PRELIMINARY REPORT OF CERTAIN POTENTIAL PLACER AREAS ON SEWARD PENINSULA-- ECONOMIC ASPECTS AND PROBLEMS

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ABSTRACT

The north central portion of Seward Peninsula is an area which is geologically favorable for placer gold deposits. It contains some mining, but the area is far from being developed to its full capacity of production. The area was roughly prospected during the Nome gold rush and the years that followed; namely, 1899 to 1904. Only the most accessible and easily worked deposits were mined because of the many hardships and difficulties encountered. Many of the early mining ventures were failures which in part were due to lack of knowledge in dealing with the various problems, the high costs, and the lack of adaptable mining machinery.

The greater portion of the area is underlain by interbedded limestone and schist of Ordovician and pre-Ordovician ages. These formations were subject to intense folding during the Mesozoic era. Large open folds and elongated anticlinal structures were formed, as a result of this deformation, with a general east-west structure. This deformation was accompanied by the major intrusives which formed the Bendeleben and Kigluaik mountain ranges. These intrusives marked the beginning of the gold deposition. In late Cretaceous or early Tertiary time a second period of deformation took place which produced a second series of open folds and anticlinal elongated domes which were superimposed upon the former ones at nearly right angles or in a north and south direction. The structural effects of this cross folding is much in evidence today with the numerous basins and domes giving the effect of an old age

topography decidedly worn down. These basins and elongated structural valleys which contain the basins were ideal for the formation of placer gold deposits during the extensive erosional periods and minor uplifts that followed. The folded formations of limestone and schist, and the coal beds with the accompanying faulting and shearing, formed ideal channelways, especially on the contacts, for hydrothermal solutions to penetrate outward toward the surface from the crystallizing magma.

Many Tertiary channels were formed as a result of the great erosive cycle of the Tertiary Epochs. These channels were confined to the structural valleys so that basins contained therein were filled and emptied many times during the progress of the rivers to the sea. Each period of subsequent uplift is represented by an extensive delta deposit which is more or less modified by sea action. The effects of these uplifts made a series of unconsolidated beach deposits across the northern portion of the area, ranging in elevation from the present beach line to 600 feet above.

At the end of the Tertiary period surface lava flows covered a section of 1,000 square miles within the area. These flows spread out, covering the greater portion of one of the larger structural basins with portions of the flows continuing along many of the Tertiary channels, causing a disruption of the major Tertiary drainage systems. The Tertiary deposited gravels were left intact under the lavas. Very little is known regarding these gravels, but in a few places where they have been mined and observed they have been found to be auriferous.

The Pleistocene or glacial epoch followed closely the lava emission with the later flows believed to have been during glacial times. Evidence of animal and vegetable life are still contained in the frozen unconsolidated deposits. The great atmospheric disturbances which took place during the glacial epoch are believed to have been the transporting agency of the lighter loose materials, including the remains of the abundant vegetable growth, from the higher points of elevation into the lower valleys and basins. This formed the extensive black muck and silt deposits that cover most of the unconsolidated deposits and makes the mining of placer deposits so difficult.

Alpine glaciers were formed in the higher Bendeleben mountains. On the north slopes of the range these glaciers were small and their movement was not so extensive as compared to the south side which apparently received a greater amount of precipitation.

The present day drainage is comparatively young and has been superimposed on the older drainage and on top of the frozen unconsolidated deposits.

The gold and sulphides are believed to have been derived from ascending hydrothermal solutions and deposited by precipitation brought about by a rapid reduction of temperature with the oxides formed from the other metals as they reached the zone of free oxygen and carbonaceous matter, all within a zone of near surface conditions.

In the various potential placer areas the geological indications appear to warrant considerably more investigation, prospecting and development. However, in association with these activities it is important to keep in mind the various problems, both in relation to mining and geology.

INTRODUCTION

Purpose and Scope of Report:

The years from 1934 to and including 1940 mark a period of temendous increase in the number of placer mining activities in Alaska. As a result of this increase many new conditions and unsolved problems have come before the Territorial Department of Mines. The department itself needs to expand to keep pace with the rapid expansion of the industry in order to direct it in the future and to maintain a steady production in metallic output from the Territory. A continuous search must be maintained for new placer areas and new lode prospects. The prospectors should be encouraged, and their properties examined and brought before the proper parties for lease or option. Operators and prospectors alike must be constantly assured that the value of gold is sound. Along with these activities there has arisen numerous mining problems and tendencies such as increased transportation rates, wages, taxes, costs of machinery, and the use of credit. These problems have the effect of retarding the industry rather than building it up and

stimulating it into greater development for the benefit of every one. The two incentives, which have fostered and caused the increase in activity, have been the increased price of gold and the greater application of mechanical machinery. They have enabled the operator to increase his potential reserves by the mining of lower grade ores and deposits, and to increase his margin of profit, which in Alaska has been mainly turned back into the industry by the purchase of more property and a tremendous amount of machinery. This is one tendency which Government agencies should consider well before contemplating further taxes on this young and growing industry.

It is a common tendency among many to place too much stress on one or two factors with regard to an industry and to neglect some of the major factors upon which the industry is based. The increase in the price of gold would not have increased the number of operations had not the deposits existed and further, had they not been discovered. In other words, the known existing discoveries actually account for the increased number of activities. To the thousands of Alaskan prospectors who spent a part of their lives and energy in the past, and to the very few remaining ones, goes the greater portion of the credit and praise for making possible our present industry. It is still the duty of the Government to encourage, to help, and to stimulate interest in mining in order to maintain a steady production of minerals which in return means a steady income to the Government. One of the many duties of the

Territorial Department of Mines is to call attention to and to supply information concerning certain mining areas which have potential reserves and those most adapted to present day mining methods.

Thus, the purpose of this report is four-fold, and it is hoped that it will contribute to the growing mining interest in Seward Peninsula and will be of direct help to the Alaskan operator, prospector and new-comer.

1. It is hoped that it will help to create interest in mining on Seward Peninsula by stimulating further prospecting and by so doing lead to more mining operations.

2. That this report will help to fulfill the demand for potential placer ground and in so doing help the industry to continue to expand and to maintain a steady gold production.

3. That it further gives the new operator a clear picture of some of the major problems and to guide him around the pitfalls which have caused so many failures in the past.

4. That it fills a particular need of bringing to the attention of Alaskan operators and prospectors some of the important geologic facts in regard to Seward Peninsula, which have been published in the past and ~~which~~ which at the present time are mainly out of print and more or less forgotten.

The scope of this report is confined to a few of the undeveloped areas on Seward Peninsula located on the northern slopes of the peninsula and to such areas where mining has not advanced to the full capacity of

the potential deposits. This area includes approximately 5,525 square miles. A general account is given of the geological conditions which are more or less favorable for placer gold deposits. A relation between the present placer deposits as originating near intrusive and extrusive igneous rocks and deposition from hydrothermal solutions is shown. The placer areas as well as individual operations are described in detail. Furthermore, many problems are discussed which apply to the whole of Seward Peninsula and suggestions are made which it is hoped will aid in their solution.

The contents of this report consist of an accumulation of data gathered from two months of field work within the area concerned. This consisted of the examination of most of the operations, several points of geologic interest, and collecting data from operators, engineers, prospectors, and others. A study of three months duration was made of the past geological literature which has been written and which consisted mainly of U. S. Geological Survey reports. Prior to this year the writer has spent four years in field work of nearly six months each year in examining both lode and placer properties throughout most of the active mining districts in Alaska. Many things in common were noted in regard to placer occurrences. Each mining district has its many difficult problems as to mining costs, transportation and physical mining conditions. Much has been learned as to the tenor of placer deposits mined, methods used, and the best adapted types and makes of

machinery. It can be stated with considerable assurance that the various areas on Seward Peninsula rank higher in opportunity at the present time under the existing conditions for the future development of placer mining than most of the other placer areas in Alaska. It is naturally advantageous to write concerning an area where the future possibilities are good and offer the best chances for development.

ACKNOWLEDGMENTS

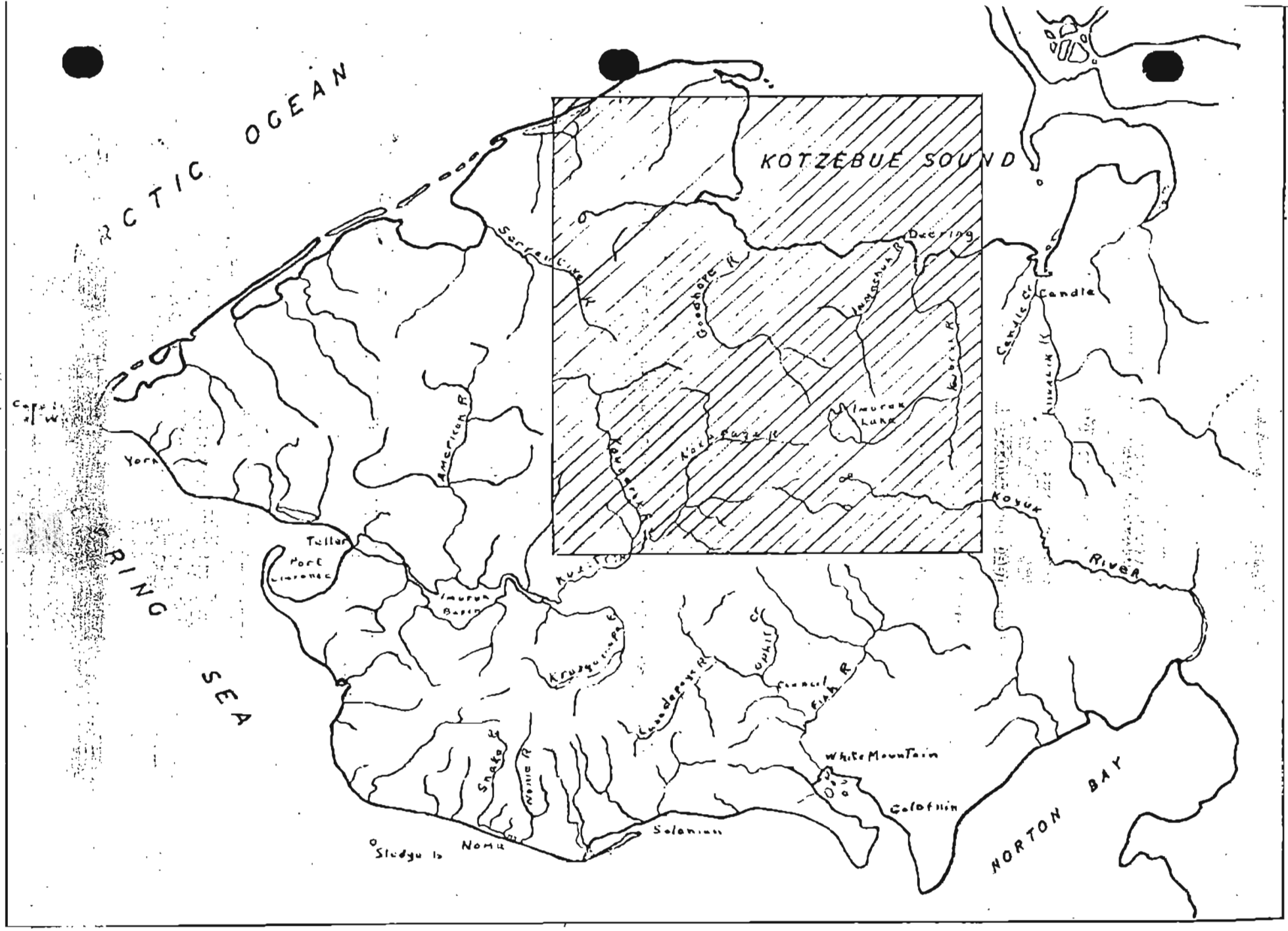
The writer is deeply indebted to Mr. B. D. Stewart, Territorial Commissioner of Mines, for the opportunity and special privilege to spend two months in field work on Seward Peninsula. This privilege also offered the opportunity to be of service to the many operators of Alaska and to collect considerable materialistic data to be later used in support of a new theory on the origin of certain placer deposits. Acknowledgment and thanks are due Mr. Aben Shallit, Associate Engineer and Territorial Assayer at Nome, who materially assisted the writer on certain field trips, and whose general and geological knowledge of Seward Peninsula has contributed much to the contents of this report. Further, to Messrs. Castleton and Keenan, operators on the Kougarok River, the writer acknowledges much free and helpful information. To pilots John Cross and P. Munz many thanks are due for the opportunities of observing many points of interest which otherwise it would have been impossible to see during the limited time available. The writer wishes

to thank further the many operators, prospectors, miners and numerous other individuals for their kind hospitality and for information which has added materially to this report.

A special effort has been made to acknowledge the contributions of others, particularly the U. S. Geological Survey, for the use of the many reports to which references have been numerous. All such references are listed at the bottom of the page on which they are used.

GEOGRAPHY AND GEOLOGY

The area under discussion in this report consists of a rectangular section 65 miles east-west by 65 miles north-south which is situated in the north central part of Seward Peninsula. The total area contains approximately 5,525 square miles which is slightly more than one fourth the total area of the Peninsula. The position is between 165°10' and 162°15' longitude and 65°20' and 66°20' latitude. This section is that portion of Seward Peninsula which contains the greater portion of the older drainage system with the present drainage in part superimposed upon the older. The southern portion is drained to the west by the Kuzitrin River and to the east by the Koyuk River. The western section is drained by the Kougarok River to the south and the Serpentine River to the north. The central and northern part is drained by the Goodhope and Inmachuk rivers. The eastern section is drained by the Kugruk River and its largest tributary, Wade or Burnt River. The Noxapaga River, the largest tributary of the Kuzitrin River, drains a large area of the central portion. The salient features bounding the



SKETCH MAP
SHOWING AREA COVERED IN REPORT
SEWARD PENINSULA,
ALASKA.

area is the Bendeleben Range along the southern border, on the north by the Arctic Ocean and Kotzebue Sound, on the west by the high plateau which marks the divide between the Kougarok and American rivers and which contains the Kougarok Mountain in the northern section, and on the east by the divide of the Kugruk and Kiwalik rivers and marked by Monument and Kiwalik mountains. The highest portion of the area is the southern boundary which marks the high divide of the Bendeleben Mountains. This divide consists of serrated and irregular mountains ranging between 2,000 to 3,000 feet in elevation. This mountain range drops down rather steeply to a comparatively flat table-land which is marked by numerous parallel north flowing creeks which drain off to the Koyuk River on the east and the Kuzitrin on the west. The lower table-land to the north of the Bendeleben range comprises the central portion of the area and is marked in the center by Imuruk Lake. This table-land is thinly covered with recent lavas. The lake is drained by the Kugruk River and numerous springs which drain from around the margins to the lower elevations, and other drainage. This lava plateau is the important distinguishing feature which marks the interval between the old drainage system, which is intact under the lava, and the new drainage system which is now superimposed on top of the lava. The new drainage system has cut through the lavas along the outer edges of the table-land. The recent hot lavas which were emitted on the surface flowed into the depressions and channels of the older drainage. This is in evidence when the various

rims are encountered as in the valleys of the Koyuk, Inmachuk and Burnt rivers, note Plate No. 4. The area, due to its superimposed drainage, is very poorly drained and contains numerous small lakes and niggerhead marshes. Between the table-land and the coastal province to the north, the section becomes more rugged and consists of intermittent structural ridges of limestone and schist, with large structural valleys in which are contained the major rivers. These valleys are broad with gentle slopes, and represent open folds. The rivers, as they approach the coastal plain, leave their entrenchment, build deltas consisting of a tremendous amount of material, and meander back and forth across the valleys.

The coastal plain is a broad flat plain several miles wide which extends up the river valleys, and which is leveled off at 200 feet elevation. Along the coast line are occasional land points which butt into the ocean and across which bluffs have been formed by wave action. This plain is made up mainly of sea wash gravel deposits that represent in part the land eroded from the higher elevations to the south.

The area is divided into three distinct provinces; the mountain province on the south, the intermediate table-land, and the coastal plain. To understand and obtain a clear mental picture of these three provinces, each merging into the other with their various degrees of slope, one has to consider the underlying structure of the formations. While structure is taken up later, as it is of importance in regard to the position of placer deposits, the present relief is effected by

structural conditions of the past plus considerable erosion. Moffit,[1] gives the prevailing structural features of this area as consisting of open folds, whose axes pitch at low angles either to the north or to the south with the intensity of the forces producing folding, increasing toward the eastern part. These north and south folds account for the prevailing strikes of the interbedded schists and limestones which make up the greater portion of the area. Thus the earlier forces which affected the area apparently were from different directions and formed the east-west folding which was followed by intrusives. This east-west folding forms the east-west elevated mass now comprising the Bendeleben Range. Thus the intensity of the folding being greatest in the southern area gradually decreases to the north. Therefore, the mountain or southern province has an east-west trend and shows the present east-west drainage, such as the Kuzitrin and Koyuk rivers, representing the valley of the underfold. The upland or central province consists of a modified north-south structure superimposed upon a modified east-west folded structure. This superimposing of one system of folding on another system nearly at right angles makes a topography of shallow depressions and rounded hills. It gives the province an appearance of being worn down to a greater extent than actually exists.

Thus, on the coastal province the north-south folding structure is the strongest feature which is still prominent, as noted by the north and south rivers. The east-west structure affects it only slightly, but

[1] Moffit, F. H., "The Fairhaven Gold Placers, Seward Peninsula, Alaska," U. S. Geol. Survey Bull. 247, p. 22.

is in evidence sufficiently to produce a topography which gives the appearance of being considerably worn down. The only feature which does not conform to this gradual south to north slope is the south flowing Kougarok River. This area on the western section of the district, which is less affected by the north and south folding, but moderately influenced by the east-west folding, contains the Hot Springs granite area of local origin which disrupts the general topography. The Kougarok River drainage will be taken up later with respect to structure and local description of the area. Generally, the area is of low relief, poorly drained, covered with tundra, few outcrops, some willow brush along the banks of the larger rivers and streams, a few alders, and permanently frozen to a depth extending into bedrock.

It is not the purpose of this paper to present a detailed geological discussion and description of the area. The greater portion of the area is covered in general by Moffit[1] and other reports.

The following sketch map, Plate No. 4 showing the distribution of formations, is a tracing from a "Reconnaissance Map of Seward Peninsula, Alaska," scale $\frac{1}{500,000}$ compiled by the Alaskan Branch of the Geological Survey, with the areal geology taken from the geologic map of Seward Peninsula, Alaska in Bull. 433, Plate II.[2] The percentages of the various formations are only approximate, being given in the order of greatest extent. The classified Nome group, which consists of various

[1]Moffit, F. H., U. S. Geological Survey Bull. 247.
[2]Smith, P. S. "Geology and Mineral Resources of the Solomon and Casadepaga Quadrangles, Seward Peninsula, Alaska," U. S. Geol. Survey Bull. 433, Plate II.

schists and limestones interbedded, represents 42 per cent of the surface land area. This formation covers the greater portion of Seward Peninsula and is the formation on which nearly all of the placer gold is found. The most favorable placer concentration is a limestone-schist contact of steep dip. This percentage of limestone and schist must be considered with limitations. Thus if one disregards the gravel deposits and accepts the bedrock below the gravels then the percentage of bedrock geology would be almost double the amount mentioned above. Also, in accepting the gravels for their full area, then it must be considered that, as the tundra and black silt cover some gravel, the percentage of gravel would be greater and the actual limestone and schist less. As there appears to be considerable area which is in doubt as to whether it is barren or gravel covered, such areas have been classified with the limestone and schist as represented on the accompanying sketch. There is also the extensive recent lava area which covers both gravel and limestone-schist areas.

As noted on sketch No. 4, an area of 35 per cent is more or less known gravels. Included within the gravels are all unconsolidated deposits such as sands, beach materials, etc. Considering the isolated gravel deposits, both known and unknown, and the old drainage gravels under the lavas, this percentage would no doubt be increased and the limestone-schist area decreased.

Descriptions of the various gravel deposits will be taken up under the descriptions of the various areas under consideration. The question arises here as to how isolated basins became filled with gravels, if gold is contained in the gravels, and whether or not it is concentrated. These isolated gravel deposits are found to exist at various elevations from 1,000 feet to sea level. In fact, it is safe to assume that they possibly exist up to and above 1400 feet elevation. It is not the purpose of this paper to trace all the geologic history of the area, as it is well discussed in the various geological reports listed in this report. It is commonly accepted that most of the gravel deposits were formed during and since Tertiary age. Thus the periods of submergence and elevation during and since that time leave their records of geological history in various forms. One bit of evidence is the isolated placer or tundra gravel deposit. Each period of elevation had its system of drainage in accordance with structural conditions. At least two cycles of elevation with intermediate subsidence are in evidence from Tertiary time to the present. It is very possible that there were more within each major cycle as there were periods of hesitation and continuance. Thus, the basin, which happens to be near the water surface or near the beach line and associated with some drainage stream or river at that particular time, becomes filled. Continued elevation lengthens the drainage, partly cuts away the former deposition in the basin, makes a concentration, and fills up the next basin along the beach or border line lower in elevation.

The deposition of the Tertiary sediments, which are in evidence on the Kugruk and Koyuk rivers, range from over 1,000 feet in elevation to near sea level. This marks a period of submergence and deposition during Tertiary time. Faulting of various areas and other various forces of structural derangement also affect drainage and help fill basins, concentrating heavy metals in them.

It must be taken into consideration that large, medium and small sized basins existed, which affected the deposition of the Tertiary sediments and the later lava flows. The period of the recent lava eruption shows by its very nature; that is, the lack of cinder cones and the usual ash, that it was emitted from large openings on the surface. These various recent flows are definitely later than the underlying gravel deposits. However, the period of erosion since has continued to have its effects upon the gravel deposits other than those under the lava. The largest basin, into which the recent lavas flowed, extends east-west along the north side of the Bendeleben Range, and in which the upper valleys of the Kuzitrin and Koyuk rivers are situated.

A. J. Collier[1] describes the Kuzitrin Basin as follows:

> "The Kuzitrin lowland deposit is the most extensive of the basin areas. The upper layers seem to be more gravelly than those of the Imuruk deposit. Around its western and northern borders there is a terrace from 50 to 100 feet above the general level, from which it is separated by a marked escarpment. There are also many isolated gravel buttes from 25 to 50 feet high scattered over the lower portion. These features are regarded as residual parts of an older surface left behind in the erosion that has reduced the surface to the present level. Remains of the mammoth, horse, and other mammals, together with some large logs

[1] Collier, A. J., et al., "The [illegible] of Seward Peninsula," U. S. Geol. Survey Bull. 803, p.

and accumulations of vegetable material, have been found in these buttes and terraces. Near the east end of this basin the gravels are overlain by lavas that flowed from vents near the head of Kuzitrin River."

This basin, in its present position east-west along the north side of the Bendeleben Range, apparently at one time contained and still contains the greater portion of the gold which was associated with the numerous granite intrusives which make up a great portion of the Bendeleben Range, note Plate No. 4. It is not assumed here that all the placer gold within the area originated from these intrusives, however, from evidence shown later this mass of closely connected intrusives were the original source of the greater portion of it. There has been much written as to the origin of the gold along the Nome beaches and the Solomon River district. In studying the various geological reports and examining the effects of various agencies in that district one arrives at the conclusion that the greater portion of the gold originated from the Kiwalik Mountain range, which is an extension of the Bendeleben Range on the west. The gold found on the beach levels and benches, as well as the rivers and streams in the vicinity of Nome, is believed to have been deposited during erosional periods by numerous agencies, mainly wave and glacial action, as partly concentrated gold in gravels which migrated along structural valleys collecting more gold and depositing it with the gold formed locally. It has always been an unsolved problem as to the whereabouts of the gold that has migrated to the north of the Bendeleben and Kiwalik mountain ranges.

The writer does not attempt to solve this problem, but the intent is to detail those areas in which the gold is most likely to be found. The reader is left to draw his own conclusions as to which of three possible positions warrant attention.

First, the large structural basin along the north side of the Bendeleben Range, containing the Kuzitrin and Koyuk rivers, which is filled with extensive gravel deposits, may be the solution. In considering this basin (see Plate No. 4) it should be noted that nearly half is covered with the recent lava flows. The Koyuk River cuts through the lavas in the eastern section. Prospectors report the gravels in the upper Koyuk Basin as thawed, and that they were unable to sink holes to bedrock. Just what portion of these gravels are thawed and frozen is not known. It is possible that heated waters may have flowed from the recent hot lavas during the last freeze-up period and kept them thawed. Further reports from this section were to the effect that the black muck, which lies on top the gravels, contains great amounts of old bones and horns of animals. These animals may have crowded into this section, attracted by the heat arising from the waters during a period of cold, perishing within the muck. Another theory for the thawed gravels, is that waters possibly drained under the southern border of the lavas into the old drainage gravels and later flowed out into the Koyuk basin and in so doing, the frozen gravels were thawed. Thus the prospectors were handicapped in the early days by the presence of thawed gravels which limited bedrock prospecting because of the lack of pumping equipment.

The western half of the basin, occupied by the headwaters of the Kuzitrin River, contains extensive gravels. The small rounded gravel buttes, as mentioned by Collier,[1] show considerable water action which no doubt had considerable concentrating action. This extensive basin has not been prospected. Information is lacking as to depths to bedrock, extent of frozen or partly thawed areas, and gold content, except along the outer extremities such as the Noxapaga and Lower Kougarok districts which are described later in this report.

The second area to be considered is the structural valleys of north and south direction which contain the larger rivers. Since the early gold rush days, gold has been found in the valleys of the Kougarok, Goodhope, Inmachuk and Kugruk rivers. The east-west area containing these river valleys represents the transitional section from the upland province to the coastal plain. Naturally, this section was the area in which most of the early prospecting was done due to shallow bedrock outcrops. Does this section contain the greater portion of the placer gold, or does it represent only a portion of the gold with the major amount having traveled on being deposited along the coastal plain, or is the gold found here only that portion eroded and migrated from the Kuzitrin and Koyuk basins?

The third area for consideration is the coastal province. Some gold has been found along the beaches of the coastal plain as at Alder Gulch in the northeast section of Plate No. 3. Occasional colors

[1]Collier, A. G. et al., U. S. Geol. Survey Bull. 329, p. 89.

have been found along the present beaches. The expectation of wave concentration and the formation of beach line deposits along the south shore of Kotzebue Sound is not within the limits of the agencies involved. The occasional rock bluffs break up strong tidal currents, and storms that reach the coast line are only from the north and these are not severe. During a portion of the winter the Sound is frozen. Had the greater portion of the gold migrated to the present beach levels it would be in delta deposits at the mouths of the present and the older rivers. The present rivers show considerable delta deposits and the effects of old channeling near their mouths. This would make for extensive low grade deposits.

The next geological formation, representing the surface areal geology in order of extent, is the recent lava flows. These cover 15 per cent of the area. The highest elevation at which they occur is 1400 feet and they are located to the southwest of Imuruk Lake, which region is believed to be the vicinity of ejection. Several small craters show from the air, but whether these are actual vents or sinks is not known. Located near the center of the lava area is Imuruk Lake, which appears, from the air, to be very deep in the center. It is believed by some to be one of the larger craters from which the greater portion of the lava was emitted. Three, and possibly four, flows are in evidence. These are thickest near the points of emission and gradually thinning out to the outer extremities. The upper Kugruk River, which drains the lake, has formed a canyon below the lake cutting through the lava beds. Prospectors report gravels under the lava in this locality.

These lavas are classified as basalts by Collier[1] as follows:

> "At a point on the Noxapaga River 2 miles above Noxapaga these lavas extend across the river, and their relation to the other rock was seen in a bluff above the river. Here the Pleistocene gravels filling the Noxapaga Valley rest on the upturned edges of the schists. The basalts lie upon these gravels, and near the contact the gravels are cemented by indurated clay. In the upper part of this gravel a few pebbles derived from basalt are found, mixed with quartz pebbles derived from the schist. This lava flow probably occurred in Pleistocene time, while the upper gravel plain of the Kuzitrin Basin was being formed. In the Koyuk Valley Mendenhall found evidence that the basalt is of Pleistocene or late Pliocene time. The evidence obtained in the Kuzitrin Basin indicates a similar age for the basalts found there."

Granite of various kinds makes up the present surface of a considerable part of the Bendeleben Range, shown in the southern part of the district. Many contact remnants of the older schists and limestones remain around the tops of the highest mountains and ridges, but they merely represent a thin hardened shell. The area is underlain by granite more extensive than shown on Plate No. 4. Several isolated peaks and ridges of granite stick up through the lavas, the latter having flowed around them. This shows that considerable of the area on the south covered by lavas is granite underneath. The actual granite outcrop comprises 7 per cent of the area.

Tertiary deposits comprise only one per cent of the area. While it is held that some of the granites are of Tertiary age, they are not included in this percentage of Tertiary deposits. It is possible that there remain, in some of the basins under the black muck and

[1]Collier, A. J., "Northern Portion of Seward Peninsula," U. S. Geol. Survey Prof. Paper No. 2, p. 31.

gravel deposits, more Tertiary sediments. These sediments (note Plate No. 4) are distributed along the Kugruk River. They are folded and distorted and contain lignite coal.

Smith[1] states concerning these sediments:

> "The paleontologic evidence as to the age of these rocks is not adequate for basing a final conclusion but it is believed to indicate that the beds are Eocene and probably are in general correlative with the beds of similar composition and relation that are so widely distributed through other parts of Alaska and that have usually been referred to as Kenai."

Eocene beds are of common occurrence in the vicinities of some of the major placer fields of Alaska. Some of the richest creek placers are in close proximity to these Tertiary beds. The relationship that these beds have to placer gold deposits has not been adequately presented in any geological literature on Alaska. They are represented as being deposited later than most Tertiary intrusives, however, there is evidence to show that some of these later intrusives may have been formed later than the Eocene. At least some of the mineralizing solutions of Tertiary intrusives may have penetrated these sediments and formed high grade deposits, now worn away, leaving gold in placer form.

STRUCTURE

The two prevailing structures of north-south and east-west folding have been explained under geography and geology. Nearly all evidence encountered in the field which is evident today is more or less controlled by these prevailing structures. Each direction of

[1] Smith, P. A., "Areal Geology of Alaska," U. S. Geol. Survey Prof. Paper 192, p. 65.

folding is accompanied by a fault structure in similar direction. This system of faulting prevails along the contacts of the limestones and schists in the north and south structure, and cuts across the beds in the east and west structure. This produces almost square block faulting, along which many metalliferous lode veins are associated, as observed in the southern section of Seward Peninsula where rock exposures are more in evidence. These fault lines, as they occur on the north and south structure, represent at least in part the beginning of the early drainage. They also represent the points of greatest weakness and the lines along which the metalliferous solutions flowed from the intrusives and along which gold deposition took place.

Along the anticlinal domes of both structures occur the intrusives. Thus the prevailing granite intrusives were most numerous on the east-west uplift represented by the Bendeleben and Kigluaik ranges. Less, but well represented, are the intrusives of the domed areas striking north such as the divides between Goodhope, Inmachuk and Kugruk rivers.

Collier[1] gives the dynamic history as follows:

> "We have thus four definite periods of crustal movements, with accompanying injections, in the northern province. The first, which was probably regional, occurred in pre-Silurian times. The second was a period of intrusion, and can be provisionally assigned to the close of the Paleozoic, or the beginning of the Mesozoic. The third was a period of folding, which was rather local in its effect. The last was an epoch of extensive lavas, which, though rather widespread, was not great in the amount of material which was ejected."

[1]Collier, A. J., U. S. Geol. Survey Prof. Paper No. 2, p. 33.

The dip changes continually in crossing a section of a fold from an anticline to a syncline. The dip is rather flat on top of the dome then gradually increases toward the center at which point it is nearly vertical, and thence less as the trough or syncline is approached. With the interbedded limestones and schists the lines of greatest weakness occur along the contacts. Faulting occurred along several contacts and formed the path for the mineralizing solutions. In the areas where the dip of the beds is greatest, it conforms with the greatest number of faults and the greatest mineralization, as compared to areas of less dip.

Brooks[1] gives the lime-schist contact as the origin of the gold:

> "It has already been pointed out that there appears to be a connection between structure and the distribution of the auriferous gravel. This view is borne out by the evidence of the geologic maps, which indicate that most of the workable placers occur along or close to the contacts of limestone and schists. These contacts have in many places been exposed to erosion as a result of the domal uplifts already mentioned. This, however, is not everywhere the case, for some of the limestone-schist contacts are simply the margins of lenses of limestone included in the schist. Be the relation of the limestone to the schist what it may, it appears to be established that the bed-rock source of the gold in most deposits is traceable to a limestone-schist contact. Furthermore, these contacts appear to have been loci of the greatest mineralization, either as impregnated zones or as fissure veins."

The structure is the important feature of the entire area. It is the controlling agency for the granitic intrusives which are the original source of the mineral solutions which carried the gold, the controlling agency for the deposition of the gold along certain contacts, and the controlling feature, with some exceptions, of the drainage basins

[1] Brooks, A. H. et al., U. S. Geol. Survey Bull. 328, p. 121.

into which the gold has migrated and exists as potential placer deposits.

GOLD ASSOCIATED WITH INTRUSIVES AND EXTRUSIVES

Gold in placer form is widely distributed on the whole of Seward Peninsula. In a study of the various placer areas it will be found that the greatest amount of gold concentrations are in the vicinities of and not far distant from intrusive and extrusive rocks. Large tableland areas[1] such as the American River drainage north of Teller, appear to be lacking in intrusives and also lacking in placer gold deposits. Areas of known placer deposits, such as the Hot Springs, Kougarok, Inmachuk and Kugruk, all contain small intrusive and extrusive rocks. The presence of the older channels[2] show the migration of the gold as having been derived in very close proximity to the intrusive and extrusive masses. The formations of many of the higher domed areas, by the presence of quartz veins, contact minerals, and foreign minerals introduced by hydrothermal action, show that they are underlain with intrusives which also have contributed to the total gold supply.

Emmons[3] Contributes and associates gold deposits with igneous rocks as:

> "The association of auriferous lodes with igneous rocks is practically universal. In areas of late metallization the lodes are associated with lavas or with intrusives formed near the surface. In areas that have older intrusives which have been subject to greater erosion, the deeper seated and generally more coarsely grained intrusives are likely to crop out. In such areas the gold lodes are almost invariably associated with granitic rocks or with porpyritic phases of such rocks. Not only are gold lodes associated chiefly with acidic intrusives, but they are found chiefly in certain positions."

[1] Smith, P. S., U. S. Geol. Survey Bull. 433 - Geol. map, page 26.
[2] Note Hot Springs Area, p. .
[3] Emmons, W. H., "Gold Deposits of the World," First Ed., p. 12.

While Emmons does not use the term extrusive rocks, it is apparently understood to be contained in the igneous rocks when he mentions the lodes associated with lavas in the later intrusives. More important consideration should be given the extrusive rocks in areas where they are known to be genetically related to the granitic magmas from which the metals originated. It is not within the scope of this report to theorize all the agencies and conditions in the transition of the gold from the igneous bodies to and until deposition in placer form. From all evidence gained in the field, the origin of the major part of the gold on Seward Peninsula has been from magmas and deposited by hydrothermal solutions, which originated under conditions of rapidly decreasing temperature and as the result of the crystallization of the magmas. These hydrothermal solutions carried their metallic content away from the lower crystallizing rocks when they were forced by pressure and accelerated by various gases. Even some of the metals, such as tin and possibly mercury, were believed to have been in a gaseous state. They were carried great distances and precipitated and deposited under environmental conditions of pressure and temperature, in accordance with the reactions of physical chemistry. These ascending solutions, as they leave the original magma, are believed to be highly acid, but upon emission at the surface, like the present hot springs, they are basic and alkaline; however, they still retain some of the non-metallic and

metallic elements of the original magma. These solutions in their course of travel through the many complicated openings, formed by the complex structural conditions[1] precipitate portions of their metallic content under favorable conditions. Where conditions were not favorable for precipitation along the entire course, as in the limestone and schist formations of Seward Peninsula, they still retain a part or most of their metallic load when they arrive near the surface, where a condition of precipitation takes place regarding which very little is known.

Thus, until conditions are studied further and more knowledge is gained regarding this area, the following observed conditions in the field appear to be in harmony with this general hypothesis:

Within the area concerned, there occur four known types of igneous rocks. These are diorites, soda granites, monzonites and lavas. In regard to age classification, the recent lavas are the youngest, while some of the lavas in the lime-schist formation are regarded as the oldest. Of the igneous intrusives the diorite is regarded as the oldest followed by soda granite and monzonite. This is based upon age classification elsewhere in Alaska, of similar igneous rocks by Mertie.[2] The soda granites of the Bendeleben Range are regarded as being older than some of the others, however, there is no definite proof. The igneous rocks observed in the field in this area have been classified megascopically. Most of the known occurrences have been classified by Moffit.[3] This classification megascopically is subject to change with

[1] Op. cit., p. 24.
[2] Mertie, J. B. Jr., U. S. Geol. Survey Bull. 872.
[3] Moffit, F. H., U. S. Geol. Survey Bull. 847.

further thin section microscopic determinations. Diorite was observed along the left limit of the Kugruk River at and above the mouth of Gold Bug Creek. Here the Kugruk River has made some exceptionally large winding bends and has cut across the contacts forming bluffs 25 to 30 feet high. This diorite is in contact with a graphitic, siliceous and limy schist. The only mineralization noted was pyrite in small quartz veinlets and associated with lime silicate minerals. No visible gold in place was noted, however, it is very possible that the mineralized schist may contain low gold values that have contributed slightly to the placer gold content of the Kugruk River. At least some of the pyrite found in the concentrates originated from these contacts. The main intrusive mass[1] extends from above Mina Creek to nearly the mouth of Independence Creek, and it is classified by Moffit[2] as monzonite. This monzonitic mass is believed to have contributed the major part of the gold found in the auriferous gravels of Mina, Montana and the lower Kugruk River.

FX44-35 At the mouth of Independence Creek on the point on the right limit of the Kugruk, a 16-inch vein was found in 1917 by I. W. Purkeypile, Barney Ford and Knapner. Ten tons of galena-gold ore was reported to have been shipped from this prospect. A shaft was sunk 140 feet and several feet of drifting was done from the shaft. A reported $80,000 was spent on the property. The galena ore occurred in kidneys 10 to 20 feet in length along the vein and the formation was reported as being

[1]Op. cit., Plate 4.
[2]Moffit, F. H., U. S. Geol. Survey Bull. 247.

black limestone. This prospect has been abandoned since 1919 and due to the inactive condition, it was not examined. It is the only lode prospect, other than coal prospects, within the area. This lode, due to its close proximity to the monzonite, is held to be genetically associated.

The small granite stocks at the head of Spruce Creek in the upper Kugruk section[1] were not visited. Reports of associated gold and cassiterite with considerable yellow granitic sand suggests that these intrusive plugs may be of the soda granite type as found in the Immachuk and Hot Springs areas.

Several of the numerous granitic outcrops in the Bendeleben Mountains were examined. The greater part of these are more or less continuous and related granitic masses which form the high mountain range. They are covered with a hardened metamorphic shell of sediments with the granite outcrops only as smaller independent masses. The individual masses[2], as they outcrop at the surface, represent more or less the contact phase of the whole crystalline granitic magma. Further erosion of these granite masses would reveal their true composition. Pegmatization is common in these masses and various textures of the granites themselves show the various degrees of temperature under which they crystallized from the parent magma. This pegmatization is more or less the transitional stage of segregation of the minerals from which the hydrothermal solutions collected and were expelled by pressure as the last exponents of a cooling magma.

[1] See Plate 4.
[2] See Plate 4.

Considerable hot spring deposition is still in evidence along the upper portion of Fish River. The latter is not shown on the sketch, but is located due south of Bendeleben Lake across the divide on the south slope of the Bendeleben Range. One hot spring is still in evidence near the foot of the range on Fish River. Considerable evidence of hot spring action shows in the granite areas south of Bunker Hill. The Pilgrim Springs are situated on the west end of the Bendeleben Range in close connection with the granite masses. These present hot springs are the result of the deeper seated crystallizing magma. The amount of hydrothermal action which took place during the crystallization of the upper zone of this magma must have been considerable. The metallic content of these earlier solutions was not deposited within this contact and pegmatitic zone. The temperatures at which pegmatites form is between 870° and 600° C.[1] The temperature range for hydrothermal deposition is held to range from 600° C. to some point well below 100° C.[2]

The present surface of the Bendeleben Range is characterized by the presence of pegmatitic granite outcroppings and contact metamorphic sediments, which crystallized at temperatures above the temperature of most common metals. The greater portion of these metals were deposited at some distance from this zone in outer lower temperature zones. The formations in which they were deposited have been worn away and deposited at lower levels through the agencies of erosion. A great portion of the unconsolidated deposits found in the basins, the river drainages, and even the coastal plain, are believed to have been derived from this range.

[1]Lindgren, Waldemar, A. I. M. E. Trans., Vol. 126, p. 358.
[2]Lindgren, Waldemar, [illegible]

The granites of this range break down into yellow sands, similar to monzonite sands, with great rapidity. From their orthoclase and plagioclase content with small amounts of ferromagnesium minerals, they were classified as of the soda granite variety. It is generally found that the most common types of granites found associated within the gold placer areas such as the Kuskokwim,[1] Iditarod,[2] Ruby,[3] and Innoko, are soda granites and monzonites. These types of granites are the prevailing granites found in the other sections of this area, such as Hot Springs, Kugruk and Inmachuk.

The metallic content, which was originally emitted from these extensive granitic masses of the Bendeleben Range by the action of hydrothermal solutions, is to be found in some form in the unconsolidated deposits. These deposits are to be found in the structural basins on both sides of the range and the structural valleys which lead from these basins. These metals are not to be found in any concentrated amounts within the range itself or on its transitory slopes. The extensive areas of granite sands with their pinkish color and content of iron oxides derived from both the granites and the recent lavas, which are found at the foot of the north slopes of the Bendeleben Range, are not favorable in themselves for placer deposits. They are believed to be auriferous by some prospectors who have been over the area. These sands are on the transitory zone and are derived from the granite which

[1]Mertie, J. B. Jr. & Harrington, U. S. Geol. Survey Bull. 754.
[2]Eakin, H. M., U. S. Geol. Survey Bull. 578.
[3]Maddren, A. G., U. S. Geol. Survey Bull. 410.

crystallized at a temperature above that for most metallic minerals. These sands are further described under the Kuzitrin lowland[1]. Small fine colors of gold can be panned from these sands in certain localities such as at Bendeleben Lake and at some of the north flowing streams from the Bendeleben Mountains. The sands are, however, underlain by numerous talus boulders from the range and mixed with numerous lava rocks from the margins of the surface lava flows. The fine gold deposition in these sands is the result of later hydrothermal action, which was only minor in amount as compared to the former action. Glacial action also disrupted any extensive concentration.

The Hot Springs granite area, located between the Kougarok and the Serpentine River drainage areas, represents the most advanced stage of erosion of any intrusive within the area. This granite area is a large amphitheater, over 5 miles in diameter, with the outside contacts rising as sharp rims above the central portion. The whole effect is that of a large volcanic crater which has sunken in the center. Numerous groups of what Collier[2] calls "ears" are scattered within the central basin. The whole central portion consists of coarse grained pinkish granite consisting of pink and white feldspar with quartz. Some ferromagnesium minerals are present but not abundant. The outer rim consists of hardened sediments and greenstones, which have been hardened through contact metamorphism so that they have resisted the

[1]See description of Kuzitrin lowland on following pages.
[2]Collier, A. J., U. S. Geol. Survey Prof. Paper No. 2, p. 30.

agencies of erosion more than the crystalline mass itself. The upper portion of this intrusive, which contained the hydrothermal and pegmatitic zone, has been worn away by erosion. As a result the gold and other metallic content has been removed from the immediate vicinity and has migrated distances of from 5 to 10 miles or more away from the intrusive. The gold is found on the Kougarok, Serpentine, and Goodhope river drainage systems.

The numerous groups of ears, which are in evidence within the intrusive mass, with the existence of the present hot springs[1], on Hot Springs Creek, are all evidence of extensive hydrothermal action which accompanied the cooling of this granite. Hot Springs Creek in its upper portion has cut through the hard contact rim surrounding the Hot Springs granite. This amphitheater has been formed mainly by the erosion of softer granitic sands by this creek, but leaving groups of needles and pinnacles, or ears which were small masses that resisted erosion more than the main crystalline granitic mass. Collier[2] attributes the formation of these ears to weathering along a double system of joints. These ears, to the old time Alaskan placer prospector, had an important significance. They were the evidence on which he decided the country was favorable for prospecting. These were often recognized as granite and many prospectors have often stated that they always prefer to have these ears in sight when prospecting for placer gold.

[1]Collier, A. J., U. S. Geol. Survey Prof. Paper 2, pp. 55-56.
[2]Collier, A. J., U. S. Geol. Survey Prof. Paper 2, p. 30.

Geologically, these ears have an important significance. They appear to be the result of weathering along joint systems, as mentioned by Collier, which normally would form depressions rather than protruding ears. Weathering, as it affects most granites, is most rapid along fractures, faults and joint planes. The intersection of two or more lines of weakness usually forms a small depression. In this Hot Springs granite the opposite effect regarding these intersecting joint planes was noted. Jointing in igneous rocks, according to Willis,[1] is the result of tension imposed by cooling. A double system of jointing occurred within the intrusive areas and it was more or less pronounced in areas of localized tension. These localized areas were the open channelways for the ascending hydrothermal solutions, which were formed as the result of deeper crystallization of the original magmas. These ascending solutions were heavily burdened with minerals in solution and, no doubt similar to the present hot springs, contained an abundance of silica and soda as major constituents. As the solutions approached these joints or channelways the temperature and pressure were reduced and precipitation began. Due to the abundance of silica and soda, these were intermingled and believed to have crystallized out together and formed the plagioclase feldspar, which in comparison with the original plagioclase of the parent rock, appears to be secondary in microscopic thin sections. These solutions also attacked the original feldspars and caused

[1]Willis, B., "Geologic Structures," First Ed., p. 31.

a recrystallization which formed zonal growths of plagioclase feldspars. These are particularly in evidence around the original orthoclase feldspars. Thus within the zone of attack of these solutions the addition of this induced silica and the recrystallization formed a harder phase or zone, than the original rock, which was more resistant to weathering.

The important fact to be taken into consideration regarding these ears is the fact that these same solutions also contained a metallic content which was deposited in a higher zone at lower temperature and pressure. The environmental condition in which this gold and other metals were deposited is not known, since the upper zones are worn away. Because this Hot Springs granite is of the soda granite variety with its abundance of soda feldspar, and since soda granite is the prevailing granite associated with the original source of the gold, considerable gold is believed to have been associated with this intrusive. The abundance of the remnants of hydrothermal action, the highly mineralized contacts, the associated placer gold on the Kougarok, Serpentine and Goodhope drainages, all point to a common origin within the inflence of the Hot Springs granite. Further evidence is the old placer channels, which point toward this intrusive, and the associated granite bearing sands with the gold itself in the upper regions of the channels.[1]

Midnight Mountain, due south of the Hot Springs granite area, is a long north and south extending dome consisting of schists and limestones. The formations show evidence of mineralizing solutions which

[1]See description of Hot Springs placer area on following pages.

originated from an intrusive mass that is believed to underlie this elongated dome. Since it does not outcrop, its type and kind is not known.

Several small extrusive masses occur along the Kougarok River, note Plate 4, but since the amount of tundra and erosive material which covers the bedrock in the entire area is heavy, no doubt many more are hidden. These have not been studied and there is no available information regarding them. Whether they are isolated individual injections of magmas, representing small stocks which have reached the surface, or whether they are merely remnants of an extrusive flow with the major portion worn away, is not known. It is possible that they represent small intrusive stocks which, upon arriving at the surface, cooled as individual lava areas. The isolated rims, which occur along the Inmachuk, Goodhope and Kugruk rivers, are known to be mainly isolated remnants. Such may be the condition on the Kougarok, however, these occurrences are isolated and scattered and apparently do not show indications of relationship to any main mass. Further study of these and the lava surrounding Devil Mountain may show some association.

It is not necessary for an intrusive to outcrop as a crystalline rock to be associated with hydrothermal solutions and metallic precipitation. Hydrothermal solutions, formed by the cooling and crystallization at depth in an intrusive, may be emitted from an extrusive. Further, it

is known that crystallization takes place at depth under dense surface crustations. Thus, whether or not the small lavas of the Kougarok area have had accompanying hydrothermal action and have contributed to the total gold supply found on the drainage is not known.

The area, with its interbedded strata of schists and limestones, the latter varying in positions from horizontal to vertical, has offered conditions very favorable for the flow of hydrothermal solutions. The folding of these interbedded strata has produced both north-south and east-west faulting and shearing. The greatest amount of shearing was confined to the schist in contact with the limestone. This shearing zone makes for favorable conditions for the ascending solutions and the precipitation of gold. Furthermore, these zones were most readily attacked by erosional agencies and formed the basins and channelways for the placer deposits.

FORMATION OF PLACER DEPOSITS

Geologic History:

It is not within the scope of this report to give the geological history of the known earlier formations until the present time. Attempt to give the geological conditions, which affected the deposition of gold and the formation of the placer deposits, is made subject to change, as the area is further studied and more mining has been done.

Gold is believed to have been deposited in this area starting with the crystallization of the intrusives within the Bendeleben Range, or by those intrusive masses which accompanied the formation of the east-west folding and which Moffit[1] holds were produced before the deposition of the coal beds or before Cretaceous or lower Tertiary times. Hydrothermal action within this range or in association with these intrusives carried on for a considerable time and it possibly was repeated by the later or second eruptive period that is still in evidence today. However, following this first period of folding and accompanying intrusive action, an erosive period followed and the Eocene sediments were formed. These sediments, as they occur in this area and numerous other areas in Alaska, appear to have been laid down in channels and in isolated basins, and are the result of long erosional periods. These Tertiary sediments may have contained a portion of the gold in placer form from this early period of mineralization, as in the Eagle-Circle district mentioned by Mertie[2], with the gold being released later by the erosion of the greater portion of these sediments. Some of the gold was apparently deposited in the east-west structural valleys as the result of erosion from the range itself. Thence came the second period of deformation with the north and south folding across the east-west folded structure. The deformation of this period, which folded the coal beds and Tertiary sediments, was accompanied by granitic intrusion of Tertiary

[1]Moffit, F. H., U. S. Geol. Survey Bull. 247, p. 35.
[2]Mertie, J. B., Jr., U. S. Geol. Survey Bull. 816, p. 161.

age, as mentioned by Moffit[1]. This resultant complicated structure formed the present undulating topography and the later north and south structural ridges and valleys and associated drainage systems. Erosion robbed in part the former valleys and filled the existing basins and formed the isolated tundra placer deposits. The younger intrusives, from this later deformation, also contributed to the gold supply in the existing basins and channels. Continued erosion formed the existing Tertiary channels. The gold began its migration from basin to basin and down channelways. Later erosion and hydrothermal action contributed more gold to the channels where the concentrations were formed. The wide structural valleys were favorable for the many agencies of erosion and these, along with the sorting action of running water, were the concentrating agencies that formed the various placer deposits.

Since the deposition of the Tertiary sediments, there has been no major period of submergence. The area, which may have experienced some minor periods of submergence along the outside coast, was one of a gradual uplift accompanied by a series of erosive periods during Tertiary times and up until the present. The highest elevation of gravel deposits believed to have been deposited along shore lines is approximately 600 feet, as observed in the Hot Springs area[2]. These are believed to have been delta deposits modified by sea shore action. The next major leveling or period of hesitation following uplift occurs at a 200 foot elevation along the coastal plain. During this period there were possibly

[1]Moffit, F. H., U. S. Geol. Survey Bull. 247, pp. 35-36.
[2]Op. cit., Plate 4.

minor periods of lesser elevations. The last level or period is at the present coast line. The amount of unconsolidated material that has been deposited covers extensive areas[1] along the coastal plain and it has filled many structural basins within the upland province. The effect of the later periods of uplift has increased the efficiency of the drainage systems, which have formed reconcentrations within the basins, transported the gold further from its source and caused intrenchment of the rivers, and formed old channels and bench deposits. This stage of active erosional agencies continued to remove further gold from the bedrocks, receive, sort, and transport additional gold from recurrent hydrothermal waters, until it was disrupted by the extensive recent lava flows and the periods of glaciation during Pleistocene times. The comparatively thin lavas, which were emitted from large open fissures, flowed over a broad structural valley which had been partly filled by Tertiary unconsolidated deposits. Due to the extent of the flows, the lavas not only covered the greater portion of the basin, but they continued to flow down the existing Tertiary channels which lead away from the large basins. In so doing, the lavas covered the gravel deposits and made them more or less resistant to later erosional agencies. The lavas dammed the large structural basins and caused the formation of lakes.

These lavas were either just prior to or during the first period of glaciation. In regard to this area, only the mountain province was affected by the destructive agency of moving glaciers. The other

[1] Op. cit., Plate 4.

effect of this glacial period, as a whole, was the freezing of the vegetable and animal growth which apparently was abundant. It stopped the agency of running water and put into effect other agencies such as frost and wind. The latter is believed to have transported the dead vegetable growth and the abundant loose fine grained material, such as silts and sands, from higher elevations into the lower valleys to form the present deposits of black muck and silts which overlie most of the unconsolidated deposits. Such agencies as hillside creep, freezing and thawing, and gravitational forces were all active during intermittent periods.

After the Pleistocene epoch, running water again became an active agency, which in many cases disregarded the old channels and began to form new ones. Lakes were formed, which in some instances were extensive, as in the Kuzitrin Basin[1], and also formed new drainage systems by their overflow and in so doing removed considerable of the frozen muck.

The era from Pleistocene times to the present is one of comparatively short duration, during which a new cycle of erosion has begun in which running water made use of new drainage systems more or less superimposed upon an older drainage that had become somewhat disrupted. This new cycle also contains many minor features which have affected the placer deposits, some of which are mentioned along with others under the descriptions of the individual placer areas.

[1]See description of Kuzitrin Lowland on pages following.

TOPOGRAPHY SINCE GOLD DEPOSITION

Change of Drainage Systems:

The deposition of gold in concentrated placer form is a steady process, beginning at the time when lode deposition comes in contact with erosional agencies and continuing until a definite stage of concentration is reached. Any particular stage of concentration is not the final position of the gold, since it is subject to the action of later and future agencies. It may be taken that the present time may be some dormant stage of the concentration which accounts for the present position of the gold. It is definitely known that the greater portion of the placer gold that is found in the various areas contained in this report is more or less confined to the older drainage channels and drainage systems. These deposits were concentrated mainly during the great erosional periods which began in the Tertiary and which continued to Pliocene and Pleistocene time. Thus the period of deposition for this area extended from early Tertiary times up to the Pliocene or to the period of lava flows followed by the glacial and freeze-up periods. Since there is a difference in ages of the lava flows, the extent of the earlier flows were small, in comparison to the later recent flows, and are disregarded. The general topography has changed very little since the beginning of the recent lavas.

The change of drainage, since the Pliocene epoch, which was brought about by the lava flows, has had the most pronounced effect upon

the topography of the structural valley to the north of the Bendeleben Mountains. An immature drainage exists on top of the lavas, under which is a mature drainage system. The older drainage is intact beneath the lavas with the leading channels distinctly marked by the outward flowage of the lavas. Thus we now have a series of very immature drainage systems, originating on top of the lava flows, cutting across the outer rims of the lava flows and flowing on top of older deposits that are superimposed upon larger and older drainage systems. This is true of all the larger rivers within the area with the exception of the Serpentine and Kougarok rivers, which have developed a new drainage system upon an older one due to causes which are explained later.

Glaciation followed or accompanied the lava flows and it also had its effect upon the topography of the Bendeleben Range and the drainage basin of the Koyuk and Kuzitrin rivers. Other than at the southern section of the area, glaciation was almost entirely absent.

The writer does not attempt to explain all the causes and effects of various agencies which have affected the topography since and during the gold deposition. They have been numerous and explanation as to their causes and effects can only be interpreted from a few remaining remnants which exist as factual evidence. It is more the writer's purpose to present the actual existing conditions with which the present day operator has to contend. The greatest amount of change in topography has been within the lower structural basins which contain drainage

channels. Evidence shows that the lava flows produced the greatest amount of change. Next in extent, and with which most operators have to contend, is the deposition of the black muck strata on top of most gravel deposits. The next effect on topography was the freeze-up period which apparently stopped the drainage altogether. It froze the vegetal and animal growth which was evidently abundant. There is evidence of their existence due to the presence of remains such as wood and bones under the lavas. From the occurrence of gravels under the lavas, as mentioned by Collier[1] and Moffit[2], and under the lava in the shafts of the Sub-lava Mining Company on the Innachuk River[3], the deposit of muck is lacking. This black muck, or combination of ice and silt deposition, is common in many placer fields of Alaska and is described by J. B. Mertie, Jr.[4]. Among the several hypotheses offered for their origin, the one which appears the most logical and backed by the greatest amount of evidence, is the wind-borne hypothesis. These deposits are also classified as the earliest Pleistocene deposits. With further study, these deposits and the climatic conditions which must have been associated with an approaching period of this kind, possibly lies the explanation for the silt deposition. The greatest problem, which concerns these silts, is not as to their origin, but as to the best method of thawing and removing them, and especially in an area which lacks natural hydraulic water and steep grades.

[1]Collier, A. J., U. S. Geol. Survey Prof. Paper No. 2, p. 67.
[2]Moffit, F. H., U. S. Geol. Survey Bull. 247, pp. 32-33.
[3]See description of [illegible]
[4][illegible], J. B., Jr., [illegible], U. S. Geol. Surv. Bull. 872, pp. 183-189.

Another agency which had its greatest effect during the Pleistocene age, and which is still much in effect today, is hillside creep or a mild form of hillside glaciation. This had the effect of lowering bench deposits and filling the frozen river valleys and covering the more or less sorted older gravels with unsorted and angular material. This caused the stream, when it began to run again after sufficient thawing, to adopt a new course superimposed more or less on top of the older pre-Pleistocene channels. The rivers which began flowing after the glacial period, were overloaded; some intrenched into the older gravels, and others flowed on top and began to cut a preferred bank. This drainage change, caused by the frozen ground, is one of the most common problems with which the operator is faced. The present tundra or accumulated vegetable growth, which varies from a few inches to several feet, acts as an insulator to the frozen muck underneath and in association with the long cold frozen winter periods tends to keep most of the unconsolidated deposits permanently frozen.

POTENTIAL PLACER AREAS

Serpentine Springs Area - Arctic Slope:

The serpentine Springs area is located in the northwest section of the area contained in this report, note Plate No. 4. The drainage, within this area, comprises the Serpentine River and its upper tributaries, which drain to the Arctic Ocean, and the Fish and Nugnugaluktuk rivers,

and Humbolt Creek, which drain to Kotzebue Sound. A pronounced structural ridge, extending from Midnight Mountain on the south to Devil Mountain on the north, divides the drainage. This ridge rises in the vicinity of Devil Mountain and slopes from Midnight Mountain toward the coastal plain on the north. Along this structure there are associated intrusives and extrusives. The Hot Springs granite area has been described in preceding paragraphs. The original source of the gold, found within the area, is related to the granitic intrusives and the related magmas underlying the extrusives. The Hot Springs granite has been the largest contributor. On the north and west contact of this granite, the schistose greenstone country rock is very heavily mineralized and this zone extends northward until covered by the coastal gravels. Hot spring action is in evidence along the zone and in the limestones and schists of the east portion of the area.

The vicinity of Devil Mountain north of this mineralized zone was not visited. Moffit[1] classifies the mountain as lava. Whether or not these lavas have been subject to hot spring action to the extent of gold deposition was not learned. The mountain is isolated in the northern section and is surrounded by gravels of the coastal plain. These extensive gravel deposits are not beyond the limits of gold deposition and since the bedrock geology is unknown, they are worthy of some investigation.

[1]Moffit, F. H., U. S. Geol. Survey Bull. 247.

The creeks which head in the vicinity of the Hot Springs granite have been known, since the early days, to carry some gold. No exceedingly rich strikes were made and the gold deposits are more or less buried. A small amount of hydraulicking has been done on Humbolt and Dick creeks. Not until this year has there been much activity within the area. Recently pay gravels were found on Schlitz, Reindeer and Bella creeks. These creeks are the main head tributaries of the Serpentine River which flow from the slope of Midnight Mountain. In so doing they cross the former drainage system which extended north and south along the structural valley, and which contained the greater portion of the gold that originated from the influence of the Hot Spring granite on the west side. This gold gradually worked its way into the synclinal basin on the west, and was deposited as a delta deposit. Extensive gravel and granite sand deposits still exist between elevations of 600 to 800 feet.

Granite sand is found in the gravels of Macklin Gulch. This gives evidence of migration southward from the Hot Springs granite. In considering the topography of the western margin of the Hot Springs granite, a low saddle exists across into Macklin Gulch. Thus the greater portion of the gold found in the upper Kougarok is attributed to this drainage southward from the Hot Springs granite. Extensive gravel benches, formed by the Arctic Ocean when the section was partly submerged, were noted between elevations of 200 to 600 feet on both the present

Arctic Ocean slope and the slopes to Kotzebue Sound. Since these gravels are possible delta deposits modified by beach action, they warrant prospecting as they are within the limits of deposition from the granite intrusives. Prospectors report that colors have been panned in all the creeks of the Arctic slope extending from Serpentine River west to Ear Mountain.

The headwater creeks of Serpentine River drain the western slope of this ridge from Midnight Mountain north, Humbolt Creek and its headwater tributaries drain the eastern slope. The upper tributaries of Humbolt have been prospected and some hydraulic mining has been done in the past. Gold was reported to have been panned from its head to its mouth, a distance of 17 miles. Gold prospects were reported discovered in the early days on Ballarat Creek, the largest tributary of Humbolt Creek. The upper tributaries of the Pish River warrant prospecting.

K449-91 Walsh Bros. of Nome have a lease and option to buy the staked ground on Humbolt Creek, and are operating a bulldozer and hydraulic operation on the south branch. This branch follows a contact of limestone and various phases of schist, the latter forming the bedrock in the creek. These schists range from chloritic to graphitic, are close-folded, mineralized, and highly contorted. The gravels range from medium to fine, with an average depth of five feet on the upper portion of the creek and increasing gradually in depth downstream. They are frozen, but with occasional thawed spots. The gravels thaw very readily with hydraulic water due to the shallow depth. The gold is fine in texture

and the fineness is comparatively low. The paystreak mined averages 100 feet in width and the ground was reported to be running $1.75 per yard. Cassiterite was observed in the concentrates, but the amount was not of sufficient quantity to save.

George Bodis has two mining operations in the area, one on Dick Creek and the other, a new hydraulic elevator and bulldozer operation, on Schlitz Creek at the mouth of Rainbow. At the operation on Schlitz Creek the paystreak was reported ranging from 110 to 130 feet wide. The gravels range from 5 to 8 feet in depth and consist of a mixture of creek gravels of medium size and fine beach wash. The elevation at the mouth of Reindeer Creek is nearly 600 feet. The gravels are frozen in winter and gradually thaw during the summer. The bedrock is even and is made up of schistose and metamorphosed volcanic tuffs and lavas. The gold is fine and has a shotty nature, with 2½-cent pieces the largest size observed. Six lines of 4-inch holes were drilled across the paystreak that averaged 65 cents per yard.

On Dick Creek, Bodis has operated with a hydraulic for several years. The paystreak averages 45 feet in width and 6 feet in depth. The bedrock is hard and has a blue clay on top. The gravels show a mixture of old well worn channel rocks and angular bedrock with fine to medium gravels. This deposit appears to be a reconcentration from the delta deposit, which formed on the west side of the Hot Springs granite,

with some local hot spring action at the head of the creek. The pay-streak has been mined over five claim lengths to where it empties into Bryan Creek. The average ground mined has produced $1 per yard. Good prospects were reported found on Bryan Creek, which joins the Serpentine River below Hot Springs Creek.

The bed of Hot Springs Creek, which is composed of granite boulders and a great amount of granite sand, shows very fine gold. This creek bed was reported to be thawed, possibly due to the former hot spring waters. Very little prospecting has been done on it. The gold would no doubt be concentrated on or near bedrock and covered with the granite sands. This creek on its lower extremities warrants prospecting, as also does the Serpentine River below it.

The area is not seriously handicapped for transportation. Three air fields, one at each mining operation, take care of the necessary supplies during the summer at the rate of 8 cents per pound from Nome. The main transportation is done, during early spring months, before the marshes thaw, with caterpillar from the road at Taylor and narrow gage railroad from Nome to Bunker Hill. A much cheaper route, over which both summer and winter transportation is possible with caterpillar, would be from Goodhope Bay between the Goodhope and Fish rivers. At this point, supplies could be landed on the beach for the approximate sum of $20 per ton from Seattle, plus caterpillar haul to the operation. It is possible to run caterpillars over the tundra in both summer and winter with the exception of the thawed marshes and larger rivers which usually can be avoided.

Kougarok and Noxapaga Drainage Areas:

The Kougarok district contains two mining districts, commonly termed upper Kougarok and lower Kougarok-Noxapaga. Since the mining conditions in each area are somewhat different, and as they have a distinctly different topography, they are taken up separately.

Upper Kougarok Area

The upper Kougarok area comprises the area directly south of the Arctic slope or Hot Springs area from Midnight Mountain south to the Kuzitrin Basin. The upper Kougarok drainage basin is situated in a wide open fold that is bounded on the east and west by flat hill tops and domes. Brooks[1] on the Kougarok Region gives the following description:

> "To the north the Kuzitrin lowland rises gently to an upland, whole flat summits stand at altitudes of 800 to 1,600 feet. Here broad, interstream areas, with flat hilltops, diversified by some higher domes reaching altitudes of 2,500 feet are separated by wide valleys. This upland level, as elsewhere in the peninsula, marks a former stage of erosion, when the entire region was planated. Subsequent uplift formed a plateau which has been greatly dissected by the present water courses."

The upper 10 miles of the Kougarok River flows from west to east with its head off the east slopes of Kougarok Mountain. It then makes a right angle turn at the mouth of Macklin Creek and follows a southerly direction to its mouth. In its southerly course it follows a structural weakness in the schists. This structural weakness represents a shear or fault zone, along which there has been movement. The east and west tributaries occupy fault zones in which there has been some east-west movement. As a result of this east-west movement, large oxbow bends

[1]Brooks, A. H., "The Gold Placers of Parts of Seward Peninsula, Alaska," U. S. Geol. Survey Bull. 328, p. 295.

have been formed along the river. These bends are in evidence at the vicinities of the mouths of the Macklin, Taylor, Henry, Coarse Gold, etc. creeks. These oxbow bends are of considerable economic importance since various stages of benching took place on which the placer deposits were formed.

Brooks[1], on the Kougarok Region, describes the benches from Taylor to the point where the Kougarok River enters the Kuzitrin lowland as follows:

> "Though the general trend of the different parts of the valley is in one direction, its course in detail is tortuous. Within the valley walls the river flows in a very irregular channel, and many of the meanders are separated by well-defined benches whose flat surfaces mark former stages of water level. This is especially evident above Taylor Creek, where the river flows through a continuous series of oxbow curves, which are separated by sloping benches.
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> "At the point where the Kougarok enters the Kuzitrin lowland both valley walls show well-marked benches. Two levels are here noticeable - one 50 feet and one 25 feet above the stream. These can be traced for several miles above Windy Creek; the walls then become steeper and the river occupies a canyon-like valley up to Left Fork. From this point to Washington Creek, 20 miles above, some evidence of benching can be observed in most places, though the benches are not continuous. The individual levels have not been traced, but in the part of the valley below Taylor Creek there are at least two high-level gravels and possibly three."

The Kougarok and Noxapaga rivers are the only south flowing rivers within the area described. Both rivers owe their positions and directions to having originated on a much older drainage system which approached the stage of planation as mentioned by Brooks[2]. Of the two rivers, the drainage of the Noxapaga is the younger and its drainage has

[1]Brooks, A. H., U. S. Geol. Survey Bull. 328, p. 316.
[2]Brooks, A. H., U. S. Geol. Survey Bull. 328.

been controlled by the recent lava beds of the upper Kuzitrin valley. It is within the bounds of assumption that subsequent to the north and south folding and the great anticlinal uplift of the Bendeleben and Kigluaik ranges, that the area now occupied by the large structural valley, which is now occupied by the Kougarok River, drained to the north as does the Goodhope, Inmachuk and Kugruk drainage basins. Features that tended to block this drainage at intervals were the lava flows of Devil Mountain vicinity as represented by greenstones and tuffs in the Serpentine River area, the Hot Springs granite area, and the delta deposit on the west side of the Hot Springs granite. As a result of the igneous activity, tilting also was associated with the drainage change. Gradually, through stream piracy from the south, the Kougarok area developed a south drainage. The gold, which was contained in the delta deposit and the former drainage system, was reconcentrated and now exists on the various bench levels and river bottoms of the Kougarok and Serpentine drainages at the present time. The present concentration is a partial reconcentration of the former deposits and accounts for the irregularity of values which range from very high to low with irregular distribution.

The present position of the placer concentrations is variable due to the various changes and influences to which the drainage area has been subject. The deposition of the great quantity of silt on top of the various bench gravels, the freezing up period, and the agencies

of erosion since glacial times, makes a very complex problem for the present day miner. It is with this thought in mind that the writer recommended to the Department of Mines that detailed topographic mapping, to show the position of the benches of the drainage system from Macklin Creek to the Kuzitrin valley, be done. In the present creek beds, to which most of the past mining has been confined, areas of exceptional values were encountered along with areas of lean pay gravels. The failures of past mining have been partially due to high costs and the lack of an understanding of these conditions. The Kougarok district has been noted in the past as one of erratic pay gravels and hard mining conditions.

The higher grade gravels of the present river courses were discovered in those localities where the rivers, since glacial times, had worn a portion of the old benches away and crossed the older channels, usually below or in the vicinity of the oxbow bends. The areas of lean pay were usually confined to the straight courses of the river on which little gold was deposited from the former levels where most of the pay still remains. The present river channel is the course which was formed after the freeze-up period. The new channel does not follow the old channel which was formed prior to the freeze-up, but it does cut across the older channel in many instances.

On the upper Kougarok above Macklin Creek, the present channel began to cut the north bank with sections of the older channel remaining intact on the south or right limit. Below Macklin Creek the older channel has been cut more often by the present river channel. The best pay has been found in the present creek channel where it crosses the placer concentrations of the oxbow curves of the older channel. At the curves formed by the older channel, the pay is mainly intact and such localities are being constantly sought by the present operators.

After the freeze-up period and up to the present time, the natural ground creep of the frozen material has been in progress on the banks. Old holes, which were drilled during the early exploration days and that are now in evidence as solid columns of ice in the frozen gravels, show this ground creep. Some of these holes are now tilted toward the river as much as 45°. This shows a movement, slow in action, greatest in amount on the surface and the steeper slopes, which compares to the movement of ice in an alpine glacier. Seasonal thawing and refreezing on the surface tends to eliminate the light constituents of the soil which flow off with the thawed water of the summer seasons. Refreezing heaves and breaks up the surface, causing a great rapidity of movement. The effect of this ground creep on the benches is to cover them with surface material and obscure their presence from view by making the surface seem to conform with the natural slopes of the surrounding topography. This is only one of natures agencies which, in a very slow

way, helps concentration, and also makes the search for mineral deposits much more difficult. As nearly all of the unconsolidated material on the Peninsula is frozen and the unusual structural condition makes for various slopes, this frozen ground creep has, along with the heavy silt covering and tundra surface, covered and buried most of the older placer deposits. The upper benches have been found mainly by prospecting and mining.

There are five known pay levels to consider, each more or less limited and affected by the latter one. The level above the present creek is the 25-foot bench. A section of this bench level has been partly mined across the river from the Taylor roadhouse at Taylor, on the Sather bench claim. This bench has a grade of 6 per cent and the bedrock consists of blocky schist, which necessitates mining 1 to 3 feet of bedrock. The gravels have a thickness of 6 feet of regular channel wash, and are covered with 12 to 18 feet of muck and ground creep angular material. The material is permanently frozen and the upper portion was removed by hydraulic. Castleton and Keenan mined the greatest amount on this bench with dragline and boxes set in bedrock. This operation began in 1936 and terminated last year with the above operators optioning the ground and dredge of the Kougarok Consolidated Placers above Taylor.

This season the Gold Bullion Company, Inc. is working a bench below Taylor on the left limit of the Kougarok River. This deposit is approximately 50 feet above the present river. This represents the second bench level, with the first bench level cut away in this section.

Between this operation and the second bench level on the right limit above, the present river cut both older channels, and exceptional pay was mined in the present river channel. Last year two partners of the Gold Bullion, Inc. operated on the third bench level approximately 100 feet above the present river between Eldorado and Dreamy gulches just below the Gold Bullion, Inc. operation. This high bench deposit consisted of 8 feet of channel wash covered with 4 feet of frozen muck. This ground was reported avereging 25 cents per bedrock foot, with considerable pay remaining in the angular blocky bedrock. There has not been sufficient mining on this second bench level to determine the pay. This year's operation was based on the drill results of the bench level. The method of mining is using hydraulic for thawing and eliminating the muck, and using dragline and bulldozer for moving material into low elevated boxes.

Below this operation the Alaska Taylor Mining Company is mining on the old channel level with dragline, hydraulic and bulldozer. Here the gravels range from 7 to 15 feet in thickness and are covered with 7 to 15 feet of muck, all of which are frozen.

This bench mining in the vicinity of Taylor represents only a very small portion of the actual bench ground that exists. This series of benches exist more or less on all the oxbow curves of the river. The values contained on them and how much can be mined under the present costs is unknown. However, with reduced transportation costs, and more efficient and cheaper mining methods, these bench deposits offer an

This season Maurice Kelliher has started mining on a bench opposite the mouth of Macklin Creek on the right limit of the Kougarok. Last winter by sinking a shaft 35 feet to bedrock he obtained good pay on a level 25 feet above the present river level. Here the gravels range from 6 to 12 feet in thickness covered with 15 to 18 feet of muck and sediment and 4 feet of black silt. The pay is confined to the lower two feet of gravels. He is operating with bulldozer and hydraulic with boxes set in bedrock.

Carl Anderson is beginning this season to mine bench ground on the left limit of Macklin Creek just above the mouth. Satisfactory returns were indicated by drill, with the ground averaging 17 feet in depth consisting of 7 to 8 feet of gravels covered by 8 to 10 feet of frozen muck. Some exceptionally high values were reported in a few holes.

Macklin Creek, which joins the Kougarok River at the right angle bend above Taylor, has a length of 6 miles and flows west and southwest from the southwest slopes of Midnight Mountain. This creek has cut across the older drainage system on the southern border of the delta deposit formed by the erosion of the Hot Springs granite. Boulders and heavy wash rocks are evident in the gravels, some ranging up to 4 feet in diameter, showing a former drainage of larger size than the present creek. Mixed with the heavy gravels is considerable granite sand consisting mainly of feldspars and quartz and identical, megascopically, to the sands within the Hot Springs granite area. The sands

and gravels are poorly sorted and loose with the gold mixed through all the gravels. The gravels range from 7 to 10 feet in thickness and are covered with 5 feet of black muck and tundra. These poorly sorted gravels, with the gold mixed from top to bottom, show the creek has been overloaded with this type of material. Half of the gold recovered consists of large nuggets, with the remaining half ranging from coarse to very fine, with a fineness of 917. The deposit is frozen and the bedrock consists of various schists. The ground is increasing in value upstream and the present ground averages $2.50 per yard from surface to bedrock. Mining has been in progress by the Laurin Bros. since 1912, who are operating a drag scraper, bulldozer and hydraulic. This creek has been consistently the richest creek of the area, however, much richer ground has been found on the Kougarok River in small concentrated areas.

This season Castleton and Keenan expect to mine one of these highly concentrated areas. This area is located on the Kougarok River, one and a half miles above the mouth of Macklin Creek. This exceptionally rich area is small in extent and consists of a short section of the old channel on one of the numerous bends on the right limit directly opposite a small tributary gulch from the north side. This gulch tributary extends to the north and reached into the older delta deposit and older drainage similar to Macklin Creek. Since freeze-up the gold has been held intact and the Kougarok River had continued to cut its north bank

and left this old channel segment intact. The gold occurs mainly on bedrock and was reported ranging from fine to very coarse. A common drill log consists of 4 to 6 feet of muck, 2 feet fine wash gravel, 1 to 2 feet of muck and ice and 6 to 8 feet of medium to fine gravel. The gravels and muck are all frozen. Mining consists of hydraulicking and bulldozing the upper muck and gravel down to the lower strata. Thence the lower gravels are thawed with hydraulic water and a dragline is used to move the lower gravels into elevated boxes.

Between this operation and the mouth of Macklin Creek on the right limit and on the same old channel, the Trinity Mining Company is operating a hydraulic and drag scraper, the latter used as a tailing stacker. A bulldozer is used in the pit with hydraulic nozzle to move material into boxes set in bedrock. While the pay here is not as rich as at the Castleton-Keenan operation above, it was, however, reported as very satisfactory.

AAA4-163 Below the mouth of Macklin Gulch, Castleton and Keenan are operating a 2½-cubic foot dredge, formerly operated by the Kougarok Consolidated Placers, Inc. A large oxbow curve has developed in this locality on the Kougarok. Here sections of the old channel were found in the curves with good pay and on the first level of benches cutting across the curves, good pay was discovered by drilling. Both the old channel segments and portions of the present river are to be dredged. The bench pay will probably be worked with dragline. The dredging ground averages 20 feet in depth. Approximately 6 feet is bulldozed off.

The ground is thawed with points. The gold is distributed mainly on bedrock and varies from medium to coarse in size. The bedrock is blocky schist with an occasional hard reef. The cost of dredging is reported at 40 cents per yard. This high cost is in part due to the high cost of transportation. Completion of the road from Bunker Hill to Taylor will give cheaper transportation to this section and lower costs. On the other hand, had a road been built from Goodhope Bay the railroad haulage and high lighterage costs would have been eliminated. This would have cut the present cost of $70 per ton from Seattle to less than half. This factor alone would account for increased dredging reserves and greater profit.

The Fox Bar Dredging Company, located 10 miles below Taylor on the Kougarok River, is thawing similar ground and dredging with a 2-3/4-cubic foot dredge for less than 30 cents per yard, exclusive of taxes. The gravels contain considerable sand and the channel gravels are medium to fine, however, a few large boulders are encountered. The depth varies from 7 to 13 feet. These shallower gravels, finer material and a shorter haul might possibly account for the difference in dredging costs.

These nine mining operations comprise the total mining along a known length of nearly 40 miles of auriferous gravels on the Kougarok River alone, and equally as many miles along the tributaries in this upper Kougarok section. Note Plate No. 3 showing known auriferous gravels. The writer does not wish to convey the impression that this amount of

mileage of auriferous gravels is all minable at a profit under the existing costs. However, with lower transportation costs, better methods of operation and recovery, a much greater portion of these gravels could be mined. Cheaper power is a factor worthy of investigation within this region.

. Lower Kougarok and Noxapaga Areas

The lower Kougarok section consists of that portion of the lower Kougarok River from the point where it emerges from the northern tableland, into the Kuzitrin lowland, to its mouth. As the topography and other physiographic features of this section are somewhat different than the northern section, it has been considered separately. This lower area and the adjoining drainage basin of the Noxapaga to the east offers one of the most interesting potential placer areas of Seward Peninsula, with its complex and unsolved problems. A short study of Plates Nos. 3 and 4 will give some conception of the main valley lowland. Then the various feeder streams from the north, with the gold which was derived from the numerous granitic intrusives of the Bendeleben Range to the south, and the gold which originated in local vicinities within the lower drainage system may be considered. The problem confronting the prospector, operator, geologist, and engineer is as to the type of deposit which this gold occurs in at the present time--whether agencies have removed the gold or buried it underneath the extensive gravel and

lava deposits contained within the basin, and whether or not the deposits will be of economic importance.

Many of the agencies, which have been discussed previously in this report, have left their marks within this area. These many features are only mentioned not to arrive at a solution of the complex problems, but to foster interest within the area which may in the future lead to their solution, with accompanying economic returns.

Brooks[1] recognized the possibilities and the complexities of the area and classified the deposits as follows:

> "The auriferous gravels forming a broken fringe along the southern margin of the highlands that bound the Kuzitrin basin on the north and west have certain features in common, which justify describing them as a unit. This belt includes the placers of Quartz and Garfield creeks, as well as those of the Noxapaga basin. The bed-rock geology of the belt is obscured both by the extensive alluvial deposits and by the products of deep rock weathering. However, a belt of graphitic phyllites and schists, including some calcareous beds, appears to stretch across the upland between Kaviruk and Kuzitrin rivers. Many of these rocks carry quartz veins, locally stained with iron. Schists occur north of these graphitic rocks, and farther north are succeeded by limestone. Though these formations cannot be exactly delineated, because of the deeply weathered character of the rocks and the absence of outcrops, yet most of the gold-bearing creeks appear to cross the contact of the limestone and schist.
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> "The unconsolidated formations embrace (1) the present stream gravels, (2) the deposits flooring the Kuzitrin lowland, and (3) the bench gravels. * * * * * Little can be added to the description of the second group already given. The bench gravels merit closer consideration."

The present creek deposits found within the area are important, as some have been steady producers since 1899. Creeks which contain economic placer deposits include Coffee, Dahl, Joe and Quartz of the

[1]Brooks, A. H., U. S. Geol. Survey Bull. 328, p. 309.

lower Kougarok drainage, and Garfield, Boulder, Buzzard, Goose and Black Gulch, of the Noxapaga drainage. These creeks are of considerable importance geologically since they contain both residual and creek placer deposits of local origin. This fact becomes very evident from a close field inspection of the bedrock as shown in the cuts of the various operations. The placer gold deposits of Coffee and Dahl creeks are mainly residual and alluvial deposits, and small creek concentrations, all of which are covered with considerable black muck. The gold, contained in the deposits, originated in the immediate vicinity from irregularly distributed localities which show hydrothermal action of hot ascending waters in the graphitic slates and schists. The most pronounced evidence of this type of deposition was noted in the bedrock at the site of the Hoven placer operation on Wonder Girl Gulch, a tributary of upper Coffee Creek. Here, under 15 to 20 feet of black frozen muck, angular broken bedrock is being mined. Gravel, except a few rounded quartz and quartzite rocks, is lacking in the gulch. Cinnabar in amorphous form with considerable yellow amorphous powder is found in the fractures of the bedrock. Associated with and in the yellow powder is considerable rough fine gold. Several of these occurrences in the vicinity have produced the gold which formed the creek deposits. Due to the highly disseminated nature of these deposits, and the apparent lack of favorable structure, it is very improbable that minable lode deposits were formed. A short description of the various operations will further support this evidence.

K-44-36 Andrew Wiurm and associates are drift mining below Wonder Girl Gulch on the left limit of Coffee Creek below the Hoven operation. They are mining from 2 to 5 feet of gravels overlain by frozen muck. The gravels consist of partly rounded and angular creek gravels mixed with some muck, but lacking foreign constituents. The gold is all fine and mainly found near to and in the soft schist bedrock.

K-44-35 The Coffee Creek Mining Company, located on Coffee Creek below the Wiurm operations, is a hydraulic operation with a bulldozer and a power scraper for stacking tailings. The gravels have a thickness of 5 feet under 20 feet of frozen black muck. They are of medium size and contain considerable angular mineralized quartz pieces. The gold, which is fine and rough to coarse, as well as nuggets with considerable quartz attached, are found.

Brooks[1] describes some of the operating properties of the early days on Coffee Creek and comments as to the source of the gold:

> "Considerable prospecting has been done throughout Coffee Creek basin and a little gold has been mined in its upper part. The lower part of the creek is incised in the gravel terrace, and here also a little gold has been found. Prospecting on the upper part of the creek is expensive because the gravels are everywhere buried under 10 to 25 feet of muck. This is true not only of the floor of the valley, but also of the slopes and the tributary gulches. This overburden is too heavy to permit open-cut mining, and the cost of fuel has so far been too great to encourage drift mining or even prospecting. As a result much of the prospecting on Coffee Creek has been confined to cuts made by ground sluicing at favorable localities during floods, and few careful tests of claims have been made.

[1]Brooks, A. H., U. S. Geol. Survey Bull. 328, p. 313.

"In the winter of 1906 some rich placer ground was found in the talus of the valley slope near the head of Coffee Creek. This peculiar auriferous deposit appeared to be almost in place. The gold occurs in 4 to 7 feet of angular schist and quartz debris and weathered schist bedrock covered by 18 to 20 feet of muck. The quartz is iron stained, but does not appear to be auriferous, and the gold probably came from the associated schist. The gold is angular, spongy, and bright colored. All these facts point to the conclusion that the material mined is a weathered part of a mineralized zone. The deposit has been traced about 1,000 feet, but is buried so deeply that its boundaries are not well known. It is indicative of the source of the gold and suggests the possibility of finding lode deposits that may carry values."

The Dahl Creek Mining Company, now on claim No. 8 above the mouth of Dahl Creek, started mining in 1900. This operation consists of a power drag-scraper and hydraulic. The total depth here is 27 feet, all of which is frozen and consists of 21 feet of muck and 5½ feet of medium gravels. Considerable of the gold is found in bedrock. The fineness at the present price ranges from 26 to 28 dollars per ounce.

Louis Nashenweng was operating a hydraulic and bulldozer on Dahl Creek on No. 2 claim above the mouth. He has 5 feet of fine to medium gravel covered by 10 feet of frozen muck on top of a clay bedrock.

Lea Steavens is mining with a caterpillar and a one-yard tumblebug scraper on Quartz Creek above Carey Gulch. The deposit consists of fine creek wash material 5 to 8 feet in thickness covered by 4 to 6 feet of muck on top of a blue clay bedrock. The gold is fine and distributed through the gravels. This deposit, like the others, is all frozen.

K-III-3 Carl Yagger on Joe Creek, a tributary to Quartz Creek, is hydraulicking and shoveling-in a deposit consisting of 1 foot of fine light gravel and 2 to 3 feet of angular slide rock. The gold is fine, rouch and 2 feet into bedrock.

Mining has mainly been done in the past on Garfield, Boulder, Goose and Turner creeks in the Noxapaga drainage system. Lack of water, low grades, considerable black muck, and lack of suitable machinery were the major problems. These were creek deposits very similar to those of the Quartz Creek drainage deposits. The only present operation is that K-III-14 of the Rainbow Mines on some recent discoveries on Black Gulch above Boulder Creek. This deposit consists of 3 feet of gravel and 9 feet of muck. The gravel is fine and rounded with most of the gold in bedrock. The gold is fine and its average content was reported to be $4 per yard. The company is operating a hydraulic and bulldozer.

Most of the mining on these creeks is confined to near their heads or to the point above where they flow onto the Kuzitrin lowland. At these places the creeks flow over extensive gravel deposits. The little mining, which has been done on these lower creek sections, has been confined to a few feet of gravel on top of a clay false bedrock. This shows a run of the creek gold over and since the clay bedrock was deposited. At the mouth of Quartz Creek these gravels were reported to be over 200 feet deep as shown by a drill hole log. A small amount of fine gold was also reported throughout the gravels, but not in sufficient quantities to mine.

There appear to be several levels of these gravels that occur as bench deposits and which are unassociated with any large river, excepting the extensive benches along the lower Kougarok. The high bench gravels are found from the right limit of the Noxapaga, around the fringe of the Kuzitrin valley, to Bunker Hill. Other than the few attempts at mining in these gravels on the producing creeks, they have not been prospected or tested sufficiently to make any statement regarding their economic possibilities. There is still the unsolved problem as to how they originated as bench deposits and as to their content.

Brooks[1] gives many interesting facts and possibilities as to their origin:

> "While the drainage channels were being incised sediment was deposited in the Kuzitrin basin, then an arm of the sea. It has been shown that the character of this sediment is but imperfectly known. Underneath Quartz Creek valley there are nearly 200 feet of white quartz gravels, which would appear to be the result of the denudation of the old planated land surface. Such quartz gravels, many of which are not greatly rounded, are most likely to have come from an area which had been long subjected to subaerial decay. Their accumulation was probably brought about by rapid erosion and sedimentation, which would indicate rapid uplift. It has been stated that both rounded gravels and sands occur on the lower part of Quartz Creek and in a terrace along the west bank of Kougarok River, and that these are believed to be of about the same age as the white gravels described above. They probably represent a somewhat later period of deposition, when the materials had become more waterworn by stream action and more or less sorting had taken place.
>
> "The explanation of the occurrence of the clay deposit underneath the Kuzitrin lowland proper is still more difficult. Perhaps an attempt to explain this deposit is useless when so few facts regarding it are available. If, as is probable, this clay bed is extensive underneath the Kuzitrin lowland, it is probably a deposit in deeper water, laid down at the same time as the

[1]Brooks, A. H., U. S. Geol. Survey Bull. 329, p. 305.

gravels described above. In other words, it is the result of sedimentation in the central part of the embayment along whose margin the gravels and sands of fluvial origin were laid down. This clay may, however, be a glacial mud, derived from the valley glaciers of the Bendeleben Mountains, which were the locus of an ice accumulation in recent time. Opposed to this genesis for the clays is the fact that the glaciation, which was confined to a very small area, occurred at a somewhat later period. One additional fact deserving mention is that the few borings made in these clays encountered several layers of vegetable matter which is in every way similar to the present tundra growth. This indicates that deposition in that part of the basin where the clay has been found has been interrupted by periods when the land stood above water long enough to permit a covering of vegetable growth."

It is to be remembered that the rivers and streams of the Kuzitrin valley show fine gravels from Bunker Hill up to and under the lavas on the upper Noxapaga and the north and south forks of the Kuzitrin River. These gravels gradually become finer as one advances upstream. They make up the lowland deposits about which very little is known, and will be discussed in a later paragraph. The many existing gravel buttes, which form the only elevations of the lowlands, show the presence of considerable water action which in turn must have caused considerable concentration.

On the south slope of Bunker Hill medium to coarse gravels are found occurring as isolated terraced benches up to an elevation of 400 feet or 200 feet above the Kuzitrin River level at that point. These gravels are distinctly water laid, however, they are none too well sorted and contain considerable sand. Gradually these benches become lower as the northwest fringe of the drainage area is followed

to the north from Bunker Hill, occurring mainly between elevations of 200 to 300 feet. Thence the gravels are modified by the lower Kougarok River, which is incised in them, and formad a level of low benches. The main gravel deposit of the Kuzitrin lowland is below 200 feet in elevation.

There are many problems concerning these gravel deposits and their deposition which remain unsolved; first, how they originated or from whence they were derived; second, how they were transported to their present location; third, what accounts for their difference in elevation that ranges from 400 to less than 200 feet, and their deposition as benches; and fourth, why do they occur only in a portion of the basin at the higher elevations and not in the other surrounding portions at the same elevations within the basin. Brooks[1] describes them as alternate layers of gravel with clay and vegetable matter, and mentions this as indicative of periods of interruption when the land stood above the water, permitting vegetable growth.

In considering the origin of these gravels, it is necessary to look to the gravels themselves for some clue. They are classified as medium to fine, containing sand and clay layers. Along the lower valley of Quartz Creek they are composed mainly of rounded pebbles of quartz, quartzite and other various rocks. Since most of the pebbles contained are rounded, they must have originated in running water of stream action. Had they originated from beach action, they would have a more ellipsoidal shape. Again, this basin may have been an arm of the sea, as mentioned by Brooks[2], one or several times. As an arm, it must have been a long narrow body of water and not subject to strong beach

[1]Brooks, A. H., U. S. Geol. Survey Bull. 626.
[2] " " " " " " " "

action. Although the contents of the gravel show more evidence of creek origin than beach origin, it is not reasonable to assume that these extensive gravels originated from the small drainage from the northwest and the Kougarok River. It is a logical conclusion to assume that a considerable part of the Kuzitrin Basin was filled to some extent by the incoming drainage and from the high Bendeleben Mountains or anticlinal uplift to the south. The upper portion of the basin was filled by the recent lava flow which is known to cover at least a part of the gravel deposits, as noted by Collier[1]. The gravels found under the lava are cemented by clay and considered as of Pleistocene age. The elevation of these gravels under the lava is about 400 feet, corresponding to some of the benches north of Bunker Hill in the Quartz Creek drainage. Above this point between the North Fork of the Kuzitrin and the East Fork of the Noxapaga gravels, ranging up to 600 feet in elevation, are shown by Moffit[2] to correspond to those of like elevation on the Arctic slope in the vicinity of the Serpentine River.

The basin of the Kuzitrin from its origin[3] to the period of planation, as mentioned by Brooks[4], was in the process of being filled by many agencies. The lower gravels would be considered the oldest in deposition. If the higher bench gravels are remnants of this deposition,

[1]Collier, A. J., U. S. Geol. Survey Prof. Paper No. 2.
[2]Moffit, F. H., U. S. Geol. Survey Bull. 247.
[3]Op. cit., Plate No. 3.
[4]Brooks, A. H., U. S. Geol. Survey Bull. 328.

they are in order of deposition the youngest. On the other hand, there is the possible explanation that these northern bench gravels have been pushed out by glaciation and deposited as outwash plain. Evidence of extensive glaciation shows in the Imuruk Basin west of Bunker Hill and within the valley of the Kruzgamepa River. Glaciers formed in and along the outer fringe of the high Bendeleben Range more extensively on the south side than the north side[1]. These glaciers may have pushed across the Kuzitrin valley or formed within the basin a solid ice sheet which moved toward the northwest. In so moving the ice may have pushed a wall of the basin gravels ahead of it and deposited them as the various bench levels on the northwest fringe of the basin. A rapid melting of the ice would account for these gravel ridges partly sorted and left as isolated deposits at elevations above the valley floor. The post Pleistocene drainage may have removed most of the glacial evidence within the valley.

There is definite evidence that the Imuruk Basin and the valley of the Kruzgamepa River contained a considerable amount of ice part of which formed on the south sides of the Bendeleben and Kigluaik mountains, moved north and around the east end of the Kigluaik Mountains, and deposited its load within the Imuruk Basin. The present day evidence shows that an ice cap of considerable extent formed around the higher elevations of the Bendeleben Range. Weather conditions and prevailing south-southeast winds deposited the greater amount on the south slopes.

[1]Op. cit., Plate No. 4.

Glaciation of a more modified extent formed on the north slopes. These north slopes were more or less modified by erosion and instead of large moving alpine glaciers a modified sheet of little or slow movement was formed in the valley. In moving slowly over these medium gravels of the existing basin little erosive action occurred. The slopes of the basin were low and the glacial force was reduced to a minimum, which caused little destructive action and left only slight evidence. This glacial condition would account for many of the problems mentioned previously, such as the existence of the high bench deposits, the clay strata contained in the gravels, their transportation to their present positions, and their existence on the north fringe of the valley at high elevations and not on the south. However, there is considerable evidence lacking regarding the glacial origin for the high gravel bench deposits.

In the future, if such a condition proves to be the origin of these bench deposits, one would not expect to find concentrated placer deposits within the gravels. Gold concentration may have occurred prior to the deposition of these gravels on bedrock from local conditions and would still be intact. The ice sheet would have acted much like a modern bulldozer in pushing ahead only the top gravels of the basin and depositing them in their present positions. These top gravels would not have contained the gold concentrations. The removal of these surface gravel deposits would in reality make for higher grade deposits of the gold deposited below near bedrock of the lowland gravel plain.

The most logical origin of the bench deposits and the present condition found within the Kuzitrin lowlands is that of the action of erosion of one structural basin draining into another as mentioned in the section on geology[1]. This basin was more or less bounded by structural basins of low north and south anticlines on the east and west. The north and south structures between the Kougarok and American rivers bound it on the west and the structural ridge between the Kugruk and Kiwalik rivers on the east. Gradually this basin became filled with lacustrine deposits from Tertiary time up to and until the basin was filled to a level of 400 feet or more above the present sea level. The source of the material was mainly from the high Bendeleben Range on the south. Glaciation during the latter stages of this deposition may have been a contributing factor to a more or less extent. The extensive lava flows acted as an additional filling of this basin and also the existing drainage channels away from the basin on the eastern and central portions. A large lake formed on the western portion of the basin which gradually cut a new outlet in the vicinity of Bunker Hill. This new outlet lowered the basin with great rapidity to and approaching the lower level of the Imuruk Basin to the west. This is the impression gained by observing the basin at a high altitude. Aerial photography, which is recommended for the area within this report, would convey these impressions and aid greatly in the solution of these geological problems.

[1]Op. cit., pp. 16-17.

This sudden outlet of the existing lake, possibly accelerated by an abundance of melting glacial ice, removed the greater portion of the deposits within the valley basin with the bench deposits along the northern fringe being left intact as remnants due to their positions around the edges.

In conclusion, it may be said that the bench gravel deposits found on the north and northwest fringe of the Kuzitrin Basin are not considered as promising deposits for gold placers, with the exception of small delta deposits formed at or near the mouths of the present producing creeks. The greater portion of the gold, which originated off the main Bendeleben Range, is confined either to the bedrock basin of the Kuzitrin lowland, the central upland province within the structural valleys, or deposited on the coastal plain.

Kuzitrin Lowland:

The Kuzitrin lowland comprises an area approximately 20 miles by 10 miles, which extends from the lava beds on the east to Bunker Hill on the west, in the central southern section of the area, (see Plate No. 4). Its north and south boundaries comprise the tableland between the Kougarok and Noxapaga rivers on the north, and the northern slopes of the Bendeleben Mountains on the south. This area on Plate No. 3 falls within those sections of the entire area that is marked as worthy of investigation for placer deposits. Since very little is known regarding this lowland basin, and only a few of the surrounding creeks have been prospected,

one has to look back over its geologic history and surrounding environment to form an opinion regarding its possibilities. Further study, with actual prospecting and considerable more field evidence, is necessary before any definite recommendations can be made with regard to a favorable or unfavorable placer area. It is, as pointed out under the section on geology, one of those structural valleys formed by folding that has since been the basin which has received the greater portion of the eroded material from the north slopes of the Bendeleben Mountains, as indicated under the section entitled "Gold Associated with Granitic Intrusives." There is sufficient evidence to assume that considerable gold must have originated from the influence of these intrusives with their accompanying metalliferous solutions. It is within the logical bounds of assumption that the greater amount of this gold may still be retained within the confines of this basin. The presence of the extensive lava flows, which disrupted the northern and eastern drainage from the basin, leaves one in doubt as to whether or not this older drainage system has removed the greater portion of the gold from the valley. If the greater portion of the gold was not removed, it is still confined to the valley floor in the older gravels, of which more than half must be intact under the lava flows. Too little is known regarding the gravels and deposition under the lavas to consider their investigation at the present time.

Portions of placer areas in other parts of the world have been covered with lavas and in mining have produced considerable wealth in gold. In Ballarat[1], West Australia, the auriferous series is covered with about 400 feet of basalt, clay and drift. The four flows of basalt aggregate 330 feet and are separated by clay and detritus. Between the folded beds and the lower basalt is a blanket of "wash dirt with rich gold gravels." These flows are given as of Pliocene age.

In California[2] some placer gravels were covered with lavas in Tertiary time and the production of these lava buried gravels amounts to about $300,000,000.

Further investigation of the Kuzitrin Basin and the areas surrounding the lava field may reveal sufficient data to determine further recommendations.

The gravel plain deposits have been described by Brooks[3] under the heading geology.

Collier[4] describes this lowland as follows:

> "This is an area of lowland covering approximately 200 square miles on the north side of the Bendeleben Mountains and drained by the Kuzitrin River. The lowland is tundra covered, and underlain by silts, sand, and gravels, probably of no great depth. It is dotted over with many small lakes, probably formed by oxbows of the meandering creeks and rivers. Around the lowland area on the west, north, and east sides there is a higher gravel plain, from 50 to 150 feet above the lowland. A well-marked escarpment usually separates this upper plain from the lowland. On the lowland surface, away from the margins, there are occasional gravel buttes, 50 feet or more in height, which at a distance resemble haystacks. These are regarded as remnants of the upper plain which have been left by erosion. At the edge of the upper plain transition phases between the plateau and the isolated buttes were noted in a few instances."

[illegible], W. H., Gold Deposits of [illegible]
2 " " " "
3Brooks, A. H., U. S. Geol. Survey Bull. 328, pp. 90-92.
4Collier, A. J., U. S. Geol. Survey Prof. Paper No. 2, p. 26.

The occurrence of these isolated gravel buttes are remnants which indicates that the basin had been filled to a much higher elevation with gravels and then was eroded rapidly. Two factors, which are both undetermined and on which much depends regarding future mining, are: First, what is the present depth of the gravels covering the Kuzitrin lowland and the depth to which they are frozen? Second, what is the gold content, and its position with respect to bedrock?

In order that dredges may operate in a valley of this size, the gravels will have to be within the range of dredging depths and contain sufficient values to produce a profit. Should the gold content be near bedrock and below the range of dredging and in frozen material but in sufficient amounts, then mining by shafts and drifts could easily be carried on under proper mining conditions.

In the formation of commercial placers, most deposits have been formed by one or several agencies of concentration. Two types are residual and alluvial deposits. Other deposits may be concentrated by the many agencies over a long period of time. Thus the question arises regarding the concentration agencies and the extent to which they acted within the Kuzitrin Basin.

Brooks[1] has shown the possibility of considerable gold having originated from the contacts and favorable slate mineralization which extend east-west along this structural valley. This bedrock mineralization may have contributed some to the gold content within the basin. The

[1]Brooks, A. H., U. S. Geol. Survey Bull. 328.

contribution of the small streams and rivers, which are known to contain gold on the northern and northwestern side, has added to this amount. The writer[1] further suggests the possibility of the gold content of the great amount of material worn from the Bendeleben Mountains as having been more or less concentrated and possibly still retained within the basin. The question then arises as to the amount of concentration.

During the very first steps of erosion from higher to lower elevations, as the different particles break from their original consolidated positions, the process of gravitation acts, gradually settling the heavy particles below the lighter. In movement down the slopes, the lighter materials on top move with greater speeds than the heavier particles beneath. Other agencies of erosion, such as water, snow, ice, etc., join in moving the particles further on their courses. As the particles come to rest within a basin the lighter material is above with the heavier below. The basin gradually fills and overflows, starting with the lighter materials on top. As the drainage system lowers within the valley or basin and the water supply becomes more abundant, the deposits of the valley begin to move into the next lower basin; the rate and amount of material removed depending upon the amount of water, height of fall, and tailing room for the material below. Under some conditions the entire amount of material may be removed to the basin below. These conditions usually are steep gradients and a considerable amount of action from the agencies.

[1]Op. cit., p. 30 on "Gold Associated with Intrusives and Extrusives."

In considering this Kuzitrin Basin prior to lava flows and glaciation in the vicinities of the Bendeleben Range, the drainage from the area to the north and east was developed to a considerable extent. The amount of the gold content that was removed along with the gravels cannot be estimated. Undoubtedly, the valley must have still contained extensive gravels from considerable stream concentration at the time the lava flow occurred. Thus, if the gold had concentrated in the lower gravels, it would be beyond doubt intact under the lavas, and it would be in the lower portion of the gravels of the Kuzitrin Basin.

In considering the present creeks which flow from the Bendeleben Mountains into the Kuzitrin Basin, one would not expect to find gold concentrations of any extent along them except within the delta deposits on the valley floor. Collier[1] arrives at this conclusion, but he also mentions some sluicing on Birch Creek:

> "Southern tributaries of the Kuzitrin - The creeks flowing into the Kuzitrin from the south side have not produced gold in commercial quantities; however, the writer was informed by a prospector that on Birch Creek some sluicing has been done. The pay gravel consisted mainly of decomposed granite, and the bed rock was also granite. The gold is probably derived from the rocks of the Kigluaik series. The mountains of the Bendeleben group are less rugged than the Kigluaik Mountains, and there has been little, if any, glacial erosion in them. If gold occurs in these rocks it is more likely to be concentrated in the gravels of the Bendeleben Range than in those of the Kigluaik Mountains."

The transitional zone between the high elevations of the range and the lowlands, as represented in the past by an area of steep slopes, is now reduced by erosion to gentle slopes. As shown in paragraphs on

[1]Collier, A. J., U. S. Geol. Survey Prof. Paper No. 2, p. 68.

"Gold Associated with Granitic Intrusives,"[1] some gold was deposited at medium low temperatures surrounding the intrusives and also with some deposition from later spring action within the granite along joints, etc. The present surface of the granite of the Bendeleben Range represents the pegmatite or a higher temperature mineralization stage, giving evidence of considerable material as having been worn away to expose this high temperature phase. Most of the gold was eroded from the lower temperature deposits and migrated down the slopes. One would not ordinarily expect to find gold within the confines of the high temperature granites. The only deposition which does occur within the high temperature portions of intrusives of this type is from the later hydrothermal solutions from greater depths below which flowed through the upper zone of crystallization and deposited some gold. This may explain the presence of the gold on granite bedrock and in granite sands. Such spring action is still in evidence along the outer fringe of this range--considerable evidence of prior existing springs may be noted in the Fish River[2] valley on the south slopes. Thus, the lower gravels of the Kuzitrin valley would no doubt compare with the lower gravels under the lava covered area. Since they are all contained within the same basin in the same position with regard to the mountain range on the south, and subject to the same agencies, the gold concentration under each should be similar.

[1] Op. cit., p. 25 et seq. on "Gold Associated with Intrusives and Extrusives."
[2] Op. cit., p. 9 et seq. on "Geography and Geology."

If, as the writer believes it to be, this history of the bench gravels on the north fringe of the basin as existing remnants of a much deeper gravel deposition than now exists is the correct interpretation, a natural concentration of the valley floor gravels should have taken place. The total depth of the gravels, which existed above the present bedrock, would be the vertical distance between the present elevation points of 400 feet to the present gravel surface level at 200 feet plus the total depth from the present surface to bedrock. The common belief in regard to these gravels is that they are not deep. If the present gravels should average 50 feet, the total depth would have been 250 feet. With the 200 feet of gravel removed from the top a natural concentration into 50 feet has taken place providing the gold had been deposited originally on or near bedrock. There must have been considerable concentration during the deposition of the gravels and the filling of the basin prior to this last removal of the upper gravels.

Since this Kuzitrin Basin compares to the lava covered area with respect to the lower gravels, it is considered as the most logical for prospecting and investigation, since the gravels are not capped with lavas. Should this section contain economic deposits, then they will lead to discoveries under the lava covered areas.

Imuruk Lake Area:

The Imuruk Lake area is that section about 30 miles square that surrounds Imuruk Lake, the greater portion of which has been covered with recent lava flows, and with arms of lava extending from the main mass and occupying the older drainage channels. These older lava filled channels represent the older drainage system from possibly Tertiary to Pliocene or Pleistocene times[1]. This drainage was developed from a basin which is considered geologically favorable for the concentration of gold placer deposits[2]. The lavas definitely cover the lower portions of the gravels and over one-half the total area of this long structural basin. Since the lavas are classed as Pliocene or Pleistocene, the underlying gravels are Pliocene or older in age. Thus it is within the bounds of assumption that the lower strata of gravels of the western half of the same structural basin, which is not covered with lavas, is of the same age.

P. S. Smith[3] gives a short description of the lava area and suggests their possible economic value:

> "Throughout Seward Peninsula are many small areas in which Tertiary to Recent volcanic rocks have been reported, and in the vicinity of Imuruk Lake, in the north-central part of the peninsula, an area of considerably more than 1,000 square miles is covered by these rocks. So recent are some of these lavas that the ropy surface of the original flow is still preserved, and in places they have flowed out over gravel of late Tertiary or Pleistocene age. * * * * *
>
> "In those places the lavas are old, though from such evidence as is available they are not so old that they antedate the Tertiary.

[1]Moffit, F. H., U. S. Geol. Survey Bull. 247, p. 34.
[2]Op. cit., p. 9 et seq. on "Geography and Geology."
[illegible], P. S., [illegible]

Furthermore, some of the gravel deposits over which the younger lavas flowed contain pebbles derived from earlier lavas. These flows must have had very significant effects on the drainage lines of the region by filling up some of the stream channels and causing the streams to take up new courses elsewhere. As many of the old stream courses elsewhere were the sites of placer concentration, the determination of the location of those that have been buried under the lava might have considerable economic value and well repay a search to discover them."

The writer had the privilege of flying over this lava area several times and to examine on foot the outer edges in several places. It is not within the confines of this section to describe these lavas in detail. They have been described by both Collier[1] and Koffit[2], as well as in the section on Geology.[3] They represent an area of recent emission into the structural basin, apparently from large fissures. They are described as mainly blocky and ropy types emitted on the surface and covering a large area. They are believed to cover the greater portion of the structural valley which previously was partly filled with gravels believed to be auriferous. The thickness of the lavas over the gravels is believed to be comparatively thin.

Iddings[4] gives the following on lava emissions of this nature:

"Liquid magmas when poured out from large fissures flood the surrounding country with a broad sheet of lava, like the waters of a lake, often very wide and comparatively thin."

A section 20 miles long was examined on foot along the southern border of this lava field. Here unconsolidated soda and biotite granite sands eroded from the numerous granites of the Bendeleben Range occupy

[1]Collier, A. J., U. S. Geol. Survey Prof. Paper No. 2, pp. 30-31
[2]Moffit, F. H., U. S. Geol. Survey Bull. 247, pp. 31-32
[3]Op. cit., p. 9 et seq. on "Geography and Geology."
[4]Iddings, J. P., Igneous Rocks, [illegible]

most of a long narrow belt along the outer border of the lavas. This long narrow belt, due to the pinkish color of the granite sands themselves plus considerable red iron oxide derived from the recent lavas, appears as a highly mineralized belt. Many pilots and prospectors who have observed this zone from the air are very desirous of learning as to whether or not it is favorable area in which to prospect for gold. From the air this zone looks very inviting to the average Alaskan placer prospector, due to the fact that several productive placer areas are in vicinities which show these same kinds of granite sands, however, geological evidence in this instance shows that the sand belt itself is unfavorable.

The largest accumulation of granite sands is in the vicinity of Bendeleben Lake. This lake is at the head of the south Fork of the Kuzitrin River near the low divide between the Kuzitrin and Koyuk river drainage systems. The shores of this lake are made up of granitic sands and large rounded granitic boulders. Due east of the lake a large flat area consisting of granite sands, several hundred acres in extent, fills the basin between the lava contact on the north and the northern slopes of the Bendeleben Range. Most of the creeks which drain from the slopes of this range carry granite sands, granitic rocks, and hardened sedimentary rocks. The hardening of the sedimentaries was caused by contact metamorphism in close proximity to the granite. The sands were panned in various localities in the vicinities of Bendeleben

Lake, and upper tributaries of the South Fork of the Kuzitrin and Koyuk rivers. In a few localities fine colors of gold were obtained, but the amount did not warrant further investigation. However, there may be small buried remnants of delta deposits near bedrock that may warrant further testing. Geologically, the sand belt is not favorable for two reasons:

First, the sand belt marks the zone of transition of the materials worn from the high Bendeleben Mountains to the low structural valley now covered with lavas. Gold worn from the disintegrated bedrock would have migrated down into the valley and possibly further along the older drainage.

Second, the erosion of the Bendeleben Range has proceeded below the zone of mineralization and gold precipitation and the recent eroded sands and rocks are devoid of gold content to any commercial extent.[1]

The granite sands are eroded from the massive granite with great rapidity in regard to geologic time. Granite of this type[2] disintegrates into sand more readily than other kinds. In various places the sands have covered the lava contact and rest on top of and are mixed with the upper surface blocks of the recently broken lavas. In the investigation of a lava covered area of this type it will be necessary to follow pay gravels down the old drainage channels and then

[1]Op. cit., p. 25 et seq. on "Gold Associated with Intrusives and Extrusives."
[2]Op. cit., p. 25 et seq. " " " " " " "

under the lava. The conditions, which exist at the present time in regard to mining and the existence of known pay, are such that considerable exploration is needed in the fields around the lava beds and near the borders of the leva to determine the buried channels and their economic possibilities.

The nearest approach to mining under the lavas has been a few attempts with tunnels and shafts under the high lava rims along the Inmachuk River. The Inmachuk Sub-lava Mining Company has in the past spent over $150,000 in sinking ten shafts with considerable drifting in search of an old high channel. The operation has not been successful. The best values, found in the various shafts, were nearest the rim and they represent a small portion of a high bench concentration which is comparatively low in values as compared to the present river bed below, where mining has been carried on for many years. This creek mining has been mostly successful and new developments have good promise for the future[1]. The unsuccessful attempt of this one company does not condemn the entire lava section. In fact it would be the lower channels and lower benches which lead up under the lavas which are most apt to contain the best pay. The guiding factor when following the gold to the lava rims will be its black coating on the outside, which it obtained from the highly acid and black solutions from the hot lava[2].

[1] See description of Inmachuk area on following pages.
[2] " " " " " " " "

The lavas have not been accurately mapped along the Pinnell River of the upper Inmachuk. There appears from the air to be more lava in this section than shown on Plate 4. This section offers one approach toward the lava area. The Goodhope River area contains considerable lava at its head and represents one of the drainage channels along which the lava streams flowed. Upper Wade Creek and the Kugruk River offer other channels that approach the area. The Koyuk River from Big Bar Creek up to and under the lavas offers one of the best areas for investigation. This section is the most isolated and it lacks transportation. The prospects and geological conditions of this upper Koyuk have been mentioned under geology[1].

The Kuzitrin basin has been discussed in preceding paragraphs. Should the under gravels prove of economic importance and active mining takes place, it is assumed that this section will lead the way for mining under the lava, as this section is the most logical one from which to attack the area.

At the present time one may consider this area as being very remote in ragard to possibilities. However, with the increased use of machinery and the increasing demand for placer fields, this area may be investigated sooner than present conditions indicate. Much depends upon the progress of the industry itself in the face of world conditions.

[1]Op. cit., p. 9 et seq. on "Geography and Geology."

This area contains one of the largest potential hydroelectric development sites on Seward Peninsula. Imuruk Lake at an elevation of 960 feet makes it a potential source of hydraulic water for power and mining operations. The undeveloped water resources are described in the section of this report describing hydroelectric power sites.

Inmachuk River Drainage Area:

The Inmachuk River is located in the central northern part of the area and drains an area of approximately 600 square miles (see Plate No. 4). It has a length of nearly 30 miles and heads to the west on the slopes of an anticlinal structure of limestones and schists which form the drainage divide with the Goodhope and Cripple river drainages. The lower 20 miles and its longest tributary, Pinnell River, follow the structural valley between the anticlinal structure on the west and the divide with the Kugruk River on the east. The upper drainage has been disrupted with lava flows upon which new local drainage has developed that is somewhat different than the older pre-lava drainage. The lower section of the new drainage has worn through the lava masses and it now conforms with the older drainage system and with high rims of lava. The old drainage system also contained the former lava channels. It is in these older channels occupied by the new drainage that most of the mining has been done. The most valuable section of the Inmachuk River to date is that section from the mouth of Pinnell River to the point where it fans out on the low extensive coastal plain. An old channel

near the present creek channel has been traced over this distance on the left limit of the Inmachuk. Other creeks of note in past operations have been Hannum, Old Glory and American.

It is held by many of the old miners and prospectors of this section that an old channel exists above the junction of the Inmachuk and Pinnell rivers. If such a channel exists, and there is sufficient evidence to suspect that it does, mining or exploration has not to date discovered its exact location. It is possible that this channel is within the structural valley and continues south up to and under the lava field and some of the gold found on the lower Inmachuk may have had its source from the basin, now occupied by the lava flows, but originally from the Bendeleben intrusives. There is also considerable evidence to show that the origin of portions of the gold of the Inmachuk was derived from the anticlinal structure to the west, which is underlain with older granitic intrusives plus the younger intrusives, of which two are represented by the Asses Ears and the granite between American and Old Glory creeks[1]. It is in view of the evidence of the mineralization which shows in quartz stringers and hydrothermal association minerals that the granites are classified as to older or younger.

In considering the placer possibilities of an area there are three important steps within its history that have to be taken into consideration: First, there must be a source of gold, either from one or more periods of

[1]Op. cit. p. 25 et seq., "Gold Associated with Intrusives and Extrusives."

mineralization; second, there must be a major concentration to produce economic placer deposits; and third, the agencies which have affected the deposits after concentration must be known--is the gold where it was concentrated or have portions been removed, or reconcentrated, or covered?

The Inmachuk area, with the amount of mining that has been done, offers a wealth of material for a study of the entire district which may lead to the solution of the various problems mentioned in this report.[1]

The gold contained within Inmachuk basin may be considered to have been derived from three sources:

First, the hydrothermal product from the older granite, which is by evidence under the anticlinal structure on the west. The association of cassiterite and galena on Hannum and Old Glory creeks points to a mineral association of the older type of granite[2]. A small amount of gold is believed to have been associated with this earlier type of granite.

Second, the greater amount of gold is associated with the hydrothermal action from the younger granites. This section contains two small stocks of the younger granite represented by the Asses Ears and the granite between American and Old Glory creeks. There may be others, in which the hydrothermal action penetrated sufficiently to contribute to the amount of gold, which are not exposed on the surface.

[1]See section on mining problems in this report.
[2]Op. cit. p. 25 et seq., "Gold Associated with Intrusives and Extrusives."

Third, a possible source of some of the gold is from the structural valley which received its gold from the numerous Bendeleben granitic intrusives.

The second condition for placer concentration is in evidence to the extent that the older drainage in this structural valley was developed prior to the lava flows on a much larger scale than the present drainage. The present river channel of the Inmachuk below Pinnell River is contained within a partly filled lava valley which was made by a river of greater size. This older and larger drainage no doubt had its source within the structural basin now covered with lava. The Pinnell River is a comparatively small, and from its very nature comparatively young river, which occupies a broad valley. Since this river does not occupy a position directly above the older channels, its own creek bed is not particularly favorable for placer deposits. It is one of those rivers with all its tributaries on one limit superimposed upon a wide partly filled valley where, rather than cut a channel, it has flowed over the valley and finally began to cut its east bank in which position it remains today. However, within the structural valley older drainage channels are known to exist and may contain gold to the extent of commercial importance.

The lower Inmachuk River below Mystic Creek has meandered over an extensive delta deposit of gravels which comprise a portion of the coastal plain. This extensive delta deposit appears to have been built

up by a river much larger than the Inmachuk. The origin of the extensive gravel deposits along the coastal plain has not been explained. The surface gravels are of creek and river origin, modified along the shores by wave action. Drill cores and pits to show the depths of these coastal gravels are lacking. The gold content is also unknown. Small amounts of gold have been found along the present beach lines, but not in economic quantities. The lower portion of these gravels have not been tested. As shown under geology[1], heavily concentrated beach deposits are not to be expected. The gold deposits, if they exist, would occur as very extensive low grade delta deposits slightly modified by beach action. Small basins near the present coast or under 200 feet in elevation may contain a concentration as found in the valley of the Kugruk River[2].

The third factor, regarding the agencies since the major concentration, has been the extensive lava flows which disrupted the drainage. The present river below Pinnell River has caused a slight reconcentration of the older concentration. Mainly, the upper old drainage is capped with lava with the central portion of the drainage more or less filled with lava and sediment. Due to lack of water, the new drainage has not cut down into the older drainage channels. The Inmachuk River below Pinnell conforms to the older drainage, and due to the convergence of the many tributaries, it has formed the present gold concentrations.

[1]Op. cit., p. 9 et seq.
[2]See description of the Kugruk River area in following pages.

In considering the gold content of the delta deposit at the mouth, it is safe to assume that since the river for several miles above contains gold, a part or at least some of the lighter gold must be contained in the delta deposit. Factors, which point toward a gold content in the delta deposit, are the rough, coarse and heavy nature of the gold found on the Inmachuk above. With all rough heavy placer gold there is usually associated a proportion of light rough gold. This lighter gold could have been deposited in the lower extremities of the river.

Moffit[1] gives a description of the gold mined and its associated minerals:

> "Gold from the Inmachuk district is dark and heavy, assaying about $18[2] to the ounce; almost no black sand is present, but considerable gray sand or pyrite is seen in the pan and the boxes always contain a large quantity of rounded hematite pebbles which the miners call "ironstones." The gold frequently contains a little quartz and is sometimes seen in the form of fine veinlets in the ironstones. Small pieces of rutile are occasionally found with the heavy concentrates and have been mistaken for cassiterite. Dr. Cabell Whitehead, of the Alaska Banking and Safe Deposit Company, has informed the writer that about 27 ounces of tin were recovered in cleaning gold brought to Nome from Old Glory Creek, so that the tin ore, cassiterite, must be present on that stream. On the upper part of Hannum Creek, a small quantity of galena is associated with the gold and ironstones. Much of the gold from the Inmachuk and its tributaries is coarse and rough. Pieces of the value of $2 or $3 are not uncommon, but no large nuggets have been found."

There has been a greater amount of mining on the Inmachuk than on any other river or stream in this area. If mining and exploration follow up the river, it may lead to the discovery of the older channels which may lead under the lavas. As it continues downstream it may lead to the exploration of the delta deposits at its mouth.

[1]Moffit, F. H., The Kotzebue Placer-gold Field of Seward Peninsula, Alaska, U. S. Geol. Survey Bull. [illegible], p. [illegible].
[2]On basis of $20 per ounce in 1906.

Gold was first discovered in this section on Old Glory Creek in the fall of 1900. This led to lower discoveries on the lower Inmachuk and the other tributaries such as Hannum, Perry, Pinnell, American and other creeks. Some mining was done in the early years following discovery, but dué to the erratic pay, low grades, and the presence of numerous lava boulders and blocks, mining was carried on under difficulty. Many of the operations on the Inmachuk have not been successful, while some others have continued. The present day operations are in a much better position than at any time in the past.

The Dry Creek Dredging Company has under lease 50 claims consisting of 1500 acres along the Inmachuk, mostly below Pinnell River. This year marks the first year of operation on the river for this company. A 3½-cubic foot Flume dredge has been rebuilt and put into operation this season with encouraging results reported. The greater portion of the creek bottom has been mined in earlier operations, but the older channel on the left limit was discovered by considerable drilling. This old channel promises even greater returns than the creek mining. This company is one of the few on Seward Peninsula that has sufficient proven ground ahead and which has a management experienced in checking costs against the values in the ground.

The Inmachuk River, due to its large valley basin and high rims, lack of tributaries, and low grade, offers no opportunity for a large source of hydraulic water. This is one of the chief reasons for

the expensive mining and also the cause of many mining failures in the early days. Dredging eliminates the need of hydraulic water; however, for thawing of the frozen gravels, with the black muck strata on top, hydraulic water could still be used to advantage. As a solution for water in the early days the Fairhaven Ditch was built at an enormous cost. This ditch starts from a dam at the outlet of Imuruk Lake and consists of three sections with a total length of 36½ miles[1]. This ditch has been used intermittently up to and until three years ago, but it was not possible to utilize this ditch alone for hydraulic water for thawing at the present rate of capacity. The company pumps water with diesel power for 600 points.

The gravels on the Inmachuk are medium to coarse and mainly deposited on a fractured limestone and schist bedrock. The gravels vary from 8 to 12 feet in thickness and are covered with 5 to 8 feet of black muck, most of which is permanently frozen with tundra overburden. Thawing costs are estimated at 10 cents per yard with dredging costs less than 30 cents per yard. The values of the proven ground on the Inmachuk are not known. The mining in the past had uncovered some very high values in localized areas. Drift mining along the creek in the early days was very profitable. The production to 1908 with a short description of a section of the Inmachuk River is given by F. F. Henshaw[2].

[1]U. S. Geol. Survey Water Sup. Paper 314, p. 235 and Bull. 379, pp. 357-361.
[2]Henshaw, F. F., Mineral Resources of Alaska, 1908, U. S. Geol. Survey Bull. 379, p. 357.

"The 7 miles of Inmachuk River below the mouth of the Pinnell have contributed a large share of the production in this basin, the total amount to date, as nearly as can be learned, being from $400,000 to $500,000, nearly all of which has been taken out by winter drifting. The gravel flat in this part of the river is from 800 to 1,200 feet wide and the depth to bed rock varies from 15 to 30 feet outside of the river channel. The greatest depth, 25 to 30 feet, is in the upper portion, on claim "No. 1 below Pinnell;" below the mouth of Washington Creek the ground is shallowest, being 12 to 15 feet deep. The channel thaws to bed rock in summer and as the gravel is mostly fine and loose, being called by miners "chicken feed", there is a large underflow of water which has hindered open-cut work of any kind. In the winter the river is filled with the ice formed by the overflow of the water from the springs, and under these conditions the ground has been drifted, the ice being used as a roof. In some places enough light came through this cover to make candles unnecessary.

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

F-11-151 The Forsgren Dredging Company owns and has under lease 33 claims on the Inmachuk River below the Dry Creek Dredging Company. This company is operating a 2-cubic foot Flume dredge and a dragline. The dredge is used along the creek and the dragline is working ground contained in the old channel on the left limit. The gravels range from 7 to 9 feet, and are covered with 6 to 8 feet of muck and tundra. This company prior to this year operated the old Flume dredge only. This year they have new pumping and bulldozing equipment. The dragline was formerly used to strip ground for dredging. It is now used to mine by elevating gravels from the old channel into elevated boxes. With a better and more efficient dredge this company could expand into the lower delta gravels.

K-41-41 Dick Hoogendorn is operating a hydraulic and scraper on the Inmachuk 2 miles above the mouth of Pinnell River. This is a bench deposit in which the gold is mixed with small amounts of gravel, lava rocks, and boulders. The deposit has the appearance of having been carried or sloughed from some other type or channel deposit.

Mining on Old Glory, Hannum and other upper tributaries has been intermittent and confined to small hydraulic operations. The gold and gravels are spotty and contain slide material. Due to the existing conditions on these creeks, a search for old channels is warranted. These creeks were not visited by the writer, but were seen from the air at a low altitude. They contain narrow canyons which open out into wide areas or small basins.

Moffit[1] describes these creeks:

> "Inmachuk River - Old Glory, on which the original discovery of gold in this region was made, is a short creek about 6 miles in length, rising in the limestone area north of the Asses Ears and joining Pinnell River 1¼ miles above its junction with the Inmachuk. The valley of Old Glory is cut in a series of schists with occasional interbedded limestones; it is broader than that of Hannum Creek, and is covered with a sheet of wash gravel, largely quartz, which extends well up on the slopes. Near the bottom of the valley the gravels have been much disturbed by the sliding of rock, gravel, and tundra from the sides. These gravels differ further from those above in the much larger amount of schist which they contain and the decrease in rounded quartz pebbles. No pay streak is known, the creek being "spotted," as is Hannum Creek."

[1]Moffit, F. H., U. S. Geol. Survey Bull. 225, p. 77.

"Inmachuk River - Hannum Creek, which flows into the Inmachuk above the mouth of the Pinnell, has produced a small amount of gold during the last two years. This stream flows through a narrow canyon-like valley surrounded by a rim of lava and sheeted over with gravels, consisting mainly of schist with smaller amounts of quartz, limestone, and lava, which appear in places as broad tundra-covered flats one-fourth to one-half mile long.

"The gold is irregularly distributed along the bed rock of the channel, or "spotted," as the prospectors say; with it is associated some pyrite and a very small amount of galena."

The old channels in this Pinnell drainage if found may offer the prospector a potential area where his efforts may be worth while. Very little prospecting has been done since the early days and this is described by F. F. Henshaw[1]:

"Some prospecting has been carried on for several years under the lava rims which are such noticeable features in the topography of the lower Pinnell and Inmachuk valleys, and many interesting facts have been brought to light. Two old channels have been located on both sides of Perry Creek near its junction with Pinnell River. The lower channel is at least 200 feet in elevation above the river, and the upper channel is 52 feet higher. In the lower channel there is 3 to 9 feet of gravel covered with about 20 feet of muck, and this is overlain with lava except where the lava has been eroded away. There is no muck overlying the upper channel, and the lava and gravel are mixed, a fact which seems to show that this channel was later than the lower one and was occupied by the stream at the time of the extrusion of the lava sheet. Pieces of wood were found on top of the gravels of the lower channel. A log 3 feet in diameter is said to have been encountered in one hole, but its relation to other deposits was not learned. The old channel can be traced down the Pinnell following the left of its valley to its mouth. It then crosses the Inmachuk to its left or north side and extends for 3 or 4 miles to a point above the Homestake group of claims, where it crosses again to the right. It was not learned whether more than one channel had been located in this portion of the valley. Fair prospects were found under the lava at the mouth of Perry Creek and also just below the upper crossing of the Inmachuk and nearly opposite the mouth of Pinnell River."

[1] Henshaw, F. F., U. S. Geol. Survey [illegible]

It must be remembered that these channels, which were found and slightly prospected, did not offer much to the prospector at that time. Lack of machinery, mainly pumping equipment, and lack of water discouraged the greater number of prospectors from working deposits of this type. Another condition, which is of interest to the prospector, is that only a very few creek claims are held and the discovery of these channels in the past may be of importance in the future. Most of the area on this upper drainage is open ground at the present time.

Goodhope River Drainage Area:

The Goodhope River has its source at the junction of Cottonwood Creek and Right Fork. These creeks drain the northwest portion of the lava plain and in their lower sections have cut through the lava beds into the limestones and schists below. From their junction the Goodhope River flows west, thence it is joined by Esperanza and Placer creeks, thence flows northwest to where it is joined by Humbolt Creek, and thence flows for 10 miles in a northeasterly direction into Goodhope Bay. Its drainage area is contained in the northern central part of the area, see Plate 4. This drainage occupies the wide structural basin between the anticlinal structure to the east of the Kougarok River and the anticlinal dome structure to the west of the Inmachuk. This drainage appears to have been much larger and developed to a greater extent prior to the lava flows than at the present time. A wide flow of comparatively thin lava followed down this older drainage basin. Therefore, it is

a new drainage superimposed upon older drainage, similar in aspect to the Inmachuk drainage basin. Since this older drainage is of the same age as the Inmachuk and Kugruk rivers, and likewise originated in the structural basins to the north of the Bendeleben Range, it is considered as a possible potential placer area.

At the present time there is only one mining operation within the basin, and due to the isolation and lack of airplane fields, the area was not visited. The following information is taken from U. S. G. S. bulletins as listed, reports of prospectors, and from a general view from the air. This basin is described by Fred F. Henshaw[1]:

> "Goodhope River is formed by the junction of Right Fork and Cottonwood Creek and flows in a general northwesterly course to Goodhope Bay. Right Fork, the true source of the river, rises in the lava near Imuruk Lake, the source of Kugruk River, and flows through most of its course in a rather narrow canyon, in places 600 feet deep. There are springs in the lava which contribute a large portion of the low-water flow of the river. Cottonwood and Eagle creeks enter from the east and Esperanza, Placer, and Humboldt creeks from the west and south. The larger portions of the basins of these tributaries lie outside the area of lava.
>
> "Esperanza Creek is the only tributary on which any systematic mining has been done. Gold in paying quantity was discovered in 1908 and the creek was worked in 1909 as far as the scanty supply of water permitted."

The area, comprising the central portion of the drainage, appears as a broad elevated tableland that lacks high uplifted dome areas except on its outer flanks. Intrusives are lacking, except those under the structures to the west of the Inmachuk and the Hot Springs granite area. This latter granitic area and Humbolt Creek, the longest

[1]Henshaw, F. F., U. S. Geol. Survey Bull. 442, pp. 399-400.

tributary of the Goodhope River, is described under Hot Springs area[1]. There may be small extrusive areas, like that of the Kougarok, within the drainage, from which there may have been hydrothermal deposition that has contributed some placer gold. The source of the gold in the drainage would be from the older drainage which led from the structural basin[2] north of the Bendeleben Mountains.

The only mining operation in this area, about which little is known, is a drift mine under lavas on Esperanza Creek by the Hoogendorn Bros. This mining may lead to a definite channel which leads up under the lava and which may be of considerable commercial extent.

The early mining of this section is described by F. F. Henshaw[3]:

> "Mining was confined to Esperanza Creek, where workable placers were first found in the spring of 1908. Esperanza Creek is a small stream which drains an area of about 20 square miles. It has a flat grade, especially in the lower portion, where the fall is only 5 to 7 feet to the claim, or about 25 feet to the mile. The stream has a narrow channel winding between muck banks and its general appearance is similar to that of Candle Creek. The pay streak, so far as developed, lies in a narrow, shallow strip in the creek bed. When the creek was visited, on June 24, preparations had been made to mine on six claims near the lower end of the creek. Ditches had been dug to convey water for sluicing and diversion dams had been put in. These ditches were for the most part about a claim in length and were built with very light grade, but even then they gave hardly enough head to raise the water into the sluice boxes. * * * * *
>
> "Placer Creek, a tributary of Goodhope River, below Esperanza Creek, was prospected by shafts during the winter, but no values were found. A hole was sunk about 6 miles above the mouth, through muck and angular material, to a depth of about 45 feet, where heavy lava bowlders were encountered.
>
> "Some prospecting was done on Humboldt Creek, which rises near the hot springs north of Taylor Creek and enters the Goodhope about 10 miles from its mouth. Values were found, but nothing rich enough to pay to shovel."

[1]Op. cit., p. 45 et seq. on Serpentine Springs Area.
[2]Op. cit., p. 37 et seq. on Formation of Placer Deposits.
[3]Henshaw, F. F., U. S. Geol. Survey Bull. [illegible], p. 377.

Thus, due to the low grades and the abundance of muck covering the gravels and the lava boulders, the area did not offer very favorable conditions for the early prospectors. It will be the information gained from future activities in the Inmachuk and Kugruk which will determine the possibilities of the Goodhope drainage. The area has not been adequately prospected, nor has there been sufficient mining to make any statement as to its possibilities. It remains, as does much of Seward Peninsula, an area to be proved as worthy or unworthy for placer deposition.

Upper Koyuk River Drainage:

The Koyuk River is situated in the southeastern section of the area under discussion and drains to the southeast into Norton Sound, note Plate 4. It heads on the southeastern portion of the Imuruk lava area and drains the eastern section of the large structural valley on the northern slopes of the Bendeleben Range. The upper 12 miles flows on top of the lavas and thence cuts through onto a wide and extensive gravel filled valley. The right limit tributaries are short steep creeks, loaded with numerous boulders and extensive granitic sands, which drain the steep slopes of the range. They are within themselves unfavorable for placer concentrations.

The left limit tributaries from Knowles Creek down to Big Bar Creek were reported as containing colors and fair gold prospects have been found. These tributaries have extensive gravel deposits,

indicating an old and larger drainage system, contained in their short valleys, and the presence of old channels is suspected due to the low worn topography. The upper Koyuk River occupies its former older valley which in its upper extremities is filled with lavas. The extensive gravels, which show at the end of the lava, extend down this wide flat valley to its mouth. The gravels below the end of the lava are reported thawed and as a result prospectors have passed them up for frozen ground which is more easily prospected when pumping equipment is not available. The origin of these thawed gravels is discussed on page 18.

The Koyuk valley, as compared to the Kuzitrin valley, is more confined to limits and one would expect the pay to be more confined to one pay channel. There is some evidence of glaciation as shown in the valleys of the small tributaries from the Bendeleben Range to the south. The small alpine glaciers may account for considerable of the extensive gravel deposits within the valley as well as Knowles and Big Bar creeks. The extent to which glaciation has influenced this valley is not known and further study is necessary to determine the effect of glaciation upon the gold concentration. Gravels under the lavas are definitely known to exist, as mentioned by Moffit.[1]

The existence of the Eocene Tertiary deposits, the close proximity of the Bendeleben granites, and the outlet of the Imuruk Basin, all point toward a favorable possibility for potential placer deposits in this area which as yet remains to be proven.

[1]Moffit, F. H., U. S. Geol. Survey Bull. 247, p. 32.

Kugruk River Drainage Area:

The Kugruk River drainage system is located in the northeast section of the area shown on Plate 3. It drains an area of 700 square miles. Its length is over 60 miles of which 45 miles is below an elevation of 200 feet and appears to be a more developed and older drainage than the Inmachuk and Goodhope rivers. The upper 10 miles of its headwaters, from Imuruk Lake and then across the lavas where it has cut a deep canyon, has the most fall. The largest tributary is Wade Creek which has a parallel drainage to the west and it joins the Kugruk 10 miles above its mouth. The underlying structure of the area is well shown by the east and west and north and south water courses of this drainage system which follow structural weaknesses resulting from the two systems of folding[1].

The writer flew over the entire drainage area of the Kugruk and covered an area of the central portion on foot. Summer traveling conditions, due to nigger-head marshes and lack of trails, is very difficult on foot, and as a result the upper drainage of the Kugruk was not covered.

This area contains three small granitic intrusives which were reported by prospectors to be in close proximity to the Eocene[2] coal beds and sediments which occur in this drainage area. Gold has been found on several of these upper tributaries, both in the creeks and on low benches.

[1]Op. cit., p. 22 et seq. on Structure.
[2]Op. cit., p. 9 et seq. on Geography and Geology.

Moffit[1] mentions the occurrence of gold bearing gravels in the valley of Dixie Creek at the head of Independence Creek. Independence Creek has a length of nearly 10 miles and it joins the Kugruk River 6 miles above Mina Creek. Holtz Creek, which is nearly as large, is its largest tributary. The upper tributaries of Holtz are Spruce and French creeks which head in the vicinities of the small granitic intrusives. Prospectors report colors in all these creeks, including those on the right limit of Independence Creek. However, values sufficient for working by hand methods were found only on Dixie Creek. The low flat benches along both Independence and Holtz creeks were reported as containing the best pay in comparison to the river beds. Independence Creek was considered during the years 1914-15 as a dredging area and a dredge was contemplated, as mentioned by Brooks[2]:

> "In the Fairhaven district four dredges were in operation in 1913, and each had a fairly successful season. One of these was on Candle Creek, one on the Kugruk, and two on Inmachuk River. The Kugruk dredge was installed in 1913 and operated for about a month and a half. Other dredges which are planned for this region may be installed in the near future. Representatives of the Dearborn Investment Co. extensively prospected the company's holdings on Kugruk River last season and expect to install a dredge in 1914. It is also reported that another company will put a dredge on Independence Creek, a tributary of the Kugruk."

Thus it will be noted from this short account of mining activities on the Kugruk prior to the World War that three dredging areas must have been established. The extent of these developments is not known. The increase of prices which accompanied the War conditions of those years apparently discontinued plans for the proposed dredges

[1] Moffit, F. H., U. S. Geol. Survey Bull. 217, p. 64.
[2] Brooks, A. H., U. S. Geol. Survey Bull. [illegible] p. 134.

and suspended activities at the operating dredge. Since that time there had been only small attempts at mining until this year. The present operation of the Kugruk Mines marks the first major attempt to mine within this basin since that time.

Due to the inaccessibility of the upper drainage of the Kugruk, it has not been prospected to any extent. There has been somewhat of a change in drainage. A very low divide between the headwaters of Spruce Creek and Dixie Creek with Knowles and Big Bar creeks, respectively, the latter being tributaries of the Koyuk River to the south, suggests that there may have been a change of drainage and that a portion of the present flow was at one time into the Koyuk River. This upper drainage, as reported by prospectors and in the geological reports, contains some very interesting geology. The presence of lignite coal beds, as mentioned by Moffit[1] on French Creek and reported on Holtz and other creeks by prospectors, is an associate that is found in many placer districts of Alaska. These Tertiary formations, or Eocene beds[2], are also found along the lower Kugruk River from Montana Creek down to Chicago Creek. At both occurrences it has been reported that gold has been found resting upon the coal beds. The coal beds are not considered valuable as a fuel due to their impurities, frozen condition, and low fixed carbon content[3]. Due to the tundra and covered bedrock in this upper drainage area, these Tertiary sediments were reported only in the

[1]Moffit, F. H., U. S. Geol. Survey Bull. 247, p. 67.
[2]Smith, P. S., U. S. Geol. Survey Prof. Paper 192, Plate 1.
[3]Moffit, F. H., U. S. Geol. Survey Bull. 247, p. 67.

creek beds and the surface extent is not known. The coal series are folded, and as a result fractured, and in close proximity to the intrusives. The main Tertiary intrusives are believed to be younger than these Eocene sediments.

J. B. Mertie, Jr.[1] has classified these sediments and intrusives by their mineralogical associations in the Yukon-Tanana Region:

> "Terrigenous deposits of Eocene age then gradually accumulated in such wide valleys, under conditions favorable for the formation of peaty deposits, from which the Eocene coals were subsequently derived. The great thickness of these Eocene deposits, however, points to a gradual subsidence of the region in the later states of their formation.
>
> "Later in the Tertiary period, after these terrigenous deposits were formed, the region was again uplifted, folded, and intruded by granitic rocks. These intrusions gave rise to a second period of gold mineralization in this region and furnished the source of later gold-quartz veins, the deposits of cinnabar, and most of the tin deposits of the region, particularly those in the vicinity of Hot Springs. It is also probable that new highland areas were formed during this Tertiary period of orogenic disturbance, and that the streams were rejuvenated, initiating renewed and long-continued erosion.
>
> "After the Tertiary granitic rocks were intruded, the old and also the newly uplifted highland areas were progressively eroded for a long period of time and were gradually reduced to a maturely dissected land surface. This period of erosion continued without interruption until late Pliocene time, when the country was again regionally uplifted. In the accelerated erosion that followed, the streams were incised in their old valleys, and the high terraces described elsewhere in this report were formed. Considerable warping of the surface also took place about this time, or a little later, thus creating anomalies in the drainage systems, some of which have persisted to the present day."

While there is no known evidence in this section to prove the representative ages of these intrusives in relation to the sediments, there is the mineralogical evidence of the association of tin concentrates and

[1]Mertie, J. B. Jr., U. S. Geol. Survey Bull. 872. p. 236.

the rock types on which Mertie bases in part his age classification. Following the erosional period which followed the deposition of these sediments, a considerable amount of those Eocene sediments must have been worn away. Either intrusives of this age which may have come in contact with these sediments, or the hydrothermal solutions which contacted these sediments, are held to have precipitated considerable of the placer gold found in this and similar Eocene areas in Alaska. In several areas in Alaska[1] where both Eocene sediments and younger Tertiary intrusives are found in close association there have been later lava flows on top of the sediments. Hydrothermal solutions from the lava magmas may also have contributed to the gold supply[2]. The presence of cassiterite in the gravels of Dixie and Independence creeks is reported by prospectors. The presence of yellowish sands in Spruce and Holtz creeks gives some evidence that these granites in the upper drainage are a soda granite type and possibly of Tertiary age. A few days of field work within this area would substantiate this evidence and add to the possibilities of the area. There is no evidence to be found showing the direct precipitation of gold in the Eocene sediments from the hydrothermal solutions originating in the vicinities of these granites, although this is a possibility. Should this evidence be found in the field in the future, it will throw considerable light upon the origin of the gold and its association within the vicinities of Eocene deposits and Tertiary intrusives.

Mertie[1] has pointed to the conditions in which these Eocene or Tertiary deposits were laid down:

> "The early Tertiary rocks of Interior Alaska, unlike the marine sediments of the Mesozoic and Paleozoic, tend to have a linear type of distribution, suggestive of ancient drainage channels, and in some areas such linear distribution coincides roughly with major stream valleys of the present day."

This condition was followed by small intrusives that caused gold deposition and elevated somewhat the sediments in close proximity to the intrusives which, due to their position near drainage channels, accounts for their rapid erosion and lack of exposures near the intrusives.

Small basins, as noted from the air, exist in this area and are traversed by the various tributaries. While information is lacking regarding this upper drainage, its potential possibilities cannot be ascertained. The conditions, as far as noted and observed, appear to be sufficiently favorable for further prospecting and more detailed examinations are warranted.

The lower drainage of the Kugruk offers more information and while mining has not been particularly successful, it still remains as one of the important potential areas of the district. From the mouth of Independence Creek to the mouth of the Kugruk the river is below 200 feet in elevation. The valley is wide and slightly intrenched in the upper portion. Numerous oxbow lakes, old channel sections, and low gravel capped benches were noted and the river does considerable winding.

[1]Mertie, J. B. Jr., U. S. Geol. Survey Bull. 773, p. 179.

The wide channel and benches have never been adequately prospected. All the tributaries from Independence to Chicago creeks on the right limit occupy wide valleys and contain auriferous gravels[1]. At Chicago Creek the Kugruk River makes an abrupt turn to the west, leaving a wide valley basin, and occupies a narrow new cut channel across the strike of the formations to the mouth of Wade Creek, its largest tributary. The prospectors in the vicinity have expressed their opinion that at one time the river continued in the direction of Chicago Creek and emptied into the sea in the vicinity of Camp or Alder creeks. This is based on holes sunk in the vicinity of Chicago Creek and the gold found in Alder Gulch.

Henshaw[2] gives an account of one hole sunk in this vicinity and a short summary of the early mining:

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

[1]Moffit, F. H., U. S. Geol. Survey Bull. 247.
[2]Henshaw, F. F., U. S. Geol. Survey Bull. 379, p. 361.

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

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

Drill records of the Kugruk Mines, Inc. of last year show the values as continuing from the Kugruk River just above the mouth of Chicago Creek onto a 30-foot bench and extending in a northeastern direction. The crescent shape of this gold deposit indicates a developed bar deposit.

Two types of granite were found in close proximity on the left limit of the Kugruk River between the mouth of Independence Creek and Goldbug Creek. The granite noted at the mouth of Goldbug is intercalated in graphitic and limy schists, containing some quartz and high in ferromagnesium minerals, it is classified as a diorite. The main mass of granite to the south is classified by Moffit[1] as monzonite. The greater portion of the gold found in Mina, Montana, and down to Chicago creeks, is believed to have originated from this monzonitic intrusive. At the time of the monzonite intrusion, it is within the bounds of probability that it came in contact with the coal measures, which are above and below at the present time, on a strike which parallels this intrusive. Since then, through erosion, this zone was worn away and the gold deposited in its present positions. Whether or not the Kugruk drainage

[1]Moffit, F. H., U. S. Geol. Survey Bull. 247, p. 23.

had an influx of gold from the Imuruk Lake basin has not been learned. Prospectors report colors and extensive gravels in the upper canyon of the Kugruk where the river has cut through the lavas, exposing the gravels underneath. Should economic values be found along this canyon, the location would be favorable for following the pay channel under the lavas.

On Wade Creek and its drainage a small open fold valley exists, down which considerable lava flowed. Lava rims are quite pronounced, as observed from the air. Prior to the new channel cut by the Kugruk River this creek no doubt flowed out to Kotzebue Sound as a separate stream. Its valley is low and wide and is extensively covered with gravels. These gravels have been only slightly prospected. Colors were reported, but the extensive amount of lavas has discouraged most prospectors. Its upper tributaries flow on top of the lavas and in places flow under the lavas. During the construction of the Fairhaven ditch, an underground passage into a sink hole on upper Wade Creek was utilized. The water was thence diverted from Wade to the Pinnell drainage[1].

44-31 The Kugruk Mines, Inc. is a new operation which began work this season. The site of this operation is 1½ miles above the mouth of Chicago Creek on the right limit of the Kugruk River. This operation consists of bulldozing and hydraulicking to a hydraulic lift, and bulldozing tailings. Water is supplied by diesel powered pumps for the

[1]Henshaw, F. F., U. S. Geol. Survey Water Supply Paper 314, p. 235.

hydraulic and the hydraulic lift. This makes a very expensive operation. A common log of the deposit is one foot of tundra, six feet of black muck, and ten feet of medium to fine well worn and rounded gravels. The bedrock is fractured limestone.

The deposit is frozen from top to bottom. It is thawed by removing tundra with bulldozer and thence natural thawing by repeated removal of thawed material with the aid of bulldozer. The gold is mainly on and in bedrock with a small amount distributed in the gravels. The various types of gold found suggest a delta beach deposit. First, the greatest amount of gold is rough with some wire gold. Second, some of the worn rounded gold is oblong in shape, suggesting wave rolling action; whereas other rounded gold has a round flattened shape. Third, some of the gold is stained rusty to slightly black, suggesting that it was deposited in dead water. The associated concentrates are magnetite and considerable oxidized pyrite. The fineness of the gold was reported as 900 plus.

From the drilling operations within the valley, good pay was reported across a width of 600 to 700 feet. Holes were placed 25 feet apart in drill lines 500 feet apart. A total of 235 holes were drilled on the river and 70 holes on Coffin Bench above Chicago Creek. The company has 12 miles of ground, part of which was staked and the remainder leased.

This basin deposit at its elevation from 100 to 200 feet above sea level is believed to have been the mouth of the Kugruk River prior to the last elevation of land. The basin was filled with gravels of stream origin which were modified by beach action. This same situation is now in progress at the present mouth of the Kugruk River near Deering. The elevation of land and the retreat of the sea to its present level accounts for the Kugruk River's new channel to the west, to which Wade Creek with its present mouth in a similar basin is now joined. The gold deposit at Chicago Creek and above is in part bench and in part delta deposition. The overflow from the basin may be contained in an old buried channel which connects up with Alder Creek, as the present drilling and log of hole, page 114, indicates. Further mining and drilling will considerably enlarge the scope of information regarding this condition.

The present operation, due to high costs and the amount of handling of the material, is a very expensive type of operation. Exploratory work, such as drilling, is recommended until sufficient ground on the river bed is definitely proven for dredging. The bench deposits may be worked by bulldozer and hydraulic, but to operate a hydraulic lift in an area lacking good grades and natural hydraulic water as well as the lack of tailing-drainage is a very impracticable method of mining.

The extent of auriferous gravels on the Kugruk drainage is very extensive but before definite limits can be established regarding them, considerable exploratory work in the form of drilling has to be done. Along with the development there will have to be newer and cheaper methods of thawing and mining [illegible] the mining methods of the past.

PROBLEMS

Geological, with Regard to Present Position of Placer Deposits:

The many complex conditions under which placer deposits are formed, such as the various destructive agencies, the removal agencies, and the agencies which tend to cover up and hide these deposits, are numerous within the area. A complete knowledge and understanding is beyond the scope of human endeavor. However, it is within the scope of most efficient mining companies to obtain much information that is available regarding the geological conditions in their particular area of operation or contemplated area. The rapid depletion of the known placer ground by machinery and the lack of prospectors places the problem of locating new placer deposits directly upon the operating official or engineer. He cannot jump the hurdle of exploratory expense from discovery to ground proven to be ready to be mined at a profit. The cost of exploratory work must be assumed to some extent and accounted for in the later mining costs.

Thus the logical procedure is to gather all forms of information and to proceed along definite lines with every possible aid for the discovery of new deposits.

The various conditions so far studied and those contained in this report are by no means final as to the exact location of the placer deposits. This problem still exists and will continue to face the operator.

This report is only an attempt to show the possibilities, numerous problems, and conditions of the area with which the operator must contend, and to direct efforts in the future along lines to procure the best results. The writer has shown that the deposits are contained within the structural valleys. The prospector, operator or engineer is still faced with three problems, the solution of which will mean the expenditure of considerable exploratory funds, as: First, the sections of the structural basins which have retained the greatest amount of gold concentration; second, the type and limits of the placer deposits with an estimate as to their average gold content; and third, the lowest amount of gold that can be contained per cubic yard and still be worked at a profit within the section. Associated with this will be the use of mining methods for the reduction of costs, and a full knowledge of economic conditions which are likely to increase them.

With the small amount of mining in this area as a whole, and the meager amount of information available, it is not definitely shown which province is most likely to contain the greater portion of the gold deposits. There may be a greater amount of gold on the coastal province in low grade gravels so extensively shown along the present coast, which may, under large capacity operations, make for large production and a long-life industry. The greater amount of deposits may be in the structural valleys between the coastal plain and the structural basin to the north of the Bondeleben Mountains. This section would give a

higher grade deposit with more confined channels and less overburden. Discoveries within this section would be more easily made and mining would be less expensive and require a smaller amount of capitalization. This section contains most of the mining operations at the present time. Higher grade deposits may be found confined to channels under the lavas in the large structural basin area north of the Bendeleben Range. Should they be discovered the problem of mining under lavas would necessitate more costly mining methods.

The solution for locating the placer deposits lies in the use of all known information and all available methods for obtaining other necessary data. Aerial photography is one method by which considerable information could be gained regarding this area. The study of aerial photographs would do much to define the limits of the older channels and to give a much larger perpective of the whole area which cannot be gained in any other manner. This is one duty of governmental agencies which would make the information available to all concerned. First, it directs the attention of the public to the area; and second, it establishes the necessary confidence for the expenditure of private capital in exploration which the entire Territory of Alaska is not now able to do. The average engineer or geologist who is called upon to make an examination in a section of this type is usually not impressed with a group of claims which, when viewed, appears as a monotonous expanse of

flat and frozen tundra. He has first to view the entire section as a whole, to study its possibilities and then to compare the particular claim group with others and to locate its position with regard to the major features and likely areas. In order to do this it is essential that he have an actual picture of the whole situation. This is possible through aerial photographs. Thus he is encouraged to make his own detailed and large scaled maps of promising sections. This will reveal detailed information as to certain bench deposits, old channels and other physical conditions which when followed by actual drilling will define the limits of existing economic placer deposits. Further geological study into the solution of the various problems mentioned in this report would be a great aid in discovering and in developing placer deposits. This is a much better policy for the Federal Government to undertake than the present policy of waiting for discoveries to be made and mining well advanced before geological work is attempted.

Prospecting and Developing Problems:

The lack of interest within the area, which has gradually become less since the early days, accounts for the lack of prospectors and the small amount of prospecting. Climatic and ground conditions, together with insufficient water and high costs, are some of the reasons for the extent of the unprospected area. The older methods of prospecting were very inadequate for this type of an area. Lack of fuel for thawing and camp uses, deep frozen gravels, considerable frozen muck,

and lava cappings sounded rather difficult for the early prospector. Because of the lack of interest and active prospecting within the area, prospecting and exploration will have to be carried on by individual groups adequately financed. The amount of finance must be such as to follow up to the acquisition of staked ground and for additional staking followed by extensive drilling to prove areas of any considerable extent.

Transportation of small parties to the area with limited equipment may be done by airplane. However, surface transportation within the area will be limited to overland transportation by caterpillar. It is necessary to transport camp equipment and supplies by mechanical means due to the niggerhead tundra which is unfavorable for packing and the use of horses during the summer season. Further, the equipment necessary for drilling would require power for operation and a means for transporting. The lack of trails, roads and airfields makes for independent transportation. The present airfields could be used as a base for supplies which are transported by plane from Nome at costs of 8 to 10 cents per pound for small lots. Once an area is located, where a more or less permanent camp is to be established, airfields can be easily constructed with the aid of a bulldozer.

Geophysical methods of prospecting for bedrock depths, and for the location of the older channels and metalliferous concentrations may be utilized to advantage. This method, which is more or less in the experimental stage, falls under governmental activities until established principles have been worked out which will be to the advantage of the public.

With regard to the building of roads, trails and airfields, this is one field of activity on Seward Peninsula in which the Government is at the present time cooperating to the fullest extent. However, to be extravagant in one form and entirely lacking in others, is not the best policy for the development of new regions.

Thawing of Frozen Muck and Gravels:

The greater portion of the deposits thus far mined, drilled, and known are permanently frozen from the tundra to and including the bedrock. This is a burden that, when added to the cost of actual mining, is the second largest item of expense. Thawing costs vary from a few cents per yard to 15 or 20 cents, depending upon available water, depth of ground and various other physical conditions. This cost, as compared with various costs of mining in the States or operations in tropical countries, is even greater than the mining costs alone. The direct cause of many mining failures on Seward Peninsula has been underestimating this cost, or failure to prepare or thaw ground in advance of operations, or to depend too much upon natural thawing.

There are various methods of thawing more or less dependent on natural thawing or the application of cold water thawing. The method is usually governed by the depth of gravels and frozen muck in accordance with grade, the available water, and tailing disposal. A combination of methods also is governed by conditions. Stream gravels which are not

covered with tundra usually thaw normally up to 8 feet in depth. A muck and gravel combination up to 10 feet in depth, or 5 feet of muck on top of 5 feet of gravel is best thawed by removing the tundra and muck with bulldozer. A combination of 15 feet of muck and gravel, with gravel not over 8 feet, is best thawed with bulldozer and hydraulic. Gravels over 10 feet are thawed by points, and an accumulation of muck and gravels of 20 feet in depth may combine all these methods. The black frozen muck thaws more rapidly with hydraulic and bulldozer methods than with points. For gravels over 8 feet in depth the use of bulldozer and hydraulic is slower and more expensive than points. However, there are instances where the reverse may be true. The two most expensive means of thawing are where bulldozers are used in large pits to bulldoze frozen gravels with little or no water, and where hydraulic water has to be continually pumped for hydraulic or for points.

The development of cheap hydroelectric power within the area would reduce thawing costs. Pumps could be operated by electric motor for hydraulic water and points used in thawing. Electric power would be cheaper when compared to diesel power, when its oil has to be transported, or the weight of the power equipment itself. A system of thawing with electrically charged points would be within the realm of possibilities for thawing muck and gravels if abundant electric power should be available.

Another system of natural thawing which may come into common practice is that of thawing by lateral systems of ditches. This system is adaptable where the deposit exists as a bench or high channel deposit covered with considerable black frozen muck, or where there is sufficient grade for water to carry a heavy load. The water is led to the top of the deposit by ditch, thence the tundra is bulldozed off. Small parallel ditches are made with a bulldozer attachment consisting of a V-shaped sharp-pointed point. One is attached to each end of the bulldozer and small ditches are constructed parallel to the grade across the width to be thawed. Thence water from the ditch is controlled and equal volumes are proportional to each ditch. The muck, which has a content from 50 to 75 per cent ice and the remaining percentage in fine sand, vegetational matter and silt, begins to melt and increases the volume of water which gives a directly proportional increase to the amount of thawing. The water content of frozen gravels averages 25 per cent. Too much grade causes a quick run-off and too low a grade does not remove the material content. In time the ditches increase in size and in depth and a slight meander along their courses begin which is similar in effect to a young drainage system. The effect of numerous ditches increases the amount of frozen surface exposed to the atmosphere and by the time the ditch is cut through to the gravels it usually contains sufficient water to

actually thaw the gravels to some extent. This system applied to a long block of ground over a period of years is the slowest, but the least expensive method of thawing, as it requires the least amount of labor.

A. H. Brooks[1], states the possibilities of placer mining in frozen areas in his summary of dredging activities on Seward Peninsula in the year 1915:

> "The cause of the decrease in production of dredge gold is not clear, as there are known to be large areas of auriferous gravels on the peninsula which appear to be suitable for profitable exploitation by dredges. One reason, however, is that most of the successful dredges appear to have worked on placers of rather high grade, and their success has been due to this fact rather than to economical mining by large operations. Little attempt has been made to work the permanently frozen placers, as has been so successfully done in the Alaska and Canadian Yukon. * * * * * It would seem that there is in Seward Peninsula a field for strong companies that could introduce economies in the operation of dredging and thawing."

The frozen tundra, muck and gravels offer some minor advantages which are worthy of mention and which in some respects offset the costs of thawing as compared to operating in tropical or heavily wooded areas or in climates of heavy rainfall, etc. Due to the frozen condition of the tundra, forest growth is lacking and the frozen ground offers solid traction for caterpillars and a means of overland transportation which eliminates the cost of road building. It further offers an advantage in test pitting as pumps are not required and cribbing of shafts is unnecessary. Its largest advantage is in drilling, as casing is not

[1]Brooks, A. H., U. S. Geol. Survey Bull. 642, p. 70.

necessary and the frozen walls offer very accurate volume checks which eliminates many inaccuracies. While thawing costs are high, these are somewhat offset by clearing and expensive bulldozing costs in areas of dense forest growth.

Mining:

The actual mining problems which face the operator after deposits have been drilled and thawed are many. The length of time in which operations can be carried on in this region, due to cold climatic conditions, is limited to a period of 100 to 120 days per year. The amount of work required each year for starting and closing operations causes an increased cost as compared to areas of year-round operations. Capacity equipment must be installed to handle sufficient ground, during the limited operating season, to carry the yearly overhead and to make a profit. The best and most satisfactory type of operation for the area is dredging. However, the presence of benches and high channels and localized deposits may be suitable for other mining methods. The choice of the right type and make of machinery for certain types of deposits is in many instances the factor between success and failure. A more standardized method of mining for certain types of deposits should be developed as compared to the many more or less experimental types that are used at the present time. The present practice in the

purchase of machinery is to purchase it from the company that advances the most credit. Cheap power for operation is another problem that faces the operator. The evolution of power in this area has been from gasoline to diesel oil units. The U. S. Smelting and Refining Company at Nome has developed diesel-electric power. Electric power for the operation of dredges, pumps, and other methods using small power is much more economical and efficient than any other form in this area. However, the development of electric power by diesel, coal or water power depends upon many conditions. Since the available coal within the area is of a very low grade, and with mining conditions and transportation costs high, diesel oil development would be cheaper than steam. Diesel as compared to hydroelectric power depends upon the future possibilities and conditions of this area. Hydroelectric development is possible within the area[1], and with a sufficient demand established it would become the cheapest form of power. Thus it is a matter of encouragement to the potential exploration company to be assured of an available cheap form of power should their developments prove worthwhile.

Another problem associated with actual mining is the limestone bedrock. The underlying bedrocks of the greater portion of the area are limestone and schist, interbedded and arranged in a north and south alinement[2]. Brooks[3] has shown the tendency for both the origin and the present location of placer deposits to be confined to schist and limestone contacts. The schist bedrock is the most favorable for mining

[1]See section on Hydroelectric Power Sites on following pages.
[2]Op. cit., p. 9 et seq. on Geography and Geology.
[3]Brooks, A. H., U. S. Geol. Survey Bull. 627, pp. 121-122.

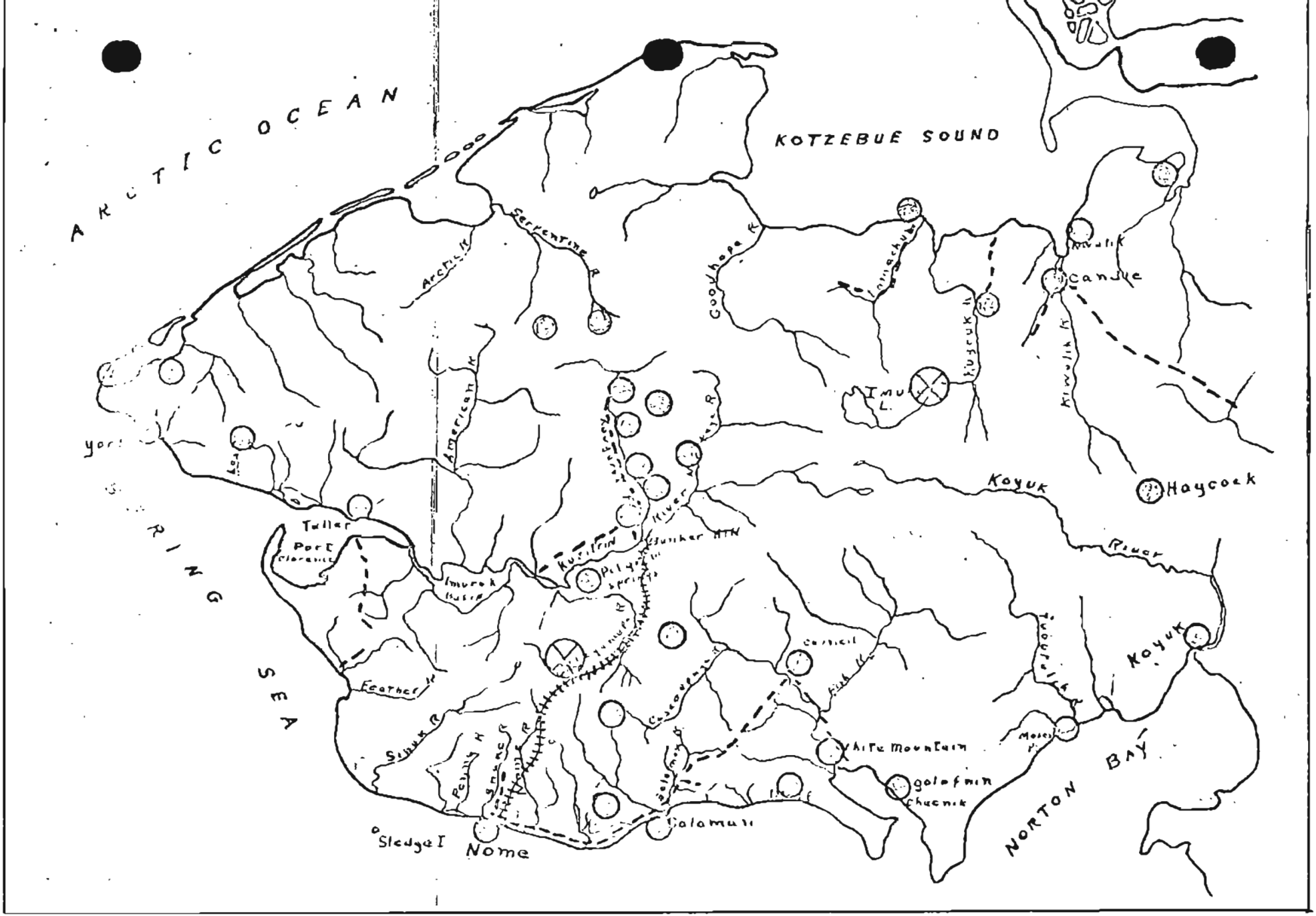
as the decomposition is usually greater than the limestone. For dredging it offers no difficult problem. The limestone offers a condition which makes for hard mining by all methods. It is usually fractured in one or more directions and is rough and has a degree of hardness which calls for strongly constructed machinery. The fractures in the limestone offer openings for the placer gold which make it necessary to mine considerable bedrock to recover the values. A heavily constructed ladder and bucket line solves the problem for the limestone bedrock with regard to dredging. The lack of provision for this condition has led to many mining failures of dredging companies on Seward Peninsula. The practice in past operations has been the use of small light dredges, mainly of the flume type with light bucket lines. The actual light weight of the dredge compared to that of a trommel screen dredge did not allow digging sufficiently deep in the limestone bedrock to recover all the values.

The reason for the use of these small dredges was the high cost of transportation and the high cost of power development. Thus the development of cheap power will permit the use of heavier machinery and the transportation problem for this whole peninsula can be reduced to a minimum figure as compared to the majority of the other interior placer areas.

Transportation (not a handicap):

One of the largest problems, which has influenced the mining operations of the past and still exists at the present time in a misconcepted way, is transportation. This misconception is the result of environmental conditions during the early gold rush days. Transportation in those days was a severe handicap. The lighterage problem of transferring supplies and machinery from boat to land was very difficult, where harbor facilities were almost lacking during all times of the year, and an open coast line was subject to storms. Land transportation was even more difficult. This was limited mainly to horses and dog teams. The construction of narrow gauge railroads was not a material improvement. The transportation of heavy machinery with horses and over narrow gauge railroads was slow and difficult, and it resulted in exceptionally high rates due both to the difficulties and the demand. The railroads were hastily constructed and considerable trouble was experienced with track and bridge conditions. No effort for permanent conditions was expended--all more or less for the present, and as a result only trails and tundra roads were constructed. The resultant conditions, which exist today, are such that monopolistic interests have control of the transportation facilities which makes for higher transportation costs than should exist.

The water transportation remains much the same today as in the early days. Two boats a season call at ports in Kotzebue Sound. While this sound is not free of ice until the month of May or early June, it does offer protection from storms. It lacks natural harbors, but



ROADS ----

AIRFIELDS

Sketch Showing
Roads, Airfields, Railroad
and
Hydroelectric Sites

NARROW GAUGE RAILROAD

HYDROELECTRIC SITES

lighterage is easy due to the extensive sand and gravel beaches. For this area the logical means of receiving supplies would be via water transportation to the sound. Spring supplies are received the fall before and freight rates are within reason.

At Deering, which is the largest coast village on the south shore, supplies consisting of general merchandise have a $19 freight charge per ton from Seattle. A $5 a ton lighterage charge makes a total of $24. Freight on oil is $15 per ton from Seattle with a $4 lighterage charge per ton. Thus oil delivered to the operations on the Inmachuk River costs 17 cents per gallon from Seattle, including the original Seattle cost. Freight costs into the Kugruk Mines, Inc. on the Kugruk River are slightly higher, due to a caterpillar haul over tundra, compared to trucks on the Inmachuk River. Supplies are lightered to the beach at Nine Mile Point. Here camp buildings were constructed on steel skids and hauled by caterpillar to the site of operations.

One of the important features in regard to camp construction for placer mining, and especially true on Seward Peninsula where frozen tundra offers a means of transporting, is the construction of small buildings on suitable skids. This enables the operator to have the camp within a short distance of the operation. Also as one deposit is worked out, it enables the camp to be moved to another site without reconstructing the buildings.

Another means of access to this area is via the narrow gauge railroad from Nome to Bunker Hill on the Kuzitrin River, Note Plate 2. From Bunker Hill a cable tram ferry operates across the river. Thence a new gravel road is under construction along the Kougarok River to Taylor. This road services the lower Kougarok operations and will, upon completion, service the upper Kougarok and the Serpentine Springs area. The present means of transportation into the Kougarok is via railroad to Bunker Hill and caterpillar to the upper Kougarok and from Teller via barges to Davidson Landing on the Kuzitrin and thence via caterpillar. This means of transportation in the past has been expensive, totaling in some instances $70 per ton from Seattle to site of operation. This rate will be considerably lowered with the completion of the road from Bunker Hill to Taylor.

Necessary parts and fresh supplies are mainly carried during the summer months via airplane from Nome. Rates vary from six to ten cents per pound for small lots, depending upon destination. The present air fields are shown on Plate 2. The construction of airplane landing fields is an item of no great expense due to the ease with which they can be built. It has been the policy for operators to construct their own fields with their machinery, and in numerous cases where fields serve a community the actual expenses are defrayed by the Territory.

Seward Peninsula and its various placer districts, with the exception of only one other area, has the lowest transportation rates of any large placer area in Alaska. The only area, which is only slightly below the rates mentioned above, is the Goodnews Bay area. Transportation, in Alaska, to the mining operations is one of the greatest problems and it is with this problem in mind that Seward Peninsula for placer mining is recommended as a place for future exploration and development by this department.

Taxation - A Growing Problem:

There are numerous taxes, both direct and indirect, which affect the Alaskan mining industry. This problem in Alaska is not as serious as in various states within the United States and several foreign countries. However, due to the rapid development and the increasing financial burdens on both Territorial and Federal Governments, this problem is on the increase and one to be seriously considered in the future. The two forms of direct tax, the Territorial 3 per cent gross tax and the Federal Income Tax, are the only two under discussion within this report. Both taxes are subject to increase. Hence the question arises as to how much these direct taxes can be increased before the industry is seriously harmed and expansion and new development are retarded. It is not within the confines of this report to discuss this question, only it must be remembered that the mining industry of Alaska is still in its infant stage of development and the future development will be in marginal properties [illegible] providing other conditions remain somewhat the same.

Of the two forms of direct tax, the Territorial gross tax is the best adapted, and regarding which there has been the least objections. Many operators have expressed their opinions and their reasons for them are many. First, it is a Territorial tax with the money retained in the Territory. They know how the money is spent and have some voice, through their representatives, as to how it is to be spent. It is spent at least in part for the development of the industry and for the good of the people of Alaska. For this one reason alone there are few objections. Second, the tax is simple and easy to understand, and at the end of the season the operators can easily figure where they stand. The new and small operator is given a chance to survive, under the $20,000 exemption, and to build up into a large operator, the very factor which propagates the mining industry. The services of taxation experts are not necessary and consequently there is a substantial saving. Third, it is a reasonable tax.

The Federal Income Tax is the most objectionable. First, it is a tax difficult to interpret and as a result numerous operators do not know how they stand regarding it at the end of the year. Second, due to its yearly basis of income alone it is unfair to new producing companies because of the seasonal working conditions and the nature of the industry.

In order to bring a placer property in Alaska into production to the point where there is an actual income, a period of from one to ten years is necessary. Exploring of the property and the proving of the ground by drill or other testing methods; preparing the deposit to mine, such as removing overburden, thawing, road building, and ditch building, all come prior to production. This work, all essential and directly applied to mining, is an expenditure accompanied by no income and which only increases the capitalization when gold is produced. Then comes the first year or years of actual income, usually a large sum compared to the actual expenses of that year, made possible by the advanced development during years of no income. The operator is not allowed to carry over from non-productive years to producing years many of these former development costs. Concerning these development costs, there is much controversy at the present time. There are many other provisions regarding this tax which the operator does not understand and as a result pays rather than hire a technical expert to examine and present additional exemption. This tax does offer a problem when starting a new operation.

The Territorial tax, under its present rate and exemption, need not be increased, under the existing conditions, to solve the need for increased governmental funds, providing the growth of Alaska is normal. The normal development and growth of Alaska should be only in

proportion to the development and growth of the mining and other taxable industries. Thus the growth of the mining industry will provide a greater production of gold and other metals with increased operations which at the present rate of taxation should provide for the increased governmental expenses. Any other development of large proportion should provide its own tax and not be thrown as an additional burden on the young and developing mining industry.

Establishing Validity of Claims:

As a result of the Nome gold rush, numerous placer discoveries were made on Seward Peninsula and several thousand claims were staked. In this area the Kougarok and the Inmachuk regions received the most attention. Of the many claims that were staked under legal discoveries, there were many staked and held without discoveries. Many claims were abandoned and a few of the most promising ones were retained. Many claims were restaked and some were restaked several times in later years. The condition as it exists today is extremely complex and, to the newcomer who wishes to acquire new ground, it offers a very difficult problem. Large claim groups are held by individuals and small groups of individuals with very little assessment work. Lone individuals hold several miles of placer claims for long periods of years, and some have no means of doing assessment work other than their own time.

Due to the lack of timber within the area, most claims are staked by using the available willows for posts. These are small, crooked and actually difficult to locate. As a result few claims have been legally staked, however, this does not throw them out as valid locations. Numerous claims are inaccurately located on the recorded discovery notice with reference to natural surroundings and monuments. This is due in most instances to the lack of natural monuments and generally known reference points. Due to the lack of roads, trails and survey lines and reference points, the distances as recorded on discovery notices are very inaccurate. Some creeks have two local names. Some claim groups are held by two or more different parties and the validity of title has never been established. Such existing conditions have done much to retard active development, not only in this area, but in many placer areas of Alaska. While this is not a serious problem, it is one for the future exploration company to keep in mind.

THE CAUSES OF MANY MINING FAILURES

There have been in the past many failures in placer mining on Seward Peninsula. One has only to travel the beach lines at Nome and the trails that lead out over the tundra to observe the many remnants of early day mining activities. These tell many a hard luck story and show many of the general causes of failure. A few of these causes are mentioned,

not to discourage the future prospector or exploration company, but to warn against mistakes and to help steer the future developments around the pitfalls of the past. These are given in order of their most frequent occurrence. Failures as a rule are not due to one specific cause or one single mistake, but are generally due to many mistakes and causes, which include a lack of knowledge, methods or conditions and environmental agencies with regard to the industry, or a volume of misconstrued or misconceived information regarding these conditions.

One of the most common causes of mining failures, which apply to this section of Alaska, is the failure to develop and accurately determine the values within the ground to be mined. It is a common procedure to assume that a particular creek contains high values over a long distance, such assumption being based upon a few drill holes, a few prospect pits, or records of early mining which may have been in concentrated areas and not generally true of the whole creek. Large amounts of machinery are purchased and sometimes considerable amounts of money are spent on the results of a few erratically placed drill holes, or at other times it may be from one or two pits which happened to hit a narrow pay streak of exceptionally high value. Occasionally, the inaccuracy of determining values from the drill holes, by not using a logical factor or by not measuring the actual volume of the hole, has resulted in higher values anticipated than actually exist. In many instances only the values contained in the gravels are figured for the

deposits, and the frozen black muck on top is not taken into consideration when figuring volumes. There are many other causes of failure which enter into this subject, all more or less common knowledge to the experienced placer engineer.

Another common cause of failure in the early day mining ventures on Seward Peninsula was the employment of men not familiar with mining conditions, costs, and the adverse climatic conditions. It is a common occurrence today during social talks in the vicinity of Nome to hear related tales of competent men who were sent to Seward Peninsula to make examinations, to operate and for other purposes, and who turned back in disappointment. Many of these men, faced with adverse climatic conditions, long hard tramps over niggerhead and frozen tundra, high costs, frozen gravels, and general disappointment in regard to their expectations, carried on and won out with financial success and established our present industry on Seward Peninsula, and to them considerable credit is due. However, many ventures were stopped upon conclusions drawn, not from the known facts of the property, but upon conditions that affected the physical discomforts of the particular individual. Many of the efforts of the past, which led to failures, have been utilized and made into successful operations due to a knowledge of the various conditions and experience gained by facing problems. Thus it is a requisite of the future organization to employ men who are familiar with conditions within the area. However, these conditions can readily be learned with sufficient reports, a knowledge of past failures, and a study of the district as a whole.

The failure to thaw sufficient ground in advance of mining is another item which has led to many failures. The thawing of ground under the present methods of thawing, such as with points, bulldozing, hydraulic, and natural thaw, requires considerable time. A number of operations, when starting, do not allow for this time factor in thawing sufficient ground and as a result the whole operation is held back awaiting the thaw. This naturally cuts down the yardage for the season and sometimes to the extent of making the entire season unprofitable. Sometimes the thawing is hastened by the hard use of machinery. This has been found unpractical due to the wear of frozen ground on machinery, and it also accounts for some loss in the sluicing of the gold. At other times in point thawing, the points are pulled too hastily. This results in the lower bedrock gravels not becoming thawed and in mining, these lower gravels which contain the greater portion of the values, are passed over for bedrock. This latter condition only occurs during dredging. It is found in many instances that the bedrock itself refreezes after the surface gravel is thawed, due to the amount of frost contained in the lower bedrock. Some bedrock has been found to be frozen to a depth of 80 feet. This refreezing, that is caused by not allowing sufficient time to thaw, makes for harder mining and lower recovery.

Another cause, which has led to many mining failures, has been the purchase of the wrong type, or inadequate and unsuitable machinery. This has been very true of the past and it is still true to some extent today. Unless one is familiar with the correct types and makes of machinery which are adaptable to mining conditions in this section, one is apt to purchase machinery that would be unsuitable, solely on a sales presentation, and this would lead to financial failure. Dredge machinery is more or less of a standard type and involves mainly the same principles. However, there are many points regarding various makes of dredges, that use various types of power and pumps, which are a decided advantage. Serious breakdowns are costly in an area of this type where the time factor in replacement is exceedingly important. This factor alone has been known to turn an otherwise profitable season into an unprofitable one. Only the best makes and types of machinery should be purchased. The purchase of new types of power and machinery, as against proven successful types, has been found to be poor policy. Auxiliary power and large repair supplies on hand have been found to be a great saving in time and expense.

Another factor, which contributes in many instances to mining failures, is the use of the too-liberal credit. Commendation is due to those agencies that have advanced considerable credit to the gold mining industry during the last six or eight years. The advancement of this credit has done much to increase the number of operations and to main-

tain the production. However, this has approached the saturation point as numerous new agencies have entered the field. The result is that credit is advanced for machinery on ground that is not worthy. On numerous properties, there has not been sufficient development in advance to warrant the amount of machinery purchased. As a result it is used for prospecting at great cost which is unnecessary. Many new companies that have limited financial means have the additional burden of interest, and often when they meet the final terms of this so-called liberal credit, it is found to be anything but liberal. This increase in the use of credit and the resultant increase of purchased machinery, unless it is checked or avoided by the new developing companies, threatens to undermine a most sound industry. This is a warning, not only to the new developing companies, but also an equal warning to the credit agencies as well.

This profitable game of advancing credit to gold operators is played by many agencies in Alaska, including the Federal Government. The Reconstruction Finance Corporation, a governmental agency, is the only one which reduces the chances of failure when a loan is made to almost nil. The other agencies are the banks, the machinery companies, through their distributors, and the large commercial companies. Should these latter agencies advance credit on the same terms and stipulations and under the same conditions as the RFC then the warning to new companies and to the agencies would be unnecessary.

There are more particular advantages to those organizations and individual operators who desire a loan to apply for an RFC loan rather than to accept the liberal credit terms of other agencies. These advantages come under the terms and stipulations on which the RFC loan is granted. This includes an examination by an RFC engineer. Additional ground is proven if necessary and the loan is not granted unless the property has sufficient merit to carry the loan. Credit by the other agencies is more or less granted on hearsay regarding the merits of the property, and the personal reputation of the operator. Further, the RFC sees that the money is spent along lines that are not out of bounds and in practical ways and for practical equipment, and that the mining is carried on in a logical and practical way. The interest rate is usually lower than the credit agencies, and the element of risk is eliminated for the operator. The element of risk is increased for the operator by the credit agencies and often at the expense of labor.

It is a common practice to purchase machinery of that agency which offers the greatest amount of credit. This many times leads to the wrong kind and type for the particular type of deposit which is to be mined.

Over-promotion falls in with the use of this too-liberal credit and has been known to be the cause of many failures. Both activities get out of proportion for the amount of metal to be mined, and the resulting condition is blamed on the mining industry. Along with credit finance through the banks, the usual stipulation is added that the gold

as it is mined is to be turned over to the banks who send it to the Mint. This adds a handling commission of 2½ per cent or more of the value of the gold produced. This, plus the credit rates on credit advances, makes a high percentage of interest and commission payment. The bank's commission for handling gold is nearly as much as the Territorial gross tax. This, compared to the Mint charge of .25 per cent and transportation costs paid by the operator, amounts to a difference well worthy of consideration.

Lawsuits over validity of claims is another factor which has terminated mining operations. There are many other factors, which may contribute to failure and which are more or less common knowledge to experienced operators. A knowledge of the causes of failure is, on the other hand, one of the essentials of success.

HYDROELECTRIC POWER SITES

The solution of one of the major mining problems in this area would be the development of a source of cheap abundant power. Hydroelectric power would be the logical form of power, providing there should be sufficient demand. It is also a development to be undertaken either by large corporations or through Governmental agencies and finance. To the future exploration company, and to those persons interested in the development of mining on Seward Peninsula, it is of interest to know of possible hydroelectric development and to feel at least partly confident of obtaining a solution to one of the major problems, should the

necessity arise. There is contained within this area, and very centrally located, a favorable location for the development of an hydroelectric plant. The site is on the Kugruk River where it is possible to utilize the water of Imuruk Lake. This is described by Henshaw and Parker[1] as follows:

"Kugruk River rises in Imuruk Lake and flows in a northeasterly and northerly direction for about 60 miles, emptying into Kotzebue Sound near Deering. Imuruk Lake lies on top of the lava plateau that occupies a large area in the central part of Seward Peninsula, at an elevation, as near as can be determined from barometer readings, of 960 feet. It has an area of 31 square miles and a drainage basin of 102 square miles. Below the lake the river is relatively flat for 3 or 4 miles. It then breaks over an escarpment at the edge of the lava and flows through a canyon about 2 miles in length which has been cut in places 300 feet deep and 1,000 feet wide. The fall in the canyon amounts to nearly 250 feet to the mile. At its lower end the river is probably at about the level which it occupied before the extrusion of the lava flow, nearly 550 feet below the level of the lake. The canyon affords a favorable location for a plant to develop electric power, for water from the lake can be diverted through the upper end of the Fairhaven ditch or through a waterway parallel with it for about 4½ miles and then through a pipe line to the lower end of the canyon, where a pressure of about 500 feet can be obtained.

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Water supply available from Imuruk Lake, 1906-1908

		Aug. 16, 1906 to Aug. 13, 1907	Oct. 1, 1907 to Sept. 25, 1908
Rise of lake surface	feet	2.17	1.53
Equivalent water supply	acre-feet	43,100	30,400
Outflow	do.	0	6,400
Total water supply	do.	43,100	36,800
Mean annual discharge	second-feet	60	51
Discharge for 100-day season	do.	217	186
Run-off from drainage area	inches	7.9	6.8"

[1]Henshaw, F. F. & Parker, G. L., Water Supply Paper 314, p. 229.

Another undeveloped water power site is located on the Kruzgamepa River in the Iron Creek region which lies on the north slope drainage between the Kigluaik and Bendeleben ranges. This site is described by Henshaw[1] and the power developed here could be utilized by many of the mining districts.

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

"This lake offers an excellent opportunity for a storage reservoir for power purposes and mining along Kruzgamepa River. The use of its water in the vicinity of Nome is practically prohibited, owing to its low elevation and the long tunnel which would be necessary to bring the water through the Nugget divide into the Nome River basin.

* * * * *

"As it (Kruzgamepa River) leaves Salmon Lake the river flows through a narrow outlet having a width of 150 feet at the bottom and 500 feet at the top, offering an excellent dam site and location for a hydro-electric power plant. Plans for the construction of such a plant have been perfected by the Salmon Lake Power Company (1907), which intends to develop 3,000 horsepower to be used on dredges at Nome and Council and on Solomon River.

"Salmon Lake at its present level, 442 feet, covers 1,800 acres; if raised to a level of 475 feet, it would cover 3,600 acres; and at 500 feet, 4,600 acres. The reservoir thus formed could be used for the storage of the water of the floods caused by the melting snow in the spring and the occasional heavy rains in the summer. The water thus retained would give a large minimum flow not only in summer but also during the winter months, when the natural run-off becomes small.

"Kruzgamepa River seldom freezes over before the first of January, and it is probable that with proper installation, power could be developed throughout the year."

[1]Henshaw, F. F., U. S. Geol. Survey Water Supply Paper 218, 1908, pp. 53-55.

That which applies to the area under discussion in regard to cheaper power would also apply to many of the other mining districts such as the Iron Creek region, Candle district, Solomon, Casadepaga and Nome areas.

CONCLUSION AND SUMMARY

In this report the writer has attempted to show the possibilities which exist in regard to placer mining in certain undeveloped areas of Seward Peninsula. There still remain areas of considerable extent, which are geologically favorable for placer gold deposits, and which have not been thoroughly prospected. A further attempt to show the relation of the deposits to igneous intrusive and extrusive rocks has been made, along with a general theory of origin and deposition of the gold. This offers, at least until further information is gained, a working hypothesis which may form the basis for the solution of many geological problems. The descriptions and geologic features of the individual areas, it is hoped, will be found useful to the present operator, the prospector and the future exploration company. The list of mining problems and the general causes of failure should be instructive to the new operator, who anticipates mining in this area in the future. The individual reader is herewith given the opportunity to draw his own conclusions regarding these areas and in so doing to act accordingly.

There are numerous mining problems to be overcome in a section which lies just below the fringe of the arctic circle. A great number of these problems have been imposed by nature and they can under normal circumstances be solved by man. In these areas as well as the whole of Seward Peninsula there exist many man-made barriers and problems that are more or less the result of the early gold rushes and the compound evolution mixed with the desire for fortunes, and the desire for capitalistic control. To eliminate these and to furnish aid to the industry is the duty of Federal and Territorial agencies, both of which owe their existence in part to the mining industry in Alaska.