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THESIS

ON:

THE GEOLGY AND MINING OF THE Nome DISTRICT, ALASKA.

BY

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The Geology of the Nome District, Alaska.

Introduction.

The Cape Nome Mining District is that portion of Seward Peninsula in Alaska lying between the drainage basins of the Cripple River on the west, and Topkok River on the east, and Bering Sea on the south. The field work covered in this thesis has been done mainly in the region between Cape Nome and Snake River, with the city of Nome as a centre. This region I have termed the Nome District. The field work was done in the summer of 1904 during the months of July, August, and September. For those facts outside the range of my field work, I have made use of the publications of the U.S. Geological Survey relating to Seward Peninsula, and of notes by Prof. W. O. Crosby on observations made in 1903 and 1904.

Topography.

Extending along the coast from Cape Nome to Cape Rodney is a low coastal plain covered with moss and grass locally known as the "tundra". The tundra plain extends back three or four miles from the shore. Rising abruptly from it are a series of well eroded hills varying in altitude from 600 feet near the coastal plain to 2000 feet near the headwaters of Snake and Nome Rivers. Many well defined benches and terraces, which will be referred to later, occur on these hills.

Drainage.

The main drainage is by the Snake and Nome Rivers. The principal tributaries, from an economic standpoint, are Anvil, Glacier, Little, Bourbon, and Dry Creeks of Snake River; and Dexter and Osborn Creeks of Nome River. Hastings Creek and its tributary,
Saunders Creek, drain the tundra near Cape Nome. Snake River heads in the upland regions to the south of the Kigluaik Mountains, and Nome River heads in the Sawtooth or Kigluaik Mountains. Both rivers flow in a southerly direction through broad gravel-floored valleys to Bering Sea. Snake River takes a sharp turn to the east, and Nome River to the west before emptying into Bering Sea. As will be shown later, most of the streams occupy the gravel filled valleys of former drainage systems.

Rocks.

The rocks in the vicinity of Nome belong to the Nome series, and consist of mica, chlorite, quartz, and graphite schists, crystalline limestone and massive greenstone. The rocks are distinctly mineralized. The schists are cut by quartz stringers which are both parallel to and cut the schistosity; and the limestone is traversed by veins of calcite. The schist is impregnated with pyrite, while its quartz veins carry some free gold, pyrite, galena, and arsenopyrite. These veins are generally of the gash or endogenous type. One distinct fissure vein has been noted. The calcite veins are said to carry free gold. Some scheelite is found in the concentrates from the sluice boxes, but no ledge of it has yet been discovered. Occasional fragments of cassiterite have been found in the concentrates together with the usual black, and ruby or garnet sands, and limonite nuggets.

Sources of Gold.

It may safely be said that the placer gold found in the creeks is derived from the eroded veins whose remnants now remain adjacent
to the placers, and from the mineralized schists. The gold derived from the schists is fine and is easily transportable, and it may be questioned whether much of it is near its source. The gold derived from the veins is coarse and has probably not been transported far. This is shown by the fact that fragments of gold, little worn and often showing attached quartz and schist have been found in the streams.

An interesting question is raised by the blank character of the present veins. They may have given up their gold to enrich the placers in two ways. Either the present veins are below a bonanza zone which has been eroded away, or the values per unit of cubic content were very small and the long-continued concentration has given the present richness to some of the placers. It could be possible to calculate the amount of material eroded to give a present valley, and knowing the value of the output, obtain a value for a cubic unit. The value obtained would in all probability be very small, and show that the concentration has been the important agent in making the present deposits rich.

The fine gold of the beach placers was brought down by the streams and deposited in the gravels and silts of the coastal plain. Wave action has since concentrated the values.

Vein Deposits.

These have as yet developed nothing economically important. Prospecting is going on continuously and big strikes have been reported, but they have amounted to nothing. Numerous quartz locations have been staked, and several companies have been formed to exploit these claims. It is the writer's opinion that ledge mining will never amount to much as conditions are very much against
profitable working. The future may, however, bring out some important developments.

Rock Creek and Quartz Gulch show distinct mineral development. At Rock Creek, a tributary of Snake River, the ore occurs in a series of intersecting gash veins. These have been prospected by means of two tunnels each about 100 feet long. The quartz assays from $12. to $16. per ton, but the best values are found in the impregnated schist. The values are free gold in the quartz, and so-called "telluride ore" in the schist. This "telluride" is, as nearly as could be judged, arsenopyrite and galena. In the creek, pieces of gold have been found which look as if they had come from these veins.

On Quartz Gulch which runs into Anvil Creek opposite Banner Station of the Nome-Arctic Railway, the following conditions exist. Bed-rock is schist and limestone very much contorted and twisted. About one-quarter of a mile above the mouth of the gulch a true fissure-vein cuts the schists. It varies in width from 24 to 30 inches. The hanging wall is sharply defined, plane, and slickensided, but the north or foot wall is less defined on account of a series of shearplanes parallel to the vein. The quartz is massive but shows a marked ribbon structure, and is in a large part heavily mineralized with arsenopyrite. The assays show gold values from $8. to $64. and silver values averaging about $2. The ore would have to be concentrated, roasted, and chlorinated in order to extract the gold. Present conditions make it impossible to work this proposition.

Placer Deposits.

The placer deposits may be divided into two classes.-(1) The
ed deposits, including ancient terraces and benches; (2) beach deposits including the old beach, the present beach, and the coastal plain deposits. These will be treated in detail later.

**Bed Rock Geology.**

_Sedimentary:_ The oldest rocks in Seward Peninsula are highly crystallized limestones and schists known as the Kigluaik series. Above these is a mass of schistose rocks characterized by a larger percentage of graphite and being very arenaceous. These have been called the Kuzitrin series; the relation seems to be one of unconformity.

Next is the Nome series, made up of limestones, graphitic mica and calcareous schists, with many greenstone intrusives, and some chloritic schists. The series is hardly a stratigraphic unit, as the lithological constitution of the beds is rather heterogeneous. Broadly speaking, the rocks of the Nome series are calcareous. Their age varies from Ordovician to Mesozoic beds.

*Brock*- Reconnaissance of Seward Peninsula- 1900

_Igneous rocks:_ These are widely distributed, and especially abundant in the Nome series are greenstones. These are also found cutting the Kuzitrin and Kigluaik rocks. They are as a rule schistose, although some massive phases are found. Granite occurs in a number of localities.

**Superficial Geology.**

The most widely distributed strata in the province are the gravels, sands, and clays, which make up the unconsolidated beds. These embrace the present stream gravel, and also the older beds which occur on high terrace deposits. They are all grouped as
Pleistocene deposits as the evidence all points to their being older than Tertiary. The oldest deposits may however be Tertiary.

The Pleistocene may be divided into two groups. The first group includes the deposits of the present rivers, streams, and sea-beaches. The second group includes marine and river terraces, and the coastal plain sediments.

River and stream gravels:— These deposits include many varieties of gravels, sands, and silts, and are developed in connection with the placers.

Beach deposits:— These are the sands and gravels within the range of wave action.

Terrace deposits:— This group includes terraces developed along present drainage system, stream deposits of former drainage channels, marine benches, and as a sub group of the latter, the coastal plain deposits.

Development of Land Forms and Drainage System.

A study of the topography of the southern half of Seward Peninsula points to the conclusion that the region may be divided into two provinces having different physiographic histories. The boundary is a line drawn between Rocky Point on the south and Cape Espenberg on the north. West of the line, the evidence points to a series of uplifts. East, there is little evidence of uplift, and the coast-line suggests marine invasion or drowned topography.

The studies, as developed, do not permit of correlation between the different terraces of the western province, except locally. Therefore, it is proposed for convenience to make three groups of topographic forms. Those of the first group which will be called the "upper group of terraces and benches" are probably
all marine, and include those falling between the altitudes of 1000 and 1700 feet. Terraces of the second group, termed the "intermediate group of marine and river terraces and benches," are both marine and fluvial, and range in altitude from 200 to 900 feet. The third group consists of the so-called "coastal plain terraces," which are of marine origin and do not exceed 200 feet in altitude.

Upper group of terraces and benches:
High terraces and benches of this group have been found in a number of different localities. The evidence in regard to them is of a fragmentary character and can lead only to tentative conclusions. The flat summits and terraces mark a level of erosion which was formed when the region stood at a much lower altitude. The depression is of wide extent as is shown by similar erosional features being found near Cape Prince of Wales. In some cases the higher benches were found enirling mountains in such a way as to show that they were marine benches. In a number of localities, old sea-cliffs were found. The present differences in altitude among these benches may be due to differential uplift subsequent to their formation. Some lower terraces occur, showing that there were intermittent conditions of stability.

Thus it seems that in early Pleistocene times there was a submergence of this western province to a depth of 1000 feet or more. It is probable that the relief in its general features was not different from what it is now. The terraces very often enirle the mountains, and if the period since the submergence had been long enough to carve such deep valley lowlands as now
exist, the terraces and benches would have been destroyed. The
submergence was relatively short, as no deep mantle of sediments
of this period has been found, and had such mantle existed more
striking examples of superimposed streams would have been found.

Summary:— The above facts point to the following conclusions:
First, previous to the time when the high terraces were formed, the
general features of the present topography had already been
developed; second, the amount of submergence may be measured by
the altitude of the highest system of terraces; third, the period
of depression was relatively short. It seems probable, also, that
these terraces and benches are of marine origin and that their
present differences in altitude may in part be explained by
deformations or warping. The occurrence of some lower terraces
make it probable that the uplift was intermittent, and that there
were periods of stability during which marine benches could be
formed.

Intermediate group of marine and river terraces:—
These are the terraces and benches which occur at lower altitudes
than those described, and above the coastal plain. Their elevations
vary from 200 to 400 feet. They are in part clearly of fluvial
origin, while some are distinctly marine. In the southern highland
belt there is abundant evidence of stream and marine benches of
this erosion epoch. Near the coast, the gravels which form these
deposits were unquestionably laid down as littoral deposits. The
shore line of this period of submergence was probably not far in-
land, as the material found in the Dexter Creek benches near Nome
is very coarse and could not have been carried far.
Coastal-plain terraces:—These terraces are not sharply differentiated from those of the previous epoch. Their upper limit is 200 feet, and they include some low river terraces of lesser altitude. These upper terraces merge into the broad flood plains of the larger rivers. In the Nome region, the highest terrace of the coastal plain is about 100 feet. The deposits are made up of sands, gravels, and clays containing vegetable matter, showing that the elevation was interrupted by depression.*

* End of Summary.

Comment on Mr. Brooks' theory:—
The principal objections to Mr. Brooks' views are that they complicate the explanation of the physiographic history. In the first place, the statement that the topography in its main features was the same before the subsidence as it is today is not warranted. Many evident cases of comparatively recent stream-capture could not be explained by his view. Again, he does not account for the accumulation of gravels up to altitudes of 1000 feet. If his theory is true, these gravels were deposited before the subsidence, and subsequent streams would have formed channels altogether different from the bedrock channels found today. Further, it does not follow that the erosion which covered the deep valleys that we find today would destroy the evidence of the benches and terraces. They might be modified to a degree, and this conforms with actual field observation.

A more simple explanation would be that the land area in early Pleistocene times was reduced to sea level; that benching
and terracing took place in many localities. An uplift of 1000 feet or more took place with many intermittent stages of stability which allowed the lower terraces to form. With the uplift came the cutting down of the rocks by the rivers, and the formation of old river-valleys and benches. The sea also began to cut in and soon wore down a flat floor. A slight subsidence, or slight intermittent subsidences and elevations, permitted the accumulation of the coastal plain sediments. The slight elevations resulted in the formation of beach lines, at least one of which has been definitely located and proved. The final uplift brought the land to its present level, and we now have the beach forming at a lower level than the other beaches.

Problem of Old Channels.

A specific problem developed by field work in the Nome region was the question of the formation of the old channels found on the divide between Anvil and Dexter Creeks, on Anvil, and on Glacier Creeks.

The facts noted are these:

On the right limit of Glacier Creek about 100 or 150 feet above the present stream channel, there is a well defined old channel with perfect tin rock. The channel begins at a point opposite to the mouth of Snow Gulch and continues well marked in a direction down stream for a distance of 500 feet. Then it seems to slope over into Glacier Creek. The deepest working is 12 feet from surface to bed rock. The gold is rather coarse and many large nuggets have been taken out. The largest weighed 18 ounces. The claim has produced nearly one million dollars.
On the left limit of Anvil Creek on a long gentle slope of
the valley at least one, and probably more, ancient channel exists
above the channel of the present Anvil Creek. This ancient channel
leaves the modern channel at claim number 3 above Discovery and
crosses 4, 5, 6, 7, and 8. Between the ancient and modern channels
and probably tributary to the former are one or two minor and
approximately parallel channels.

The modern channel is much broader and more strongly developed
than any ancient channels so far developed. But it does not follow
that it necessarily richer, as it may carry less gold, and many not
have inherited the gold of the ancient channel. For, the latter may
hold all the gold set free in the erosion of that portion of its
valley down to its level; and the latter, only that portion set free
in the deepening of its valley from the level of the ancient
channel to the present level. This is very slight. Granting that
the original richness of the valley is uniform for unit volume,
the richness of any channel must be proportional to the amount of
country rock which it has worn down or eroded.

A deep drill hole, and a shaft, north-east and south-west
respectively of Banner Station, seem to indicate another channel
which extends south-westerly and which may be continued in the
Moonlight Channel, one of the distinct old channels. The new
channel indicated by the drill hole and shaft would be of an
earlier date, as it is found higher up the valley. Between the
present channel of Anvil Creek and the Moonlight Channel, the bed-
rock comes within 6 to 8 feet of the surface, showing that there
are really two distinct channels.

Specimen Gulch is a tributary of Anvil on the left limit.
It has carried coarse wash and gold values down into the lower channels making them richer at the expense of the upper channels.

Nikola Gulch is also a left limit tributary of Anvil, and extends to the divide between Dexter and King Mountains. The gravels here are very deep, 200 feet or more, and very rich. The Snowflake, and the Mattie claims are in this deep gravel.

Dexter Creek, a tributary to Nome River; heads on the divide between Dexter and King Mountains. Dry Creek, a tributary of Snake River, also heads on Dexter Mountain near the divide.

A study of these general relations suggests that King and connected Dexter Mountains were once continued in one continuous ridge. This is shown by the trend of the spurs on these mountains. Further, from the western slope of this ridge, over what is now the upper part of Dexter Creek, three channels diverged.- The Nikola Gulch, the Specimen, and the Dry Creek Channels. The first two were tributary to Anvil Creek, which was then continued northward where Glacier Creek north of the Great Bend now flows, as a main stream parallel with Snake River on the west and Nome River on the east.

A tributary of Snake River, similar to Rock Creek, captured the head waters of this stream at the great bend and thus originated the modern Glacier Creek. Similarly, a short tributary of Nome River, aided by the easily eroded limestone of Dexter valley, cut back through the King.- Dexter ridge and captured the heads of the three channels first mentioned, and damped their gold values into the Modern Dexter Creek. The breadth, flatness, and uniform elevation of these various divides seems to refer them to an ancient base level, with the present mountain summits and ridges rising.
above them.

A case of stream capture similar to that of Glacier Creek occurs further east at Osborne Creek. This probably represents a capture of the headwaters of Hastings Creek by a small tributary of Nome River, and thus developing the present Osborn Creek. There are several reasons for this belief. In the first place, Osborne Creek makes a great bend at the mouth of Michael Creek. That part of Osborne Creek between the great bend and Nome River carries little or no values, while the remainder of the creek is workable. Further, Hastings Creek has little or no stream at the present time, and its valley is much too large for the present stream.

The Old Beach Line.

An old beach deposit has been traced westward from Cape Nome to Dry Creek. It occurs about 50 feet above sea level and from a half to one mile back of the shore. It has little or no topographic expression except an occasional low hill or bluff, which marks the place where the sea has cut in. Evidences from excavations and shafts show that the composition and structure is that of a true beach. Layers of ruby and black sand and quartz pebbles are prominent features. Large shingly boulders and clay form the false bedrock. These represent the uneroded tundra and the residual boulders so often found on a beach. The depth to the false bedrock varies from 10 to 30 feet. Sometimes a clay seam near the surface forms the bedrock on which values occur, although the usual clay-boulder bedrock lies below this.

The old beach is older than the present tundra creeks, as the latter have cut through it and locally been enriched. The varia-
tions in the depth of the false bedrock or in the thickness of
the beach deposit are due in part to erosion, but more to landslips
and wash from the bluffs behind the beach. This is definitely
shown in the shafts. Pay is usually confined to the beach sand
and gravel, and the rocker pay to thin layers in the ruby sands
at the bottom. But it is certain that the values have been derived
immediately from the tundra formation.

It is very clear that the beach is richest where there is a
good bluff behind it; and the pay streak is close against the foot
of the bluff, or seemingly under it wherever covered by the slide
material. The bluffs are 15 to 25 or 30 feet high, and this added
to the depth of bedrock gives a bluff 40 to 50 feet high or about
double the height of the bluff of the modern beach. This means
more extensive erosion and consequently a greater concentration,
and larger aggregate gold values. Another source of concentration
is by the tundra streams already referred to. These may be regard-
ed as secondary concentrators.

Additional Notes on the Gravel and Gold.

The depth and character of the gravels, and the coarseness of
the gold varies in the different creeks. In general the gravel
is coarsest at the head and finest at the mouth of the creek. The
depth of gravel increases downstream proportional to the gradient.
The coarsest gold is found toward the head of the creek, and the
fine gold, being lighter, is transported further down-stream. The
same relations hold between the creeks, coastal plain, and beach
deposits, the gold is coarsest in the creeks and finest on the
beach. The gold amalgamates readily, and in most of the workings
mercury has to be used to catch the fine gold. The best values
occur on bedrock, which, in many cases, is also worked to a depth of several feet and washed. Often-times the best values are in the bed-rock. In these cases, pyrite accompanies the gold. On the beach, the ruby sand is looked upon as the pay streak, and clay layers form the false bed-rock.

The general value per cubic yard of dirt varies. The lowest value at which claims can profitably be worked is $2.00 per yard. Claims are often "spotted" so that at some places no values occur, while in other parts coarse nuggets are common. This makes mining extremely risky. The largest nugget ever found in the district was worth in the vicinity of $3200.00. The fineness of the gold gives an average value of $17.00 per ounce for all creeks.

The writer has not attempted to give complete details in regard to each creek in the Nome District. For such information the reader is referred to a paper to be published by the U.S. Geological Survey on the "Placer Mines of Seward Peninsula" by Mr. Arthur J. Collier, who has carefully explored the field.

Conclusion.

The main facts relating to the geologic conditions in the principal creeks and the old beach have already been described. The modern beach represents agencies at work similar to those which formed the old beach. As the creek claims have gradually become worked out, attention has been drawn to the bench and terrace deposits. Prospecting has disclosed the value of such claims, but water conditions make their development, at the present time, impossible. Many of the rivers and creeks away from the present centers of mining are still virgin ground, and on them will depend, in a large measure, the future worth of the district. These have extensive developments of shallow low-grade gravel.
too poor to be worked by the present methods. Intelligent analysis of geologic evidence may bring to light interesting developments in old ground as well as in new unknown territory. At the present time, every appearance indicates successful activity for many years to come.
OUTLINE.

Mining of the Nome District.

1- History of the Nome District.

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Present city.

2- Economic Considerations.

Labor, wages, living.

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Steamers
Railroads
Wagon roads

Fuel and Timber

3- Kinds of Mining.

Vein Mining

Placer Mining
Gold
Water
Place for tailing dump.

4- Mining Operations.

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Hand Shovelling
Steam shovels
Dredges - bucket and dipper types.
Hydraulic Mining
Nozzle and elevator.
Discussion of Miocene Co. outfit
Method
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5- Costs of Mining.

5- Conclusions.

Present difficulties
Future development.
the creeks and hills.

The city of Nome, today, is no longer a city of tents, but has advanced and expanded in many ways. There is a fair city government, and there are three banks, three newspapers, two good hotels, and many up-to-date mercantile establishments. A newly installed telegraph system connects Nome with the outside world, while a local telephone service connects the mining camps with each other and with Nome. The city is lit by electricity. Water is piped four miles to the city, and is sold at distributing stations at the rate of four buckets for twenty-five cents. Mails are received during the open season every ten days.

The greatest drawback to the development of the city is the fact that its location on a flat beach makes wharves and landing facilities difficult. Passengers and freight have to be transferred from the steamers to lighters, and then transported through the surf before they are landed on the beach. In other ways, the city is quite a model mining camp.

Economic Considerations.

In the consideration of the mining industry of any district, note must be made of the economic and industrial conditions such as labor, transportation, fuel, etc. These conditions have had an important bearing in developing and influencing mining in this district, and a brief summary of existing conditions will not be out of place.

Labor.

Labor is generally of the unskilled type. The rush in 1899 and 1900 attracted a class of men eager for gold but without any training in mining methods. All classes and conditions of men
came and those physically able to handle a pick and shovel were able to earn $10 per day. Today the rate of wages for ordinary miners, the pick and shovel men, is $5.00 per day and found, or an equivalent of $6.50 to $7.00 per day. Skilled labor such as mechanics and the like, receive as high as $7.50 and $8.00 per day and found. Although this may seem to be very good pay, when one considers that the working season is never over 100 days long, it will be seen that in the end the net result is lower than wages in the States. Living at the camps is very fair, as the mining companies aim to give their men as good food as can be obtained, although canned goods, enter considerably into the bill of fare, as a necessity; fresh meats, eggs, and vegetables whenever obtainable find a place. The companies have found that a man can work much better when he is well fed, and the outlay for food is well invested. The men sleep in large bunk-houses accommodating as many as 30 or 40 men at a time.

Transportation.

Nome is connected with the outside world by a number of steamship lines. The most important of these, of course, are the lines to Seattle and San Francisco. Generally there are vessels every ten days to these ports, and thus a continuous service is established for mail and supplies. There are numerous coasting vessels to St. Michaels, Solomon, Teller, York and other parts of Seward Peninsula. By means of this service, with Nome as a center, mining supplies may be shipped from Seattle and reach the various ports in from two weeks to one month.

Transportation on land is not so well developed. Roads are few and poor, and freighting is expensive. One railroad, dignified
by the title of the Nome Arctic Railroad Co., is a short, one track, narrow-gauge line eight to ten miles long connecting Nome and Dexter Creek. Fare is $1.00 each way, and freight rates are high. Freight-
ing in summer is a difficult task owing to the swampy condition of
roads. Rates are 3¢ per lb. for ordinary hauls to the creeks.
Whenever convenient, freighting is done in winter over the ice. This
is a much easier and cheaper method. Good government roads would be
a potent factor in developing the country, and it is to be regretted
that the government has not taken any active interest in this matter.

Fuel & Timber.

The Nome district is situated in a region barren of timber.
Stunted willows, unsuited for anything, is the only timber to be
found here. Fuel as well as timber has to be brought from the
States. Wellington Coal sells at $18.00 per ton during the summer,
and at $25.00 in the winter. The new developments of coal on Cape
Lisburne may have some future importance, but as yet are unimportant.
The tundra has some excellent peat development, but nobody
seems to realize its fuel value and it is neglected as a fuel.
Gasolene, and crude oil are coming to the front especially for engine
purposes. Gasolene is shipped in 5 gallon cans and sells at about
20¢ per gallon for best qualities. Crude oil is being shipped in
tank steamers, and is pumped to the creeks through pipe lines.

Kinds of Mining.

Vein Mining.

Vein or lode mining in the Nome district is of little importance and of no present interest. Prospecting is going on continuously
and if anything develops it may have some future interest. Conditions are not favorable for exploitation except for very rich deposits
Placer Mining.

It has been truly said that for hydraulic or placer mining three conditions are necessary: 1- Gold. 2-Water. 3-A place to dump tailings. The first two conditions are absolutely necessary, the third is of minor importance.

In regard to the occurrence of gold we have already seen that the metal is present in paying quantities. The third condition, room for tailing dumps, has been met in a number of ways. Where a number of claims adjoin it is often possible to leave the lowest claim for this purpose. In bench claims, it has often been found practicable to sluice off into the creek. In most cases it is possible to purchase tailing dump privileges in adjoining workings.

The water problem has been the most serious to confront the district. Rainfall is relied on to furnish the water for sluicing, and when this fails the output of gold falls off materially and business conditions become depressed. During the summer of 1904, the precipitation was very slight. The result was that very little mining was done, men went idle, and business was slack. Several methods have been tried to bring water to the camps. The Wild Goose Mining Co., has a pumping station on Snake River and pumps water to the head of Dexter Creek, a distance of about eight miles. The Pioneer Co., pumps water from Nome River to the head of Dexter Creek, a short distance but against 600 feet head. Both these methods are very expensive and do not yield sufficient water owing to friction losses. The Miocene Ditch Co., brings water from Nome River and its headwaters so that at Glacier Creek they have 360 feet head. The ditches of this company are about 50 miles long.
and at sufficient altitude to give a good head for hydraulic elevator work. This company controls a good part of the rich ground by virtue of its water monopoly. The ditch-building fever has taken hold of the operators and many new ditches are being built. One company is aiming to build a ditch over that of the Miocene Co., and already there are numerous lawsuits over the water rights. Another ditch from the Flambeau River to Hastings Creek and the tundra east of Nome River has been started. Several small ditches have been built to furnish water for one or two camps. It is hard to say just how far the ditch fever will go. In a great many cases, the outlay for ditches is greater than the values of the claims which are to be worked.

Mining Operations.

Underground Work:--

Mining is done in two ways, by underground workings, and by surface workings. The underground working is rather unimportant and may be dismissed in a few words. In a few cases where the gravels are very deep, the pay streak is mined by means of a shaft and drifts. The dirt is washed on the surface in the usual way. In some cases, the dirt is mined underground only during the winter, and piled up on the surface to be washed in the spring with the ice water. The objections to the method are the cost of timbering and thawing.

Surface Work:--

The first operation in surface work is stripping the surface mantle of moss and grass, which is an effective non-conductor of heat. Then the ground is ready to be thawed, either naturally by solar heat or artificially by means of steam points or water.
Steam points are hollow wrought-iron pipes, 1 to 1 1-2 inches in diameter and 5 feet long. At one end is an acorn-shaped fitting which is perforated with small escape holes. The other end has an entrance for steam. These pipes are driven into the frozen ground and then connected with a small donkey-boiler which furnishes the steam. They are allowed to stay in the ground for about twelve hours when it is expected that they will have thawed the area of a sphere of five feet radius.

Water is the most effective thawing agent. Where a hydraulic nozzle is to be used to break up the ground, the water will also be effective in thawing it, and no other thawing methods are necessary. Where the dirt is to be broken up by other methods, "ground sluicing" must be used to thaw the ground. This consists in allowing running water to flow over the ground and make a series of parallel ditches. After these ditches have once been started, they thaw readily and as soon as the ice in the ground melts, the residual dirt collapses. Then it is ready to be shovelled into the boxes. This latter method has for its greatest objection the large consumption of water, which generally cannot be used over again; but the method is the most practical where shovelling is the mining method.

After thawing, the ground is ready to be shovelled and sluic...
sluiced. There are numerous ways of mining the dirt. I shall
name the methods, employed and give a typical example of each of the
more important methods. The simplest method, of course, is to
shovel into a rocker or tom. I found this method in use on Nome
Beach; on the "old beach" line where the dirt was very rich
and a man could rock out $100 per day; and on some of the creeks
where prospecting was being done.

Next in order of simplicity is direct or hand shovelling into
the sluice boxes. This is the most general method used. Long
"Number 2" shovels are used, and the sluice boxes are generally
placed no higher than the level of a man's head. The men work in a
"cut", which is a strip 16 feet wide the length of the sluices.
It is figured that one man should average 6 to 10 yards of dirt
in 10 hours. I know of one case where a record of 14 yards was
established. This was done by undercutting and saving a bench
deposit. The average per man for all men around a camp including
foreman, teamsters, cooks, etc., is about 3 1-2 to 5 yards per
10 hour shift. At claim No. 8 on Anvil Creek, the surface was
first ground-sluiced, and then shovelled into cars which are hoisted
up an incline and dumped into the sluice boxes. The force is 18
shovelers per shift of ten hours, and a total force of 60 men
altogether. Capacity is about 750 cars per day, each car holds 21
cubic feet of dirt. Cost 46 cents per car to get to the sluice boxes,
not considering cost of water.

The next methods to be considered use machinery such as
hydraulic nozzles, and elevators; steam-shovels; and dredges of
bucket and dipper types. In general, most of these methods are
supplemented in some way by hand shovelling.
One steam-shovel is in operation at claim No.5 on Anvil Creek. The following data was obtained in regard to it: Operated by Barnhart's Steam Shovel, Style C. Dirt dumped into Truax Automatic cars which are hoisted up inclined track to sluice boxes by means of a stationary engine. The shovel is operated by crude oil, and handles all the dirt that the sluice boxes will take. The bucket is 1-2 yard in capacity, and it takes three buckets to fill a car. Sluice capacity is 700 to 800 yards per day, and shovel handles this easily. Some difficulty on account of frozen ground. Value of dirt shoveled about $2.00 per yard. Disadvantages of machine:- costs of oil and repairs high; cannot work in frozen ground; not good on bed-rock.

Only one bucket dredge was in operation at the time of my visit. This was dredging in Bering Sea just off shore, but it was driven on the beach during a storm and put out of commission. Another dredge was in process of construction. It had a one yard bucket, and was to be built in two parts. One float was to carry the bucket and machinery, and the other float was to carry the sluices and pumps, the two to work side by side. No figures could be obtained about either of these dredges.

The dipper dredges have been tried with more success. Two are in operation on Bourbon Creek, and one on Nome beach. The one on the beach had about 20 dippers and was operated by a 6 H.P. engine. Its capacity was 400 to 500 yards per 24 hours. Another 12 H.P. engine on the beach pumped water from Bering Sea for the sluice boxes which were mounted on the dredge. Engines were operated by gasolene. The dipper dredges of the stacker type on Bourbon Creek were being replaced by a new one which embodied the following features:
It was to have a 50 foot beam with a reach of buckets to give a cutting face from 60 to 75 feet diameter. One 20 H.P. petroleum engine to run the dredge and pump water to sluices. Fifty buckets or dippers on the chain, with a dumping capacity of one yard per minute. The main features of this machine were that a giant was to be used in advance of the dippers to break up the ground and make less digging work for them to do; and that the tailings were to be stacked ahead of the machine. In most types of dredge, a good part of the ground must be saved as a road bed for the machine to travel on. By the new arrangement, all the ground is dug out and sluiced, and the tailings dumped ahead to make a road bed for the rails on which the machine travels. The advantages of this type of machine are the cheapness and simplicity of the method of working. The disadvantages are that it cannot work in frozen ground nor can it clean bed-rock.

The last method which I will consider is the hydraulic nozzle and elevator system. The nozzle which operates under high pressure of water is often used alone to break up the ground and wash the gravel directly into the sluice boxes. This is possible only where there is sufficient tailing dump room at the end of the sluice box. The method is employed at the Hot Air Claim on Glacier Creek. This is an old channel about 100 feet above the level of the creek, and the tailings fall from the sluice boxes directly into the creek below. One nozzle was employed to wash into one sluice box, while three boxes are in operation to wash the bed-rock material. Bed-rock is scraped clean and the rich material is washed in these boxes. The rough work is done by the giant. In many cases a giant is used to remove tailings.
Hydraulic elevators are operated by the Miocene Ditch Company. This company is the only one doing scientific mining, and it was possible to get some intelligent information. The method of mining at their camps is as follows. First, a pit is dug to a depth of 10 or 12 feet and an elevator is set up with its throat in this pit. A giant is set to work to enlarge the pit and wash the material into the elevator. As the pit is deepened, the elevator is lowered until bed-rock is reached; then, the elevator and sluice boxes are set up permanently. Now, the giant is taken off some distance, a bottom sluice or two are placed in the pit, and then the stream is turned on. The ground is broken up and washed into the elevator by way of the bottom sluice. Then it is elevated to the upper sluice where most of the gold is caught. The tailings are dumped off over the end of the sluice. After a few days everything is ready for a clean-up. The giant is shut off and only free water goes up the elevator. The bottom sluices, which carry riffles, are cleaned as well as the upper sluices. The method of cleaning up is as follows: First pull out the upper riffles, loosen up the gravel and concentrates with wooden or iron paddles, and let the material work down over the lower riffles. The gold will drag behind, and it is scooped up from time to time. Great care must be taken to break up any clay or fine material that may be packed on the bottom of the sluice on the removal of the riffles. Use only a small amount of water in cleaning up. The last 6 or 8 feet of riffles are left in till all the upper gravel is washed down. Put a tub under the mouth of the sluice to catch and save the concentrates in the last riffle. These concentrates should be put in the upper sluice when work is started, or they may be melted or treated, according to conditions.
The elevators used by the Miocene Co., are of the Campbell type, made in San Francisco, and shipped in parts to Nome. This type of elevator differs little from the usual elevator except that it introduces manganese steel castings for throat parts, and is so constructed that there are no flanges to come in contact with the gravel. On claim No. 2 on Glacier Creek, the company operates two elevators in one pit. The object of this is:—first, to have one elevator always ready in case the other should choke up; and, second, to use as a pump to take care of the excess sump and water.

The following figures are given in regard to the work of the elevators. In one case with 600 inches of water under 550 feet head, the elevator lifted an average of 1000 cubic yards per 24 hours to a vertical height of 30 feet. An inch of water may be expected in practice to lift from 1 1/2 to 2 1/2 cubic yards of gravel each 24 hours under this head. These elevators have lifted the gravel 50 feet under the same 550 feet head.

The elevators are usually set up at an angle of 60 degrees. Hydraulic elevators can handle all the gravel put into throat, as far as distance is concerned, but we might block the upper sluice. The more water and more pressure in elevator nozzle, the better efficiency per inch of water. As the pit sluice delivers from 10 to 25 times as many tons of water as gravel to the elevator throat, it is evident that the pit water and not the gravel delivered that chokes the elevator. With three hundred inches or more water, and 150 feet or more absolute pressure, we can raise as much water and gravel from the pit sluice as water goes through the elevator nozzle to a height equal to 12\% of pressure height on nozzle, and higher as pressure or amount of elevator water increases. The above
conditions apply when throat and nozzle are in the right proportions, and elevator is the right size. The above pressures mean those shown on gauge at nozzle when mining.

All of the lifting is done by the elevator, which takes its own supply of water from the penstock. In addition, water under the same head is fed to a giant which tears the earth to pieces and feeds it into the elevator pit. The company uses sluices made of iron plate and fitted with riffles to guide the broken material to the throat of the nozzle. In addition to the water fed by the nozzle, there is also drain water from the various sources fed into the pit.

Following are some further facts concerning the sluices. Depth of water and grade in sluice boxes depend on amount of water in sluice and size of boulders. Water should run about 10 to 12 feet per second over the surface. Surface velocity of 10 feet per second means an average of 7 1-2 feet per second.

Gravel drags on bottom of sluice, so we can handle more gravel than narrow sluices within certain limits. We should wash 4 to 5 cubic yards of gravel per inch of water with all conditions favorable and plenty of muck through the gravel to give the water body. We usually figure 2 to 3 cubic yards per inch of water. It is a poor plan to allow water to run through the sluice boxes when no dirt is being dumped, as it wears out the boxes. The sluice boxes are set as follows:

(1) First 12 feet box is level

(2) Next " " slopes 1" in 12 feet.

(3) " " " 2" " " "

(4) " " " " 3" " " "

(5) " " " " 4" " " 
(5) Next 12 feet box slopes 4" in 12 feet.
All other boxes slope 5" to 6" per 12 feet.
Slope of tailings dump is 3 to 4 feet per 100 feet.

Some miscellaneous facts:

Sluices:

The lower sluices have been referred to as being made of iron plates. Experience here has shown that they are much better than wooden boxes although their first cost is higher. They wear better, can easily be taken apart and set together, and are easily transportable. For the upper sluices wood boxes are used. The standard length of a sluice is 12 feet. For flumes, it has been found that to get most economical rectangular flume for carrying water, the sides should be one-half the width of the bottom.

For example:

<table>
<thead>
<tr>
<th>Sides</th>
<th>Bottom</th>
<th>Area</th>
<th>Wet perimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>3'</td>
<td>3'</td>
<td>9'</td>
<td>9'</td>
</tr>
<tr>
<td>2' 3&quot;</td>
<td>4' 6&quot;</td>
<td>10.125'</td>
<td>9'</td>
</tr>
</tbody>
</table>

The latter is more economical.

Riffles:

The small sluices use cast-iron riffles of the Leland design shown in the drawing.

Railroad Iron.
For sluices two feet wide and upwards use 12 pound railroad iron in four feet lengths with 1 1-2 inch spaces, and cleated at the ends and centre; or block riffles 5-6 inches in depth. In long flumes block riffles are very good, but the gold, especially the fine, runs through a considerable distance and the railroad iron is better to catch it with.

Costs of Mining.

The writer was unable to get any definite information in regard to the costs of the various operations. The U.S. Geological Survey has been investigating this problem for the whole of Alaska, and will shortly publish a report on this matter (Bulletin 263 by C.W. Furinton.) For present brief statements of costs, the reader is referred to an advanced summary of the report by Mr. Furinton in U.S. Geological Survey Bulletin 259, pages 32-46.

Conclusions.

Mining in the Nome district can be carried on only three months in the year. The winter work does not exceed 15% of the total yield. The methods employed in the past have been the make-shifts adopted by men eager to get as much gold as possible in the quickest time. Methods which have been tried successfully in other parts of the world have failed, while the crude methods employed by men without previous experience have often proved the most satisfactory.

The reasons for the difficulty of mining operations are the short season; the low gradient of the streams; poor water, timber and fuel resources; high costs of labor and transportation; the great thicknesses of barren overburden; the frozen ground; lack of wagon roads; and inadequate mining and police regulations. In a general way all of these factors have been working against a wholesome
development of the region.

A word concerning the mining and police regulations will not be out of place. The size of claims as determined by the local custom is 660 X 1320 feet. Approximately 20 acres. Further, it was originally agreed that no more than one claim on a creek could be located by one man. Powers-of-attorney soon found a way out of this difficulty, and claim after claim was staked for Tom, Dick, and Harry who were several thousand miles away, while the legitimate prospector found everything staked. At the present time, a person may stake as many claims in his own name as he wishes; and he may also form an association of eight men and locate association claims of 160 acres. The government requires recording within 90 days of location, and assessment or representation work to the value of $100 within one year after January first of the year following the date of location. The performance of the assessment work is a farce. Men dig a little trench in three or four days' work and then give notice that $100 worth of work has been done. Claims are held year after year on this system. Another abuse is claim-jumping and litigation. The general way is to allow a man to prospect and work a claim until he finds something. Then he is served with papers for a dozen law-suits. The lawyers are making more money in Nome than are the miners. Corrupt judges and government officials are the rule, and it is hopeless for the small operator to do anything to maintain his rights.

The future of the camp is promising. With good roads and transportation facilities, cheaper wages, effective regulation which can be accomplished, large deposits of low-grade gravel wait to be developed by intelligent mining methods. Men who are
careful, energetic, economical, with some capital to invest in proper machinery will find that the Nome district has much to offer them.