. A large area of limestone extends along the east side of the Darby Range from a point east of Death Valley of the Tubutulik to the coast near Mount Kwiniuk. Another series of massive limestones occurs on the west side of the Darby Range, stretching southward from the Omilak mine. Several other large areas where limestone forms the country rock are in the Fish River canyon near White Mountain, at the head of Fish River, near Bluff, north of Koyuk River near the head of Kiwalik River, and west of Council. Not all the limestones are lithologically similar. Some are dolomitic, but most are not. The dolomitic limestones are of two main types, one compact, slightly crystalline, and whitish gray, and the other nearly black and more crystalline. The nondolomitic limestones present a number of different types. Some are white, coarsely crystalline, and friable; others are bluish white, thinly laminated, and fine textured; and still others are nearly black and practically indistinguishable from the black dolomites except by chemical means. Abrupt transitions from one type to another are noted locally. All the limestones in places grade into calcareous schists through shear-

ing, so that all stages from a nearly pure calcite rock to a rock containing large amounts of chlorite and mica are found. Apparently, however, the limestones have not been subjected to the same amount of deformation as the older schists.

The structure of the metamorphic rocks is complex and close folding, shearing, and faulting are the rule. It is impossible to determine the broader structural features until much more detailed surveys have been made. As has been noted, there is some evidence that the thicker limestones as a whole have not been subjected to as many periods of mountain building as some of the schists. If this conclusion is supported by closer investigation, it indicates an unconformity between part of the schists and the limestones.

Owing to the absence of precise structural data it is not possible to make any close estimate of the thickness of the metamorphic rocks. From the facts at hand it is certain that a thickness measured in terms of thousands of feet must be assumed. Limestone beds at least a thousand feet thick are known, and it is believed that these form the smaller part of the section. Reduplication through intense folding is so common that actual thickness and apparent thickness seldom coincide.

OLDER IGNEOUS ROCKS.

The group of older igneous rocks as described in this report contains members of different ages, composition, and method of formation which are treated as a unit only because they have all been produced by igneous activities. In composition these rocks range from acidic granites to basic lavas and in method of formation from surface flows to deep-seated intrusive rocks. Three main divisions—diorites, granites, and ancient lavas—merit further description.

The granites are confined, with few exceptions, to the mountainous regions of the Bendeleben and Darby ranges and the divide between the Kiwalik and the Buckland. Some of the granites are medium fine grained with pegmatitic phases containing relatively small amounts of dark-colored silicates. This type is particularly characteristic of the Bendeleben Range and of the hills west of the Buckland, forming areas 5 to 10 miles in diameter. In the Darby Range, particularly in the Kwiniuk basin, a porphyritic granite with feldspar phenocrysts averaging about 1½ inches in length, forms areas 15 to 20 miles long and 5 to 6 miles wide. The granite is usually unsheared, but here and there gneissic phases are found. Two small areas of fine-grained igneous rocks, apparently not associated with the intrusions noted, occur near Ungalik River.

Diorites and similar granular basic rocks form portions of the Darby Mountains and the divide between Buckland and Kiwalik rivers. These intrusive rocks have not been carefully separated from

the granites in the field, and their areal extent can not be closely estimated, but it seems probable that they are not so widespread as the granites. Some of these basic rocks are sheared and slightly schistose, but their cleavage is much less pronounced than that of the metamorphic rocks and they have been subjected to fewer periods of deformation. Some diorites preceded, but others followed the intrusion of the granites.

The third division of the ancient igneous rocks consists of those forming a large part of the hills of the Buckland-Kiwalik divide. In the northern part of the area these have been studied by Moffit and are reported to be andesites. "They are of a dark-gray or greenish color and on an exposed surface have a spotted appearance due to the alteration of the feldspar phenocrysts."[a] South of the Koyuk these rocks were recognized only in the hills near Alameda Creek. At this place the lavas are amygdaloidal. In places they show marked deformation, but this has not gone far enough to produce schistosity. These lavas can be most easily distinguished from the recent lavas by their geologic relations and by the absence in the former of fresh glass and unfilled gas cavities.

CRETACEOUS ROCKS.

The eastern part of the Nulato-Council region is occupied by unmetamorphosed sedimentary rocks, extending from Koyuk River on the west to and beyond the Yukon on the east. North and south they extend beyond the field investigated. Outlying areas of sedimentary rocks occur on Koyuk River at its mouth and at a point a few miles west of the mouth of East Fork and in the divide between Tubutulik and Kwik rivers. These unmetamorphosed sediments apparently comprise a single conformable series of great thickness. Though the structure and relations of the beds are not finally determined, three rather distinct types of deposits are recognized; in their apparent order of occurrence these are a basal conglomerate, an intermediate group, and an upper group of sandstones and shales.

The lowest member of the series is a basal conglomerate. It is exposed over considerable areas on the Ungalik and on East Fork of Koyuk River and along the Kwik-Tubutulik divide. It is usually coarse, bowlders up to 1 foot in diameter being common. In the coarsest phases bowlders up to 3 feet in diameter were noted. In composition the conglomerate seems to agree in each locality with the underlying terrane, suggesting local origin and slight transportation. On the Ungalik and East Fork the bowlders are of various igneous types, corresponding to the series of ancient lavas with intrusive granitic dikes from which it is derived. The granite was readily dis-

[a] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula: Bull. U. S. Geol. Survey No. 247, 1905, p. 31.

integrated and is represented in the matrix of the conglomerate mainly by numerous angular feldspar crystals.

In the western part of the East Fork area the conglomerate is composed almost exclusively of granites corresponding to the massive rocks of that vicinity. Between the Kwik and the Tubutulik limestone conglomerate is found in a limestone area and schist conglomerate where the underlying formation is schist. Obviously the conglomerate rests unconformably upon the older rocks.

Overlying the conglomerate is a great thickness of beds, mainly sandstones. These beds are uniformly fine grained and massively bedded, composed chiefly of feldspar and quartz with varying amounts of calcite. Interbedded with them are varying amounts of black shales. Some of the shale beds are very carbonaceous, and at the mouth of the Koyuk the series contains lignite. The lower sandstone beds closely resemble the matrix of the underlying conglomerate, pointing to continued sedimentation from the same source.

In the eastern part of the area occurs a series of similar sandstones which have been described by Dall under the name Nulato sandstone. They are probably equivalent to a part of the sandstone series farther west. They comprise alternating sandstone, shales, and grits, as a rule rather thinly bedded, and include several thin lignitic layers. Cross-bedding, ripple marks, worm borings, and plant remains are common.

In the central part of the area, along the Nulato-Gisasa divide and westward to the head of the Shaktolik, the beds exposed are predominantly black shales. They probably represent a vertical gradation into finer sediments upward in the series, though lateral gradation is not impossible. The shales are usually indurated and on weathering break down into pencil-like fragments. Schistosity has been developed very locally near structural axes in some of the more carbonaceous members.

The main structural axes in the entire sedimentary area run generally in a northeast-southwest direction. Open folds with dips of 30° or thereabouts are typical in the vicinity of the Yukon, but to the west, on Shaktolik River, the dip ranges within a few degrees on either side of 90°. In the most western exposures of the unmetamorphosed sediments in the area west of Kwik River the dip is vertical. Faulting evidently occurs generally throughout the area. Faults of small throw were actually observed and in several places considerable displacements are required to account for the attitude and relations of the beds.

Measurements of the unmetamorphosed sediments indicate an enormous thickness. Close estimates, however, were not obtained, as in the less deformed regions exposures are poor, and in the more deformed regions reduplication through faulting and folding is likely

to vitiate the observations. A measurement of the basal conglomerate on the ridge between Tubutulik and Kwik rivers gave a thickness of about 1,800 feet for this member. Atwood and Eakin in 1907 measured a section of the intermediate member exposed along the Yukon, which showed a thickness of about 10,000 feet. A section of the upper member exposed to the west of Divide Peak, if no reduplication has affected the beds, would indicate a thickness of over 5 miles. Although none of these sections can be regarded as complete, it is believed that they overestimate rather than underestimate the actual thicknesses.

POST-CRETACEOUS LAVAS.

Lavas of such recent date that in places they still preserve the surficial characters of flows are found in the Koyuk and Buckland basins. The general distribution of these rocks is indicated on the geologic map (Pl. VIII). Little study of the flows was made during 1909, but the following quotation from Moffit's report[a] gives a clear idea of these lavas as a whole:

> In color the lavas are dark gray, green, or nearly black; they are usually very cellular or even spongy in appearance, but at times compact and without the amygdaloidal cavities. * * * That a succession of outbreaks of lava has taken place is shown in a number of places, but probably most plainly in the region about the head of Kuzitrin River, where positive evidence is afforded in the terraced condition of the different flows, three distinct benches occurring in one locality. * * * On the upper part of Koyuk River a similar relation of basalts and gravels was observed by Mendenhall. He found on the truncated edges of the schists 5 feet of gravel made up of schist, vein quartz, and granite; this in turn was covered by an undisturbed horizontal sheet of olivine basalt, which had been but little affected by the erosive action of the stream since it came to rest.

As the low divide between the Buckland and the Koyuk is formed of these recent lavas, it is an interesting speculation to attempt to reconstruct the surface on which the lavas were poured out. No data, however, are available as to the thickness of the recent lavas. At certain places, as, for instance, in the Koyuk basin, near Knowles Creek, the lavas run out into lobes not over 20 feet thick, but in other places a much greater thickness is indicated. Taken as a whole, however, the recent lavas probably form a relatively thin veneer on the preexisting surface.

VEINS.

Veins of different mineralogical character, formed at different times and under different conditions, have been noted in many places. They are abundant in the areas of metamorphic rocks and are practically absent in the greater part of the area occupied by the nonmetamorphic sediments. In the schist area veins are numerous in

[a] Moffit, F. H., op. cit., pp. 31-33.

the quartzose and graphitic schists and are fewer in the calcareous and feldspathic schists and limestones. Most of the veins in the limestone areas have calcite as the vein filling, but few of them are extensive either horizontally or vertically, and most of them appear to have been formed by shearing and the infiltration of calcite from the adjacent limestones. In veins of this class there are usually no other minerals than calcite.

Quartz veins of at least two distinct ages have been recognized in the schists. The veins of one age are much contorted and sheared; in those of the other crystalline quartz with characteristic comb structure is found. So far as can be determined, the mineral content of both of these classes is nearly identical. Sulphide mineralization is usually absent. Both classes of quartz veins in places carry small amounts of gold. Few of the contorted and sheared veins are more than a few inches in width, and most of the later veins are also narrow. The later veins, especially in the black carbonaceous schists and quartzites, are here and there so numerous that they form a stockwork through the rock. In selected specimens seven or eight of these veins may be recognized in a linear inch. Larger veins, however, occur in both types, and masses of quartz up to 2 or 3 feet in thickness, found in the float, show that veins of at least that size exist. All the veins are somewhat shattered, and few of them can be traced for any considerable distance on the surface.

UNCONSOLIDATED DEPOSITS.

No attempt will be made at this place to describe in detail the unconsolidated deposits of the Nulato-Council region. Later, in the section dealing with the placers, attention will be paid to those unconsolidated deposits in which minerals of economic importance have been found. It will be sufficient to state that many different types of unconsolidated deposits have been recognized. Coastal-plain gravels occur along the eastern coast of Norton Bay; beach gravels, of course, are formed along the entire coast line; creek gravels are present in all the streams of the region; low-bench gravels occur on many of the streams; high-bench gravels are to be found in a few of the valleys, where they have been disclosed by prospecting; gravel-filled basins occur behind lava barriers and in those places where deformation has obstructed drainage. Rock waste unsorted by water action is abundant on the hillsides. Glacial deposits are found in the mountainous regions where valley glaciers formerly existed. Glacial deposits, however, have not been recognized more than a few miles from the Bendeleben and Darby mountains and do not occur elsewhere.

GEOLOGIC HISTORY.

From the description of the different kinds of rocks and deposits found in the region an idea of the past conditions is afforded. As it has not been possible to set forth all the data, however, it is desirable to present the sequence of events as it has been made out. The earliest recorded event was the deposition of sandstones and limestones, now the metamorphic rocks, which were intruded by dikes and cut by veins. Interruptions of this deposition may have occurred, but this has not been definitely proved. Some of these sediments were laid down in the earlier and middle parts of the Paleozoic era. Subsequently mountain building took place, probably with vein formation and igneous intrusion. During this period the ancient igneous rocks were formed. Later, sediments were laid down in the region east of Norton Bay. To judge from the relation of the Nulato sandstone, in which fossils have been found, to the rest of the series, it is believed that the sediments in the region are in the main Cretaceous, though Eocene beds may be included in the upper part of the series. This group of rocks represents more or less gradual encroachment of the sea upon the land. Consolidation of these deposits took place and was followed by a period of pronounced deformation by which the Cretaceous rocks were thrown into a series of northeast-southwest folds. During the later stages of this mountain building some intrusions of granite, such as that at Bonanza Creek, occurred, probably with some mineralization. Long-continued erosion of the mountains followed and has gone on down to the present time with only slight interruptions. The recent lavas record one of these breaks in the period of erosion, but these were distinctly local in distribution. Other interruptions that have occurred are shown by the warpings of the crust which have brought certain areas above the sea or depressed others. The incised character of some of the streams also affords evidence of the folding that certain parts of the region have recently experienced. The absence, however, of any widespread deposits of sediments over the region subsequent to the Cretaceous-Eocene points to the conclusion that since that time the region as a whole has been land, and therefore subjected to erosive processes, rather than that it has been under water, and therefore an area of deposition.

ECONOMIC GEOLOGY.

From the preceding description of the areal geology of the region it has been shown that east of Koyuk River the country is formed of late sedimentary rocks little if any metamorphosed, whereas the region to the west of this stream is predominantly one of schists, limestones, and igneous rocks. So far as has been indicated by mining in con-

tiguous areas, the metamorphic rocks are those in which deposits of gold may be searched for with some promise of success, whereas the unmetamorphosed sedimentary rocks are but little mineralized.

GOLD IN THE AREAS OF NONMETAMORPHOSED SEDIMENTS.

GENERAL DISCUSSION.

In the unmetamorphosed sedimentary deposits the chances of finding economically important gold deposits are relatively slight except under rather local conditions. It is well known that the deposits of Cretaceous-Tertiary age, the unmetamorphosed sediments, were formed from the material eroded from the earlier rocks and deposited on the sea floor and in estuaries and marshes in essentially the same way that sediments are being deposited at the present day off the coast. However, it is known that some of the present-day sediments are auriferous, and it might be asked why similar placers should not be found in the older sedimentary deposits. Under conditions similar to those of the known coastal plain, gold placers should occur in the Nulato-Norton Bay region, but there are few places where such conditions prevailed.

In order to understand the different conditions at the two places it is necessary to point out the salient facts concerning the productive placers of the coastal plain, as, for instance, those at Nome.[a] The known placers are not more than 3 or 4 miles from the old land from which the sediments were derived; the depth of gravel covering the bed rock is in few places more than 100 feet; the gravel is as a whole fairly coarse; the rich ground occurs in ancient beaches which mark areas of concentration; the country immediately adjacent to the rich placers is known to be heavily mineralized. Consider the physical and geographic conditions which these facts entail. First, the short distance from the ancient shore line suggests that the gold did not travel far seaward from the place where it might have been formed. This is, of course, a conclusion which would have been reached by anyone accustomed to the action of gold in a sluice box. It might be safely postulated that in general the farther from the source the less gold there would be, other conditions being equal. Evidence of the proximity of the placer deposits to the old land is shown by the second fact stated above, namely, that the depth of gravel is as a rule not more than 100 feet. This condition, like the preceding, is valuable in establishing the nearness of the gold to its source. The third fact also is of value in further establishing this conclusion, but it is also important as showing that the agencies by which this material was transported were of sufficient strength to permit con-

[a] Details as to the character of the surface of the bed rocks, etc., are omitted as they are not important in bringing out the point of the following paragraph.

siderable sorting of the gravel and thus allow concentration of the particles of gold. The fact that the coastal-plain placers are found along old strand lines shows that in order to make a deposit of economic importance it is necessary to have a marked concentration of otherwise disseminated particles. It is of course unnecessary that this concentration should be effected by the sea, for streams would do it equally well, as is shown by the numerous creek placers. Perhaps the most important condition which must be fulfilled in order to make a rich placer is the presence of a highly mineralized area in the more or less immediate vicinity. Without this the other conditions are ineffective.

It has also been pointed out by others that certain physiographic conditions are essential for the production of placers, such as long-continued subaerial erosion followed by rapid sweeping off of detritus by revived drainage. As the physiographic history of northwestern Alaska has not yet been worked out in sufficient detail to permit the application of this criterion, it can not be critically considered in this discussion.

On turning now to the Nulato-Norton Bay region and considering it in the light of the premises enumerated above, it at once becomes evident that few of the conditions in this region are analogous to those postulated. It is true that there are places where the Cretaceous basin is in immediate contact with the old land. This has been proved by the basal conglomerate extending from a point near the Tubutulik northward along the east side of the Buckland-Kiwalik divide and noted by Mendenhall[a] on the Kobuk, from which it swings southeast and was recognized, although not correctly correlated, by Schrader on the Koyukuk and by Dall, Collier, and Spurr, and correctly correlated by Maddren on the Yukon near the Melozi.

In the belt occupied by the heavy conglomerate the deposits were certainly near enough to the shore to permit the formation of placers, but the physical conditions under which this conglomerate was deposited do not seem to have been well suited to the unlocking of gold from bed rock. Instead, the bowlders were riven from sea cliffs and were subjected to trituration rather than decomposition or disintegration, and whatever gold may have been in the rocks was so abraded before it was deposited that it undoubtedly formed flour gold, which would be much more widely disseminated than flake or shot gold. Furthermore, over a considerable part of the region where the basal conglomerate was seen by the Survey party the country rock forming the old shore line against which the sediments were deposited consisted of limestones and igneous rocks. So far as is known from a careful study of the known placer camps farther west,

[a] Mendenhall, W. C., Reconnaissance from Fort Hamlin to Kotzebue Sound: Prof. Paper U. S. Geol. Survey No. 10, 1902, p. 39.

practically no gold is found in the limestones, and little, if any, is known to be associated with the granites or other igneous rocks. It will be seen, therefore, that in the shoreward portion of the metamorphic area the important condition of near-by highly mineralized country rock from which the sediments were derived is lacking. For this reason it is believed that search for economic placers, while not entirely out of the question in the conglomerate area, is to be discouraged unless the field evidence is such as to show that conditions other than those in general encountered in the basal member exist.

It has been shown that over the greater part of the Nulato-Norton Bay area the lower member marking proximity to the old shore line is not exposed. It seems probable that through this part of the region the deposits are much higher geologically. From the physical character of the sediments and from the structures observed, such as cross-bedding, it seems certain that the higher geologic members were deposited in relatively shallow water. This fact, however, does not mean that the deposits were near the old land of metamorphic rocks. Figure 6 shows in diagrammatic manner the conditions

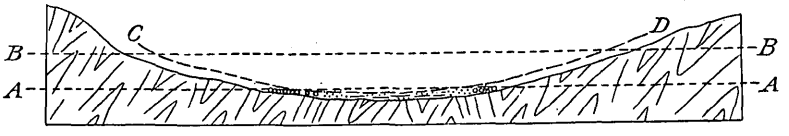


FIGURE 6.—Diagrammatic cross section of the Nulato-Norton Bay region during Cretaceous deposition.

believed to have prevailed in the Nulato-Norton Bay region during Cretaceous time. The metamorphic rocks to the left may be considered as representing the schists of Seward Peninsula and those to the right the rocks near the Melozi, the intervening area being the Nulato-Norton Bay region at the beginning of Cretaceous deposition, with sea level indicated by the line *A–A*. At this stage conglomerates were laid down close to the old land shore and sandstones and shales toward the center of the basin. Gradually depression took place, and continued at such a rate that the surface of the deposits was always within a short distance of sea level. It is evident, therefore, that if this depression continued until the surface of the deposits and sea level stood at the line *B–B* no part east of *C* as far as *D* had ever been close enough to the metamorphic area, which is assumed to have been the source of mineralization, to have received any notable amount of gold. Consequently, in this part of the region, unless subsequent folding exposed rocks at the surface outside of the part included within the line *C–D*, the probability of finding auriferous deposits is slight, and that only if the old land area from which the sediments were derived was sufficiently mineralized to afford placer gold.

It has been the object in the preceding paragraphs to point out that, on the whole, the chances of finding gold in the area of unmetamorphosed rocks are slight. From the fact that only under exceptional conditions are valuable deposits likely to be found, it seems that the ordinary prospector for gold should be warned against spending much time in the region east of Koyuk River. Not only does this conclusion seem sound from a theoretical standpoint, but it was learned from prospectors on the Inglutalik that they had been from that river eastward to and beyond the Gisasa and had not been able to raise a single color of gold.

It is not the purpose of this warning, however, to assert that no gold will be found in this region; for, as has been previously noted, there are three conditions under which deposits may be found. The first of these conditions, as has already been described, is that the unmetamorphosed sediments under discussion may have been those originally deposited at no great distance from the shore of a mineralized area of metamorphic rocks. Such deposits might be found at several places even in the middle parts of the basin if subsequent deformation brought up to the level of erosion the underlying rocks. As an example of this condition may be cited the area of metamorphic rocks which appear between Kwik and Koyuk rivers.

The second condition which might permit the formation of valuable gold placers in the Nulato-Norton Bay region is long-continued concentration of the material, either by streams or by the ocean. Concentration of this sort may have been effected either during the time when the sediments were being deposited or at a much later time. Throughout the period occupied by the deposition of the sands and gravels the region was apparently undergoing almost uninterrupted depression, so that although there was, of course, water sorting, it was nowhere so effective as it would have been if the region had been one of alternate erosion and deposition, like the coastal plain at Nome. In other words, the ancient placers at Nome seem to have been subjected to at least two periods of concentration, whereas the deposits of the other region seem to have undergone but one.

Since consolidation the sandstones and shales of the Cretaceous-Tertiary have been eroded by the streams, and a present-day concentration is being effected. Some of the reported finds of gold in the Yukon basin are probably due to this sorting, although as yet too little is known about the occurrences, and they may have been formed by original sorting before the consolidation of the sediments. If, however, the Cretaceous rocks were relatively devoid of valuable minerals because of their distance from a mineralized area, it is evident that such concentration would not produce very rich deposits.

The third type of locality where search for gold placers or lodes in the area of nonmetamorphic rocks would be warranted is at those

places where mineralization has occurred since Cretaceous time. Such places are, so far as known, closely associated with the areas of intrusive igneous rocks. The effusive rocks or lavas of Tertiary-Recent age do not seem to have brought any valuable minerals, and therefore placers or lodes due to post-Cretaceous mineralization are not to be sought in those areas where only these rocks occur.

Intrusive rocks later than the Cretaceous have been noted at two places, and a more detailed investigation of the area would undoubtedly result in discovering others. The two places where these later granitic rocks have been examined by the Survey party are on Ungalik River south of camp A 16 and at Bonanza Creek. From reports of prospectors it seems that the placer-bearing gravels of Anvik River may have been derived from a similar area of intrusive granitic rock, although too little is known of the geology of the country to advance this interpretation more than tentatively. Spurr,[a] in his summary of the occurrence of gold in southwestern Alaska, says:

> The gold in this region is by no means so abundant as it is along the belt of the Yukon geanticline, where the ancient schists with their inclosed quartz veins are found. The mineralization of southwestern Alaska is of a later date and not so intense or widespread. Within the area examined by the writer's party last summer (1898), the Tordrillo Mountains are undoubtedly the chief seat of mineralization, and this appears to be directly dependent upon the fact that these mountains have also been the chief seat of intrusion of igneous rocks.

BONANZA CREEK PLACERS.

Bonanza Creek is the only stream between the Koyuk and the Yukon where placer mining has been successfully carried on. The creek is only about a mile long, but values have been found almost the entire length of its course, and from the character of the gold seem to be of distinctly local origin. Gold was originally discovered on this creek in 1899 by Thomas Moon and his partner, who staked claims. The absence of water and the boom that the Seward Peninsula placers were having prevented any considerable development in the first year or so. After the lower claims had changed hands several times they were at last bought by the Nelsons, who have since been the most industrious miners there. Other outfits have held ground on claims No. 2 and No. 3 above the Discovery claim, and some work has been done in the last two or three years.

At first the creek claims were the ones from which the values were obtained. On the lower claim the pay streak was 400 feet wide, but it narrowed upstream so that at the northern line of No. 1 above Discovery the width was only about 75 feet. The gravels were

[a] Spurr, J. E., Reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 261.

typically river wash in form and consisted of material from near-by rocks, although some of the pebbles were undoubtedly derived from higher-level gravels which were not of local origin. The bed rock is a much shattered black slate or shale, on the whole rather thinly laminated and not so quartzose as the black quartzitic slates of the metamorphic group. The slates are cut by igneous rocks of the granite family. An exposure of one of the intrusive dikes occurs a short distance north of the cabins at the junction of Bonanza Creek and the Ungalik. Here the dike is apparently about 10 feet wide and shows by its undeformed character that it was injected subsequent to the period of folding and faulting of the slates. It trends obliquely to the slates, having a strike of N. 5° E., and stands vertical. It is heavily iron stained in places. This iron is probably derived from the decomposition of sulphides, some of the unaltered material under the microscope showing pyrite.

Above the creek on the northeast side of the valley is a bench on which gravels have been found that are highly auriferous. After the exhaustion of the creek gravels attention was turned to this high-level ground and satisfactory returns have been obtained. Aneroid readings give the elevation of the bench as about 80 feet above Bonanza Creek at the cabins, but some gravels have been found up to an elevation of 150 feet above the stream. The gold on the benches is medium coarse and of a dark-reddish color. None of it is black gold. Several nuggets were seen that had small pieces of quartz attached. From the owners it was learned that the largest nugget taken from this creek was worth about $21. The value of the gold is high, that from the lower claim being reported to be worth about $19.25 an ounce, and some obtained higher up on the creek and not from bench ground was reported to assay from $19.05 to $19.15 an ounce.

Concentrates from the bench ground show a good deal of magnetite or black sand. Some of the fragments of this mineral were as much as one-fourth inch in length. Together with the magnetite is also ilmenite, the oxide of titanium and iron, which is nonmagnetic. Garnet, or the so-called "ruby" sand, is practically absent in all parts of the creek. This was to be expected, for none of the rocks in the neighborhood show any such development of this mineral as can be seen in the Seward Peninsula placers. Some float pieces of antimony are occasionally found in the gravels of Bonanza Creek. Foreign material, not derived from the immediate Bonanza Creek basin, is abundant, notably felsite and fragments of other effusive rocks.

Bonanza Creek has so small a supply of water that the extraction of the gold from the gravels has been a serious problem. In the early days the separation was accomplished by the use of rockers, and even during the summer of 1909 this method was still in use on some of the creek gravels half a mile or so above the mouth of the stream.

With the discovery of gold in the high benches the need of a supply at considerable elevation compelled further consideration of the water supply. Ditches, except of such length as to be prohibitive in cost, were not feasible and the experiment was tried of pumping water from Ungalik River. Wood cut in the neighborhood of the mines was used for fuel. Although no figures are available as to the cost of the water delivered on the ground, the fact that this method was pursued until the claims were worked out is sufficient proof that the owners were satisfied with the project.

The method of work was to make cuts at intervals at right angles to the trend of the old channel. In these trenches sluice boxes were placed in such manner that their lower end discharged toward Bonanza Creek. The abrupt cliff that occurs at the edge of the bench deposit offered particularly favorable topography for the discharge of tailings onto the lower ground so that the boxes would not become choked. The water pumped in two lifts was delivered to the nozzles on the bench ground and the gravels and overburden were washed through the sluice boxes. After the gravels had thus been sluiced off, the bed rock was taken up by hand and cleaned. In places 3 feet of the rather angular blocky slate had to be picked up to recover the pay values, but over much of the bench ground it was necessary to take up only from a foot to 18 inches.

During 1909 the last of the bench and creek ground nearest the mouth of the creek was exhausted and the boiler and pump were dismantled and put into condition to be shipped away, so that the lower claims may now be regarded as worked out. Good bench placer ground, however, continues from the north end line and the next claim upstream undoubtedly contains valuable deposits. During the early part of 1909 the owner of this ground was engaged in building a small ditch from the upper part of Bonanza Creek to bring water to this bench. The small amount of water available, however, makes it probable that the operations will be much hampered. The bench ground is frozen, so that either a strong head of water will be required to break down the gravels or else the owners will be forced to resort to thawing.

On the fourth claim above the mouth of Bonanza Creek little work was accomplished during 1909 and that mainly of a prospecting character. The unusually dry season made this part of the stream practically dry by the middle of July, so that the only gold taken out was by means of rockers. At this place specimens of gold in a black graphitic slate were seen. This occurrence suggests that the carbon which is abundant in the slates may have been effective in causing the deposition of the gold.

At the mouth of Bonanza Creek some gold has been found in the gravels of Ungalik River. Several shallow holes have been put down

in the river flats a few score yards north of the mouth of Bonanza Creek and good prospects have been reported. On the whole, however, the tenor of these gravels is low and although occasional 5-cent pans have been found the average indicated is so low that the ground could not be worked without labor-saving devices capable of handling large amounts of gravel at a small cost. The gold is reported to be irregularly distributed, so that rich pockets separated by intervals of barren ground are to be expected, and this condition is not one calculated to encourage the development of large undertakings.

Scores of lode claims have been staked on Christmas Mountain, which is about 5 miles east of Bonanza Creek, but with the exception of a little sulphide mineralization few indications of profitable veins have been disclosed. In spite of the apparent absence of lodes that would warrant extensive development, it is believed that there is a disseminated mineralization in the vicinity of this mountain that might justify a search for placers in the neighborhood. From the reports of prospectors it was learned that colors of gold had been found in the gravels of many of the streams heading in this mountain and draining into either the Ungalik or the Shaktolik. Several placer claims have been staked on Christmas Creek, which enters the Ungalik 3 or 4 miles north of camp A 16, but no mining has been done. It seems probable that owing to the inaccessibility of the region it would not be profitable to work any but a rather high-grade placer at the present time at this place.

It is further reported that stibnite (antimony sulphide) float has been found on the divide between the Shaktolik and the Ungalik, about 4 miles northeast of Bonanza Creek, on the slopes of Christmas Mountain. This mineral was not found at this place by the Survey party, but its presence would indicate that the sulphide mineralization already noted may have introduced many different minerals.

In the same general region but not definitely associated with intrusive igneous rocks are streams that are said to contain some auriferous gravels, but the geology of the places is too indeterminate at the present time to warrant even a suggestion of the origin of the valuable minerals. Garryowen Creek, a tributary of the Inglutalik heading in the Inglutalik-Ungalik divide, is reported to yield colors of gold. Negromoon Creek, which joins the Inglutalik from the west upstream from Garryowen, also shows gold-bearing gravels. The values, however, on both these streams are so low that they are of no economic significance at the present time and can not be worked under existing conditions. No adequate prospecting has been done on any of these streams, and it is therefore impossible to make even an approximation of the tenor of the gravels.

GOLD PLACERS AND LODES IN THE AREAS OF METAMORPHIC ROCKS.

GENERAL DISCUSSION.

As the metamorphic rocks are older than the unmetamorphic rocks, broadly speaking, they have been subjected to at least the same number of periods of mineralization as the latter plus whatever number occurred before the laying down of the Cretaceous-Tertiary sediments. It is of course realized that mineralization may be distinctly local and may affect one region and not another, so that it is not intended to assert that the richness of a region is necessarily dependent on the number of periods of mineralization it has undergone. The object of the above statement is, however, to suggest that according to the law of chances such a generalization is sound. From the field evidence this view receives corroborative support, for it is found that in most of the Seward Peninsula placer regions there were at least two periods of vein formation, during each of which gold lodes were made, whereas in the area of unmetamorphosed sediments only one has been recognized.

Valuable gold deposits have been mined most extensively in Seward Peninsula, where the metamorphic rocks are most abundant, and it is believed that regions underlain by them are the most promising areas in which to prospect for new placers. In general, the richest placer areas are near the contacts between the heavy overlying limestones and the underlying quartz-chlorite schists. So far as known the intrusive igneous rocks older than the Cretaceous are slightly if at all auriferous and the recent lava flows are entirely devoid of valuable minerals. Therefore areas deriving their surficial deposits from such rocks are not likely to afford valuable placers.

Several of the various placer camps located within the area covered by the map of southeastern Seward Peninsula were not visited during 1909 and will not be described in this report. In order, therefore, to gain a complete account of the economic geology of the eastern part of Seward Peninsula, the reader should also refer to the published reports of Brooks, Moffit, Collier, and others.[a] In the treatment of the gold placers of the areas of metamorphic rocks a geographic order will be adopted. The placer deposits of a single river basin will be treated from the mouth toward the head of the stream. The various river basins tributary to Norton Sound will be described from east to west, starting with the Koyuk, and this will be followed by descriptions of the various basins emptying into Kotzebue Sound from the Buckland River westward.

[a] Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., Gold placers of parts of Seward Peninsula: Bull. U. S. Geol. Survey No. 328, 1908. Moffit, F. H., The Fairhaven gold placers, Seward Peninsula; Bull. U. S. Geol. Survey No. 247, 1904.

KOYUK RIVER BASIN.

At the present time no gold placers are being mined in the Koyuk basin, and there are few places where mining has been carried on in the past on an economic basis. Colors of gold have been found on many of the streams and a number of different outfits have been brought into the region, but so far without sufficiently encouraging returns to keep a permanent force on any of the streams.

About a mile west of camp B 17, at the mouth of the Koyuk, there is a black limy schist and limestone that occurs east of a lighter-colored schist, the dip of both being practically vertical. On the beach at this place and extending for a considerable distance to the east and west are many large angular pieces of quartz float that suggest vein material. Pans of broken-up material from the schists near this place show a number of very small colors of worn placer gold. From a prospector living near by it was learned that 1 per cent pans had been found, but the small returns were not sufficiently encouraging to warrant any considerable expenditures either of time or money.

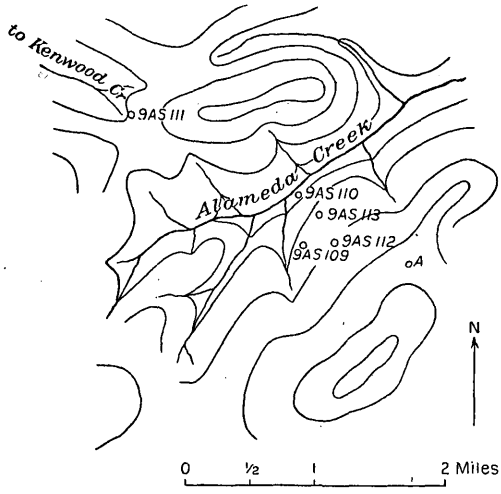


FIGURE 7.—Sketch map of Alameda Creek.

Alameda Creek, a small tributary to the Koyuk from the west, joining the river a short distance below the mouth of East Fork, was visited in the early part of August. Although no active work was in progress, the problems that have been raised by earlier prospecting are such as to attract the attention of the geologist. Figure 7 shows the headward portion of this stream, with the location of the different prospect holes that have been sunk. The elevations given are only approximate, as the weather was so changeable that an aneroid was of no assistance.

At locality 9AS109, south of Alameda Creek, a shaft 192 feet deep was sunk, all the way through well-rounded, predominantly quartz gravel. The upper part of the gravel is whitish, with black quartzite pebbles and some glassy lava. Not many pebbles of the lava were found. Midway in the shaft the gravels are yellower and more iron-stained than in the upper part. In the lower part of the hole the fine material is of a greenish-white color, but is otherwise similar to

that above. On reaching a depth of 192 feet the miners were forced to abandon the shaft, as a great deal of water was encountered. This condition suggests that the bottom of the shaft was close to bed rock, a conclusion that receives some support from the fact that in the bottom of the shaft pieces of ancient lava, probably the country rock here, became more numerous.

It is reported that in the section cut by the shaft a few thin sedimentary layers were found that gave fairly good prospects. A pan of the gravel from the dump, which was said to have come from near the top of the shaft, gave two small colors. Samples from the gravels said to occur near the bottom of the shaft showed also minute specks of gold. In the concentrates from the same part of the section there was a good deal of black sand, but garnet was practically absent. A good many pieces of undecomposed sulphides were also recognized in the concentrates. Within a hundred feet of the shaft a pan from the surface gravels directly under the grass roots showed several bright colors of gold and some magnetite and ilmenite.

Nearly due east of the last locality and at an elevation about 100 feet higher another shaft had been sunk (locality 9AS112). The depth of the shaft was somewhat over 70 feet and it had not reached bed rock. The material on the dump consisted mainly of well-washed white quartz gravel, with some pebbles of black quartzite and red lava. About 25 feet east of this hole and at a slightly higher elevation was a shaft 45 feet deep that had been sunk without reaching bed rock. The material on the dump at this shaft was more sandy and the pebbles smaller than from the shaft at locality 9AS112.

Northward down the slope, at locality 9AS113, another shallow shaft had been put down. It was only about 15 to 20 feet deep and in it no gravel at all was reported.

On a low bench on the south side of Alameda Creek, at an elevation of less than 10 feet above the water, there is a caved shaft (locality 9AS110). This was originally 32 feet deep and reached bed rock, which belonged to the group of ancient igneous rocks. There was a great deal of well-rounded quartz gravel on the dump, but as a whole the material was much darker than at locality 9AS109, and there was a much greater proportion of lava fragments. The prospectors who sunk this shaft reported that the values were found entirely on bed rock and that the lower gravel went about 1 cent to the pan. The present gravels of Alameda Creek upstream from this shaft are reported to carry no gold, whereas to the northeast, or downstream, the creek gravels yield about 7 cents to the 10-pan bucket. A mile and a half downstream, however, even this amount of gold disappears and the gravels are barren. From these facts it would appear that the present creek may derive its gold from the earlier channel. It

should be remembered, however, that if the values occur mainly on bed rock in this channel the bottom is still below the level of Alameda Creek, and therefore the reconcentration has not affected the richest portion of the old channel.

Directly across the creek and at the same elevation above the stream as locality 9AS110 a shaft 12 feet deep has been sunk to bed rock. The bed rock at this place also was dark, much-fractured, fine-grained old lava. A pan of gravel from the dump at this place showed an abundance of green lava sand with numerous hornblende crystals. Several well-rounded garnets were also noted.

A mile and a half west of this shaft, on one of the small tributaries of Kenwood Creek, some further prospecting has been done to locate the northwest continuation of the old channel. At locality 9AS111 there is a shaft 24 feet deep, now badly caved. The material on the dump is nearly all angular, almost completely decomposed rock, which seems to contain some rounded black pebbles. The material is so badly changed that it is impossible to assert definitely whether it represents a recent slightly consolidated gravel or a more ancient sandstone or fine grit. It was claimed by the prospectors that bed rock was reached in this shaft and samples of the material supposed to be from the bottom of the hole showed thin quartz and calcite veins with decomposed material between. Some of the quartz was much slickensided.

At 45 and 65 paces west of locality 9AS111 were two other prospect pits at a slightly lower elevation than the one just described. The western one showed undoubted gravel on the dump, some of the pebbles being 3 to 4 inches in diameter. There were very few white quartz pebbles, the greater number being of black quartzite. There seems to be little room to doubt that this is a portion of the same deposit encountered in the deep shaft at locality 9AS109. It is unfortunate that the depth to bed rock has not been determined at the two places, for it might afford information as to either the direction of the old drainage or the amount of deformation since the cutting of the channel.

On the broadly open saddle 1½ miles southwest of locality 9AS109 quartz gravel is reported to be abundant and it is believed that this low pass may mark the southern continuation of this channel. On this assumption prospectors were engaged in examining the ground and a party of three or four men intended to winter at this place. It should be pointed out that even if this should be the old course of the valley it does not follow that the gravels will be auriferous, for, as has already been noted, so far as prospected the gravels in the deep hole on Alameda Creek are not sufficiently gold bearing to be mined at the present time.

Not enough facts are as yet available for more than a tentative interpretation of the conditions under which the old channel was formed. It is evident from the presence of lava in the gravels of the channel filling that the channel was carved and occupied by a stream later than the effusion of the recent lava. It seems probable that a rearrangement of drainage may have resulted from the extrusion of the tongue of lava which occupied the low country between Koyuk and Buckland rivers and flowed down the present Koyuk Valley below East Fork. This may have resulted in turning the lower part of the Koyuk out of its former course and allowing it to cut the gorge here discussed. After the gorge had been eroded, either by change in the relation of the land with respect to sea level or by capturing, the old valley was filled and the stream was diverted, so that it took up a course parallel with the tongue of lava that flowed down the Koyuk Valley. It eroded the lava, thus etching out and uncovering its former valley, in which it now flows.

In regard to the origin of the gold found in the old valley gravels there is some question. Alameda Creek is near the area of metamorphic rocks and the presence of a great number of pebbles of vein quartz in the gravels suggests that they at least have been derived from the quartz stringers in this series. If this vein quartz has been derived from this source there is a strong presumption that the gold has also come from the same place. On the other hand, it should be noted that there are indications that some of the ancient lava is mineralized. A shallow prospect pit has been sunk on a ledge of amygdaloidal trap outcropping on the divide between the Koyuk and Alameda Creek shown at A, figure 7. Assays made at Nome of material from this pit are reported to have given as high as $3.72 in gold to the ton. The rock shows no macroscopic mineralization and considerable doubt is felt of the accuracy of this determination.

Kenwood Creek, which enters the Koyuk from the south above East Fork, has been prospected near the head, as already noted, and a little work has been done also on the lower part. Two prospectors, who were reported to have found good prospects at this place several years ago, went to the lower part of Kenwood Creek during the summer of 1909. The low water prevented their getting upstream far enough with their boat and they returned. It is probable, however, that bed rock through the lower part of the creek is deep and difficulty with water will be experienced.

On Willow Creek, which enters the Koyuk from the south above Kenwood Creek, there are signs of former prospecting, but the stream is now deserted. J. L. McPherson, who visited this region in 1907, during the progress of a survey made for the Alaska road commission, has stated that at that time location notices were seen which showed that the prospecting had been done about five years before.

Peace River is one of the northern tributaries of the Koyuk west of East Fork. About 12 miles above the mouth it forks, and near this place some prospecting was done during the winter of 1908. Two shafts were put down on the east bank of the river, but they were so badly caved that only the upper 3 feet or so was visible. This part of the section shows brown irregularly bedded sands of even texture having in general a dip toward the west—that is, toward the stream. The material on the dump is fairly well rounded river wash consisting almost entirely of igneous rocks with some red iron-stained gravel of the same nature. The eastern of the two holes was probably not more than 15 feet deep, but the other may have been 25 feet deep. Some material put aside as though it were the pay gravel was a greenish-brown sand.

About 100 yards east of this place and on a slightly higher bench there is another shaft now filled with water. This pit was probably not more than 5 to 10 feet deep. From the material on the dump it appeared that the gravel is not so well rounded and there is much more mud mixed with the sand. The upper 2 or 3 feet, which was the only part visible, instead of consisting of sands as in the western holes, was entirely formed of muck. From prospectors later in the season it was learned that some gold had been found in these holes, but not enough to warrant further exploitation. It was currently reported that one piece of gold found there was worth 4 cents, but this was the largest piece. The presence of gold at this place suggests the possibility that some of the ancient lavas have been more or less mineralized, but the evidence is not sufficiently definite to preclude other sources of origin.

Mendenhall[a] notes that in 1900 Knowles Creek had been prospected and a mining district established there. He was unable to learn the success of the operations, but the fact that in 1903, when this region was visited by Moffit, no work was in progress and the creek was deserted shows that the gold tenor of the gravels must have been too low to make mining profitable.

A tributary creek farther upstream, heading in the hills near the low pass into Death Valley and the upper part of the Koyuk basin, is mentioned by Mendenhall[a] as follows:

> Just above the camp of September 5 another tributary enters from the south carrying only schistose pebbles. These, however, are very calcareous. Most of the streams which enter the upper course of the river from the north lie without the lava belt, but the schists here have not the aspect of the gold-bearing members. At Cheenik in the fall we met prospectors who had been up the river and reported finding colors all along its course.

Moffit, in 1903, reported no mining in this part of the river basin and no signs of recent work were seen by the party in 1909.

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[a] Mendenhall, W. C., A reconnaissance in the Norton Bay region, Alaska, in 1900; a special publication of the U. S. Geol. Survey, 1901, p. 213.

KWIK RIVER BASIN.

No mining was in progress during 1909 on any of the streams in the Kwik River basin, and so far as could be learned little or no prospecting has been done in the past in this area. On the head of Quartz Creek, about 3 or 4 miles east of camp C 3, there were some old claim stakes and some sluicing had been done several years ago. J. L. McPherson noted that in 1907 he found location notices of about five years previous date on this creek.

TUBUTULIK RIVER BASIN.

During the time that the Survey party of 1909 was in the vicinity of the Tubutulik no prospectors were seen and no evidence of any recent mining was observed. Practically the only thing that is known about the mining in the basin is furnished by the report of Mendenhall,[a] in which the following statements are made:

> This stream, while farther from the known productive districts than the Fish, was the object of considerable attention during the summer of 1900. The surface gravels of the river bars gave colors quite as heavy as those on Fish River wherever a pan was washed out—at least as far up as the granite area. We had no reports from the head of this stream, and did not have an opportunity to examine it ourselves, but the area drained by it is not particularly promising.
>
> Mr. C. C. Alexander and members of his party, who had been prospecting on Chukajak and Vulcan creeks during the fall of 1899 and the summer of 1900, report the finding of coarse gold early in their work on the former stream, but more thorough development did not fulfill the promise of this first find. Reports of favorable prospects here, however, had reached Golofnin Bay and Nome, and a small stampede toward the Tubutulik resulted. When we left the river, late in August, many outfits were reaching the field. Reports toward the end of September did not tend to confirm the earlier accounts of rich strikes there.

It was reported that some mining was done several years ago on the next stream above Lost Creek. According to Mendenhall the name of this creek was Admiral, but the claims were described as on Camp Creek. It seems probable that the two names are applied to the same stream, but which is correct could not be determined. From the character of the bed rock near this stream it would appear that the geology is complex and that the older schists form the lower part of the valleys, so that it is presumed the gold was derived from them. Placer mining on Camp Creek was carried on by means of horse scrapers, but the absence of any recent work in the vicinity seemed to show that the returns were not satisfactory. From the strong evidence of glaciation of the valley type in many of the streams heading in the Darby Range and entering the Tubutulik from the west it seems unlikely that any rich placers will be found in that part of the basin. The eastern boundary of the basin in the southern part is formed of the Cretaceous conglomerate, so that strong mineraliza-

[a] Mendenhall, W. C., op. cit., p. 212.

tion is not to be expected in it. Farther north the eastern part of the Tubutulik divide is formed of the Paleozoic limestones, and these are not promising rocks from which to derive placers. It is felt, therefore, that a large part of this drainage basin is not particularly favorable for economically important placer deposits.

KWINIUK RIVER BASIN.

Practically the whole of Kwiniuk River and its tributaries flow in valleys carved in the igneous rocks that make up the Darby Range. So far as is known these rocks are but slightly mineralized. Consequently there is but little chance that the detritus worn from these rocks would form valuable placer deposits. In the lower part of the course, where the bed rock is heavily covered by unconsolidated deposits, the character of the country rock is not clear and the more mineralized schists may occur. If this is the case, there is some possibility that, where concentration has been effective, placers may be discovered. The depths of covering and the problem of handling water would make the development of such placers difficult.

FISH RIVER BASIN.

The main Fish River basin has not been important as a placer district, although the tributaries of the Niukluk, its longest western branch, have produced more gold than those of all the rest of the region. According to Mendenhall,[a] Fish River carries gold from its mouth to the north end of the gorge. Throughout the lower part of the river the colors are very light, but they become heavier in the constricted part of the valley, where the stream crosses the belt of limestones and schists. Opposite the mouth of Anaconda Creek, as the lower part of Parantulik River is called, pans taken from the broken rim rock yielded from half a cent to 1 cent each. According to the same author prospectors found nothing in the upper flats of Fish River, and so far as reported the streams flowing out of the mountains to the north do not yield colors.

From the geologic description of the northern and eastern parts of the Fish River basin it is seen that the rocks are schists and limestones which appear to be the same as the rocks in some of the placer regions, except that the schists contain much greater quantities of biotite. Veins are equally abundant in both types, and it is believed that the absence of placers may be explained in part by the valley glaciation that has scoured out the water-sorted deposits from most of the valleys heading in the Bendeleben and Darby mountains. This process has scattered the deposits which may have existed in the valleys prior to this erosion. Information on the subject is still

[a] Mendenhall, W. C., op. cit., p. 212.

too meager to allow a final judgment as to the reason for the absence of placers in this part of the basin, but it is believed that the physical history rather than the lithologic character is responsible for the apparent absence of placers.

Placer gold has long been known in the region around Council, having been reported in 1865 by members of the Western Union Telegraph Company, and in 1892 John Dexter is said to have notified members of the Silver-Lead Mining Company that he had found gold. It was not until 1896–97, however, that the discovery of Ophir Creek, the richest stream in the Council district, was made by Mordant, Melsing, Libby, and Nelson. Although apparently gold was found at that time, it was not until the spring of 1898 that the district was organized and active placer mining begun. So valuable have the placers turned out that in 1903 Collier estimated that the gold output up to that year was between $5,000,000 and $6,000,000.[a] Since that time $2,000,000 to $3,000,000 more has been taken out, so that this camp has been second in production to that of Nome.

The productive streams in this so-called Council region from southeast to west are Fox, Mystery, Melsing, Ophir, Goldbottom, Camp, and Elkhorn creeks. All except Fox Creek are tributaries of the Niukluk, and Fox Creek joins Fish River less than 4 miles below.

BLUFF REGION.

The region around Bluff has not been visited by Survey geologists since 1906. Gold is said to have been found at Daniels Creek in September, 1899, by William Hunter and Frank Walker. Beach placer ground was located soon afterward and within less than six months $600,000 had been taken from a strip of land less than 1,000 feet long. Meanwhile the two lowest claims on Daniels Creek were opened and in 1900 yielded probably $200,000 in gold. Most of the 1901–2 production came from Discovery claim, at the mouth of Daniels Creek. Meanwhile gold had been found on Eldorado and Ryan creeks and on Swede Gulch. In 1902 a strong company was organized and has been engaged in mining the important placer ground ever since. For further notes on the Bluff region reference should be made to the report by Brooks of his visit in 1906.[b]

RIVERS TRIBUTARY TO KOTZEBUE SOUND.

The only stream tributary to Buckland River on which gold placer has been found is Bear Creek, which heads in the ancient lava hills that form the western margin of the basin. The first

[a] Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., Gold placers of parts of Seward Peninsula: Bull. U. S. Geol. Survey No. 328, 1908, p. 236.

[b] Brooks, A. H., The Bluff region: Bull. U. S. Geol. Survey No. 328, 1908, pp. 383-393.

claims recorded on this stream were located by R. S. Hoxie, L. Tendness, and A. Barr in August, 1901. During 1903, according to Moffit,[a] about 40 men were at work on Bear Creek and its tributaries, Sheridan and Cub creeks, but as only about $10,000 in gold was won from this basin during that year it is evident that the work was not very profitable. Moffit says:

> Mica schist is said not to be found in this creek, although mica does appear in the sands and gravels, which are composed largely of eruptive material and on some of the bench claims reach a thickness of 20 feet, with several feet of muck overlying. In places on the creek a considerable quantity of a heavy red cherty rock remains in the boxes with the gold and is a source of some annoyance to the miner. This is especially true on Cub Creek. On Sheridan and Bear creeks the gold is mostly on bed rock, differing in this respect from that on Cub Creek, where it is found throughout the whole thickness of the 2 feet of stream gravel; on the other hand, gold from Bear and Cub creeks is light and flaky while that from Sheridan is heavy. All the gold is bright yellow in color, assaying $19.20 to the ounce. A little "white iron" pyrite is present and also an abundance of black sand which is entirely removed by the magnet.

From 1903 to 1907 a little desultory prospecting and mining was done, but during the latter year the building of a ditch along the west slope of the valley revived interest in the region. The small precipitation of 1908, however, prevented any extensive use of the new ditch and in 1909 there was little evidence that productive mining was in progress.

In spite of the small production of gold, this region is of interest as indicating that the placers have been derived from the ancient lavas that form the Buckland and Kiwalik divide. It will be remembered that this source was suggested as a possibility for the placers on Alameda Creek, in the Koyuk basin, on the southern extension of this lava series. It should be pointed out, however, that while a little local mineralization may have affected this group of rocks here and there, so far as can be foretold by present indications there is slight chance of finding any considerable extent of rich placer ground on those streams where the ancient lavas form the country rock. In other words, it is believed that only "one-man camps" will be established on streams deriving their gravels from areas of ancient lavas.

Although auriferous the larger part of Kiwalik River lies outside of the area represented on the map accompanying this report and as the region was not visited in 1909 by the geologists of the Survey party it is desirable to omit any detailed description of the placers. Complete descriptions, as the facts in hand warranted, have already been published by the Survey.[b]

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[a] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 247, 1904, p. 64.

[b] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 247, 1905, 85 pp. Henshaw, F. F., Mining in the Fairhaven precinct: Bull. U. S. Geol. Survey No. 379, 1909, pp. 364-369.

SILVER-LEAD DEPOSIT.

Within the area of metamorphic rocks of southeastern Seward Peninsula one deposit of argentiferous galena has been of some economic value. This lode, staked in 1881, was probably the second one discovered in the entire Territory of Alaska. Although the claims were not recorded until July, 1881, galena had been known for a year or more before and Petrof, in the census report for 1880, mentions the fact that silver-lead ore had been found in the vicinity of Golofnin Bay. The developments at this place have been carried on at a single group of claims located on a low limestone-schist hill on the western flanks of the Darby Range. As has already been

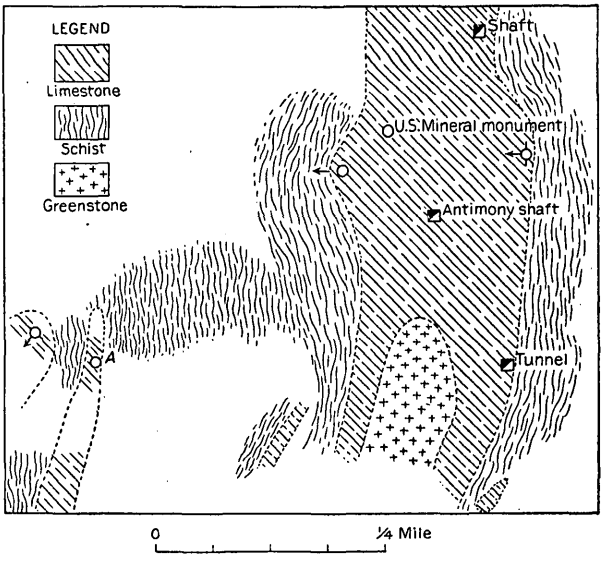

FIGURE 8.—Sketch map of Omilak mine.

stated, the claims were located in 1881. In 1882 a company was formed and in 1883 was absorbed by the Omilak Gold and Silver Mining Company, which continued to hold the ground until 1898, when the Russian-American Mining Exploration Company took the properties. This transfer was one of name rather than of personnel. As the claims were patented in 1894, there has been no recent controversy as to the ownership of the property.

The geology in the vicinity of the mine is so complex that without more detailed study than was made in 1909 the stratigraphy is not determinable. East of the mine, toward the head of Umalik Creek, is a large area of white crystalline limestone which in the main appears to dip westward at high angles. This is succeeded toward the west by schistose rocks containing much biotite and quartz and some graphite. Farther west, in the immediate neighborhood of the

mine, the distribution of the various rocks is as shown in figure 8. Although from this map it appears that the dip is in general westerly, the evidence on the ground shows that the rocks are much deformed, and tightly appressed folds have been recognized pitching steeply toward the west. With such an amount of folding the structure is by no means so simple as appears at first sight, and even the determination of bedding is in many places impossible. It is believed, though it has not been definitely proved, that the schists represent younger or overlying rocks.

In addition to the dark biotite schist and the limestones there is an area of slightly sheared igneous rock similar to the greenstones of the more western part of Seward Peninsula. Although the exposures were not sufficiently clear to preclude other interpretations, it seems probable that these greenstones intrude the limestones. Owing to the amount of deformation and consequent metamorphism it is possible that some of the greenstones may be included in the areas mapped as schist. The fact that the greenstone is more easily recognizable in the midst of the limestone may be due to the protection given to it by that rock, which is more easily deformed than the schist, whose resistance to dynamic metamorphism is more nearly equal to that of the igneous rocks.

According to Mendenhall [a] the ore occurs near the contact of this intrusive rock and the limestone. From the study of the region in 1909 this conclusion could not be verified, as the shaft was inaccessible and the only mineralization seen was in the midst of the limestone. Owing to the absence of ore-bearing minerals in the greenstone, however, it seems doubtful whether the galena could have been introduced at the time of the intrusion. Furthermore, the well-crystallized character of the ore suggests that its deposition was later than the deformation of the region, whereas the greenstone was earlier.

Two kinds of ore minerals are found in this deposit—argentiferous galena and stibnite. So far no interrelation between the two has been shown, but it is believed that both were introduced at essentially the same time. It should be noted that the deposits containing the galena seem to be topographically above those with stibnite. This is not the condition that would be expected to result if the two ores had been deposited from the same solutions according to their relative fusibilities.

From the reports of others, as it was not possible to see the underground workings personally, it was learned that "no continuous vein of galena ore existed, the same being found only in irregular and disconnected pockets." [b] None of the pockets were of large size and the

[a] Mendenhall, W. C., a reconnaissance in the Norton Bay region, Alaska, in 1900; a special publication of the U. S. Geol. Survey, 1901, p. 214.

[b] Idem, pp. 213-214.

better ones occurred entirely within the limestone. Some of the ore was thickly covered with products of oxidation, mostly lead carbonate.

About 400 paces south of the galena shaft there are a shaft and incline which were used to explore the stibnite leads. The limestone is much fractured and the ore occurs in thin streaks in the shattered zone. None of the veins seen by the writers were of sufficient size to warrant mining. The stibnite is well crystallized, the thicker stringers apparently occupying fault planes and sending small offshoots into the limestone, which near the ore is abnormally granular and sugary.

Considering the number of years the ground has been held and the large expenditures that have been incurred, the amount of development work is astonishingly small. A shaft 180 feet deep has been sunk near the eastern margin of the limestone on top of the hill, and two short drifts have been turned off in the search for ore pockets. The upper part of the shaft is in limestone, but the lower is in schist, as the contact dips toward the west. The shaft is well timbered and is fairly dry. Hoisting is done by power, using a bucket not running on guides. Electric lights are used around the shaft house and underground. Two outfits for drilling have been used, one an air compressor and air drills, and the other an electric drill plant. Electricity for these uses is furnished by a coal-oil engine, located near the main bunk house on Umalik Creek.

At 200 to 300 feet vertically above Umalik Creek an adit has been started to intersect the shaft in depth and thus obviate the necessity of hoisting the rock to the top of the hill and then taking it down again for shipment. The length of the adit is 187 paces, or approximately 500 feet; this distance was in massive white limestone somewhat shattered but nowhere showing mineralization.

In addition to the equipment directly at the mine there are bunk and storehouses at Cheenik, on Fish River, half a mile or so below the mine on Umalik Creek. At the latter place is a repair shop, electric plant, assay laboratory, electric sawmill, stable, and the other things usually found only at large producing mines. The company also owns a large river steamer originally built for freighting the mine supplies up the river, but it has never been used.

The production of the mine is not definitely known, but it has probably not been more than 400 tons nor less than 300 tons. A part of this was obtained from the various pockets below ground, but a considerable amount is understood to have come from hand picking the float found on the hillside. The following tables show the returns from assays of the ore as shipped. It should be noted that owing to the high transportation charges the ore was carefully hand picked and some of it washed before shipping.

Returns from assays of ore as shipped from Omilak mine.

Number.	Weight (pounds).	Gold (value per ton).	Silver (value per ton).	Lead (pounds per ton).	Lead (value per ton).	Total value per ton.
1	4,230	.....	$137.29	1,538	$61.52	$198.81
2	545	$2.07	106.62	1,320	52.80	161.49
3	130,000	3.09	98.72	1,128	45.12	146.93
4	68,078	.....	104.00	1,300	52.00	156.00
5	12,167	2.07	125.19	1,440	57.60	184.86
6	82,100	.....	132.95	1,494	59.76	192.71
7	86,885	7.43	49.60	502	20.08	77.11
8	27,787	1.54	41.40	606	24.24	67.18
9	13,606	1.54	38.10	566	22.64	62.28
10	2,675	1.03	54.93	770	30.80	86.76
11	6,569	2.07	46.46	890	35.60	84.13
12	164	7.53	65.54	816	32.64	105.71
13	595	2.07	71.15	980	39.20	112.42
14	380	2.07	86.86	966	38.64	127.57
15	26,175	2.07	120.33	1,222	48.88	171.28

1 to 6, inclusive, solid ore from Omilak mine; 7 to 14, inclusive, carbonate ores from Omilak mine; 15, carbonate ore concentrated by washing in sluice boxes.

Unfortunately in the above assays the data are not sufficient to determine the percentage of any of the constituents except the lead, so the following assays, less complete in certain other ways, are given:

Silver and lead in ore from Omilak mine.

Number.	Silver (ounces per ton).	Lead (per cent).
1	173.00	75.0
2	141.00	80.7
3	158.00	78.0
4	153.70	82.0
5	162.97	78.5
6	149.16	73.0
7	142.20	74.7
8	94.30	55.9
9	60.00	10.27

Assays 1-2 by Herford Copper Works, Swansea, England; 3 by Pennsylvania Lead Company, Pittsburg, Pa.; 4-6 by W. P. Miller, San Francisco; 7 by T. Price, San Francisco; 8-9 reported by W. C. Mendenhall, op. cit., p. 214 (8, yellow carbonate; 9, red carbonate ore).

Assays and relative weights of part of the different ores shipped by the Omilak mine in 1889, with the price paid in the open market for the same, are given in the following table:

Assays and weights of ore shipped by Omilak mine in 1889.

Commercial name.	Weight (pounds).	Gold (ounces per ton).	Silver (ounces per ton).	Lead (per cent).	Price received per ton.
Red carbonates	380	0.1	92.9	48.3	$93.00
Gray carbonates	595	.1	76.1	49.0	81.00
Yellow carbonates	6,569	.1	49.7	44.5	57.00
Argentiferous galena	82,100	.....	142.2	74.7	154.00

It is evident that the ore is high in silver and also usually carries a small amount of gold. Its metallurgical treatment is simple and

the ore is especially valuable to mix with other more refractory ores. The absence of fuel at a reasonable price prevents treatment near the mine and the high charges for transportation restrict shipments to only the higher-grade ores.

From the foregoing descriptions certain facts are evident which may be summarized as follows. The claims have been inadequately prospected and large expenditures have been made without disclosing a workable vein; the ore found is of excellent quality, but the quantity seen by the writers was not sufficient to warrant extensive developments. The most promising area to prospect is in the limestone near its contact with the schists, but the deposits likely to be found will probably be pockets not easily adaptable to cheap mining methods and not capable of affording a large, constant amount of ore.

GOLD LODE PROSPECTS.

Although, as has been shown, placer gold has been found on many of the streams in the area of metamorphic rocks, no veins sufficiently rich to allow lode mining have been discovered. This is probably due in part to the diffused character of the mineralization, but is also due to the absence of adequate prospecting. Quartz veins containing gold have been found at many places, at a few of which pits have been sunk. In order to give an idea of the places where auriferous veins have been exploited to a greater or less extent the following notes may be of service.

A sample taken from the schists adjacent to some quartz strings near the mouth of Ophir Creek contained gold in such amounts that when crushed in a hand mortar and panned free gold was obtained. On Crooked Creek, a tributary of Ophir Creek, there "is a mineralized belt 12 feet wide which strikes northwest. In this impregnated zone vein quartz is associated with pyrite. It is reported to assay as high as $8 to the ton." [a] Near this place, on the divide between Goldbottom and Crooked creeks, is a gold-bearing vein which seems to be a continuation of this lead. Mineralization on a small scale has been recognized at several places at Goldbottom and Warm creeks, and a short distance from the mouth a vein on which some development work had been done was found at the contact of schist and limestone. "Near the mouth of the creek are two quartz veins, one about 3 feet wide and the other about 1 foot wide, striking N. 30° E." [b]

In the Bluff region, according to Brooks [c]—

So far as observed, the schists appear to be mineralized only near their contact with the limestones. At these places quartz veins cutting the foliation of the schists are not uncommon. The individual veins appear to be of small extent, but at some

[a] Collier, A. J., Bull. U. S. Geol. Survey No. 328, 1908, p. 252.
[b] Idem, p. 255.
[c] Brooks, A. H., Bull. U. S. Geol. Survey No. 328, 1908, pp. 286, 291-292.

localities a stockwork forms a considerable mass of low-grade ore. The ores appear to be chiefly iron pyrite, with some chalcopyrite and arsenopyrite.

* * * * * * *

An impregnated zone is well exposed along the sea cliff about three-fourths of a mile east of the mouth of Daniels Creek. * * * At this locality a belt of mica schist about 60 feet wide is more or less impregnated by pyrite-bearing quartz stringers. The belt, including some irregular limestone masses, is bounded by graphitic limestone walls which dip away from the schists and form a small anticline much broken by faults. * * * At the west contact a band of schist 20 feet in cross section lies between one of the included limestone masses and the country rock. In this band the mineralization is more intense than in the rest of the schist. Here a series of gash veins, the largest of which is 18 inches in width, cuts the foliation of the schist. A mass of crushed material or gouge forms the hanging wall of this deposit and along this zone, which has been a plane of movement, the quartz veins are cut off abruptly. Stringers of quartz do, however, occur in the limestone on both sides of the schist. The ore appears to be chiefly iron pyrite and mispickel, with some chalcopyrite; the gangue is mostly quartz, with some calcite.

Although this mineralized zone was known for several years, not much active exploitation was undertaken until 1907. At one claim a shaft 50 feet deep was sunk and a short drift about 15 feet in length was turned off. On the adjoining claim the zone of mineralization is so wide that two shafts, one on the hanging wall and one on the foot wall, have been sunk. One of these is reported to be 100 feet deep; the other is slightly less than half that depth. On the next claim also two shafts have been sunk to a depth of approximately 50 feet. Two shorter shafts have been put down on the next claim and one shaft about 75 feet deep has been sunk near the end line of the next claim beyond. In 1907 the ore from these properties was crushed in an arrastre which was operated by a horse and it was intended to erect a stamp mill later. The developments at this place have, however, not been ascertained for the last two years.

According to Brooks[a] in 1906 a lode 3 miles east of Bluff had been developed to some extent. It was located near the shore and was said to be 14 feet wide and to yield up to $30 in gold to the ton. The ore is reported to be iron pyrite and mispickel. A few tons have been sacked and prepared for shipment but practically nothing is known about the mode of occurrence.

COAL RESOURCES.

Wherever the Cretaceous-Tertiary sediments are extensively developed throughout Alaska there are indications of coal. Some of these croppings in the area under discussion have been prospected and claims staked, but there are no producing mines within the Nulato-Norton Bay region. Detailed field examinations of many of the Alaskan coal deposits along the Yukon have been

[a] Op. cit., p. 292.

recently completed by W. W. Atwood, but the results have not yet been made available. As the party of 1909 revisited none of the coal prospects along the Yukon no new data were procured and descriptions will therefore be omitted.

In addition to that in the Yukon basin coal has been reported at a number of places along the eastern shore of Norton Bay, but so far as known no beds of a sufficient size to allow profitable mining have been discovered. Dall mentions a 2-foot bed of shale and lignite on Ulukuk River, a tributary of the Unalaklik from the north.[a] It was reported to have no commercial value. Brooks[b] states: "Capt. D. H. Jarvis informed the writer that some very good looking coal had been found near Unalaklik Cape, near the eastern shore of Norton Sound. These probably belong to the same series described by Dall."

Several openings have been made near the mouth of the Koyuk on the west side, close to camp B 17. Unfortunately the shafts were not in condition to be examined and the only information gained was from a study of the material on the dump, as there are no exposures of the coal-bearing rocks in the neighborhood. Although lignitic material was found at this place, several years of desultory prospecting have failed to disclose a workable bed. The shafts cut a series of sandstones and clays which have weathered badly on the dump and appear much less consolidated than the average sandstones near Nulato. It is understood that during the last year the company formerly interested in this claim has abandoned the enterprise.

In this same region coal float has been found on Coal Creek and claims have been reported, but none of them was being prospected. Probably little of value was found, as the series is without doubt similar to that near camp B 17.

Mendenhall[c] states concerning his work in southeastern Seward Peninsula: "The only rocks encountered in the reconnaissance likely to carry coal are the sediments supposed to be of Tertiary age outcropping on the Tubutulik and Koyuk rivers in narrow belts. No direct evidence of the presence of this mineral was secured on the Koyuk, but along the river bank associated with the sandstone outcrops on the Tubutulik are numbers of small pieces of bright, compact coal, seemingly of good quality." The presence of this coal float has long been known to prospectors, but so far no beds that would warrant investigation have been discovered. On the Rathlatulik, a tributary of Fish River, about 8 miles above the junction

[a] Dall, W. H., Correlation papers, Neocene: Bull. U. S. Geol. Survey No. 84, 1892, p. 246.

[b] Brooks, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 560.

[c] Mendenhall, W. C., A reconnaissance in the Norton Bay region, Alaska, in 1900; a special publication of the U. S. Geol. Survey, 1901, p. 214.

of the streams, there is a woody lignite of relatively recent age. A shallow pit has been sunk here and slightly carbonized fragments of wood have been found. Underneath this layer of woody material is a bed of blackish-green calcareous muck which is nearly flat but has a slight slope toward the east. A cross section of the valley at this point shows a low bench about 5 feet above the water succeeded toward the east by another bench 15 feet higher a hundred paces beyond the stream and separated from the lower bench by a steep cliff. All the material from the stream to the top of the 15-foot cliff is well-rounded gravel. Several abandoned river beds are found on the lower bench.

The coal is not over 18 inches thick and is of poor quality, having advanced little beyond the wood stage. Resin is abundant in many of the samples of this material. No tests of the coal were made, but from its physical character it does not seem possible that it could be used for fuel except very locally. No accurate estimate of the amount of material available could be made without further exploitation, but it is believed to be of very slight extent and not of sufficient value to warrant further development.

There are certain conclusions that may save prospectors from spending their time unprofitably in the search for coal in the region between Nulato and Council. Coal will be found only in the areas of nonmetamorphic sediments. No economically important beds are to be expected in the unconsolidated alluvium, such as that in the Fish River basin on the Rathlatulik. From the fact that so far there is no productive mining of any of the coal-bearing rocks outcropping along the Yukon within the mapped area it seems improbable that workable beds in the same series of rocks will be developed in the more remote regions where transportation facilities and markets are wanting. While thicker beds may be found here and there, the additional cost of transportation for each mile that the deposit lies back from the river or from some other cheap avenue of communication increases much more rapidly than could be reasonably assumed for the thickness of the bed. It is improbable that workable coal will be found in the Nulato-Council area where it is not now known and the prospector is warned that on the whole search for such deposits is more likely to be followed by failure than by success.